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THE IMPACT OF HACCP ON U.S. SEAFOOD EXPORTS: THE CASE OF FISH, MOLLUSKS, AND SHELLFISH OTHER THAN MOLLUSKS*

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ABSTRACT

This article investigates the effects of HACCP implementation on U.S. exports of three seafood categories: fish, mollusks, and shellfish other than mollusks. The Poisson Pseudo-Maximum-Likelihood method with fixed effects is used to control for unobserved country characteristics and zero trade observations. The results indicate that food safety regulations have differential effects across seafood products. The HACCP effect on seafood exports of mollusks, which have higher inherent hazards, is positive and statistically significant. This coefficient infers that mandatory HACCP implementation has improved the exports of mollusk products. The effects on the other two categories are positive, but not statistically significant.

Keywords: fish, food policy, HACCP, mollusks, shellfish

JEL Classifications: O24, O38, P33, Q18

INTRODUCTION

Food safety is a major concern facing the seafood industry as seafood consumption and reported outbreaks of food-borne diseases have substantially grown during the last few decades. There has been a concerted movement, led by Codex Alimentarius Commission (Codex), encouraging countries to focus their food safety regulations on improving public health through the use of risk analysis principles (Caswell and Bach 2007). Codex recommends the Hazard Analysis Critical Control Point (HACCP) system as a preferred set of standards to control food safety hazards (Unnevehr and Jensen 1999). A HACCP system monitors and controls critical points in the production process to prevent food safety hazards.

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This article seeks to explore the effects of food safety standards, specifically U.S. HACCP regulations, on U.S. exports of some seafood products, namely fish, mollusks, and shellfish.

The hazards of seafood lie in the different food borne diseases inherent in various categories of seafood products. High concentration of pathogens, biotoxins and chemicals, as well as disease agents, may be present in seafood and therefore constitute serious hazards. Mollusks are a special concern because they are traditionally eaten raw or very lightly cooked; this further increases the risk (Huss, Ababouch and Gram 2004; Rippey 1994). For shellfish, Norwalk and gastrointestinal viruses are the most common causes of shellfish-associated diseases (Huss, Ababouch and Gram 2004). Unlike mollusks, the levels of pathogenic bacteria and viruses presented in raw fish are quite low and it is very unlikely that this low level of pathogens could cause any disease as the product is cooked before consumption. Non-indigenous bacteria and bacterial contamination during processing are responsible for most disease incidents in fish consumption (Ferri 2005).

The HACCP system has been widely adopted by many countries to identify risks inherent in different kinds of seafood from the very beginning of food production. However, countries implement HACCP in many different ways, and there are no universally accepted procedures to assess risks. In general, developed countries implement food safety regulations in a stricter manner than developing countries (Wilson and Otsuki 2003). Empirical evidence suggests that food safety standards may be raised to act as protectionist barriers to trade, especially if the effective level of enforcement is more rigorous for imports than for domestic supplies (Grant and Anders 2010).

For government regulators, HACCP adoption is motivated by a desire to improve food safety, particularly by the control of food-borne pathogens. Trade facilitation is an important but often secondary goal of HACCP adoption (Caswell and Hooker 1996). Recently academics have attempted to quantify the non-tariff barrier effects of HACCP standards on trade flows. Since developing countries hold great potential in seafood production, the majority of this research focuses on demand-oriented trade flows, i.e., exports from developing countries (Baylis, Nogueira and Pace 2010). For the seafood industry, conforming to and harmonization of HACCP with original sanitation or food safety standards is a big issue for both exporting and importing parties. However, very few studies focus on the supply side. This article seeks to investigate how HACCP implementation affects supply using a case study of U.S. seafood exports market.

The purpose of this article is to quantify how HACCP implementation influences U.S. seafood exports among three disaggregated seafood categories. After taking into account the differential inherent riskiness of seafood products and corresponding different requirements of U.S. HACCP, U.S. fishery exports are classified into three categories: fish; mollusk shellfish; and shellfish other than mollusks shellfish (SOM)[1]. It is hypothesized that the imposition of new regulations does not have significant effects on U.S. seafood exports. It is also hypothesized that the regulatory effects differ by seafood category. This article tests these two hypotheses by using a gravity model estimated by the Poisson Pseudo-Maximum-Likelihood (PPML) method with fixed effects to deal with zero observation and endogeneity problems. This article is the first to test the differential effects of HACCP on U.S. seafood exports using disaggregated categories. The results contribute to the discussions of how HACCP affects trade flows of seafood supplied by developed countries. The next section

[1] Mollusk shellfish include snails, slugs, clams, and squid; Non-mollusk shellfish include crabs, lobster, and shrimp.

provides a brief summary of current research on this topic. A discussion of the specification of the gravity model and data used are followed by the results and conclusions.

LITERATURE REVIEW

Governments mandate several food safety standards to control associated risks with seafood products. Canada was the first country to establish a mandatory food inspection program for fish and fishery products based on HACCP principles in 1992 (Allshouse et al. 2003). In 1991 and 1994, the European Commission adopted regulations concerning health conditions for production and marketing of fishery products roughly based on HACCP principles (Caswell and Hooker 1996). In 1995, the U.S. Food and Drug Administration (FDA) promulgated a HACCP program for fish and fishery products and enforced the regulation after 1997 (FAO 2000). The U.S. system focuses on controlling the production process instead of testing the final product. Under HACCP, seafood processors develop a production system such that critical points for preserving food safety are identified and monitored. A plan is implemented to establish good production and sanitation practices that prevents or eliminates pathogenic contaminations and produces safe food (FDA 2011). The HACCP plan will differ based on production process and product characteristics.

Because food safety standards differ among countries and the inspection procedures vary, there is great potential for problems at the port of entry for imported food, which enhances the chances for import refusals. According to the Huss, Ababouch and Gram (2004), the main products and reasons for import refusals for EU countries include: the presence of pathogenic bacteria (e.g., Vibrio spp., Salmonella, etc.) for chilled and frozen fish, shrimp, crayfish tails and crab-tails; high content of histamine or mercury, presence of Salmonella or detection of toxin, viruses or bacteria for tuna-fish products; and the presence of pathogenic bacteria for mollusks shellfish. The distinct reasons for refusals imply that food safety standards may have different effects on trade for different kinds of seafood products.

In regard to the effect of HACCP on trade, some studies have argued that food safety standards are "catalysts" for exporters. For example, Henson and Steven (2008) and the World Bank (2005) highlight the potential benefits provided by stricter emerging standards. These tighter standards not only provide certain countries with competitive advantages and increase their market shares, but also provide incentives for developing-country producers to adjust and improve their export industry. In addition, higher food standards in rich countries could potentially benefit poor country consumers through strengthened food and health standards. Caswell and Bach (2007) point out the possible spillover effects on consumers, which results in beneficial health impacts. Yet they show that the spillover effect is weak with their case study of Brazil.

Many academics hold the view of "standards as barriers," meaning that such standards are raised to act as protectionist barriers to trade, especially if the effective level of enforcement is more rigorous for imports than for domestic supplies (Grant and Anders 2010, 573). A growing body of literature argues that many developing countries do not have effective food safety control systems in place. Stricter safety standards and regulations imposed by major importers may impede trade flows through the creation of prohibitive costs of compliance (Anders and Caswell 2009; Caswell and Bach 2007; Grant and Anders 2010). A fairly extensive literature provides empirical evidence that HACCP works as a "standard

barrier" for seafood exports from developing countries (Otsuki, Wilson and Sewadeh 2001; Wilson and Otsuki 2003; Nguyen and Wilson 2009). Baylis, Nogueira and Pace (2010), and Baylis, Martens, and Nogueira (2009) suggest that as the purchaser, developed countries require importers of seafood to meet higher standards which lead to more seafood import refusals. Buzby, Unnevehr and Roberts (2008) find that developing countries account for most of the import refusals by the U.S. and EU.

Developed countries, which largely account for enhanced food quality and safety standards, could experience either negative or positive effects from HACCP introduction on their exports to other countries. Currently very few empirical studies test whether domestic HACCP requirements increase or reduce exports. Previous analyses focused on imports because the U.S. has been most concerned with the health of its population, which is affected by seafood imports. The HACCP requirement for all U.S. seafood producers (and importers) make consumers better off; but the HACCP requirement has potential effects on U.S. seafood exports too. Caswell and Anders (2009) focused on the U.S. import market and found that at the aggregate level, developed countries were positively but not significantly affected by higher U.S. standards. They found larger or more established seafood exporters from developed countries increased their exports to the U.S., while smaller exporters suffered reductions. Their findings suggest that economic status is not the only criterion for judging HACCP effects.

At the disaggregated level of seafood products, Nguyen and Wilson (2009) analyzed the product-specific impacts of strict standards by investigating the EU, U.S. and Japanese import markets and found that shrimp is the most sensitive to changing food safety policies, while fish is the least sensitive. These findings indicate that food safety regulations can have different effects across seafood products[2]. In this research, we focus on fish, mollusks, and shellfish other than mollusks. The results show HACCP system has differential impacts on those products.

MODEL DEVELOPMENT

The gravity model, which is analogous to Newton's law of universal gravitation, constitutes the theoretical approach used in this study. Since larger places attract people, ideas, and commodities more than smaller places, and places closer together have a greater attraction, the gravity model incorporates these two features into a model of international trade. In the basic theoretical model, bilateral trade flows between countries are predicted based on each country's economic size, divided by the cost of transportation (Anderson 1979).

In economics, gravity models have achieved empirical success in explaining inter-regional and international flows (Cheng and Wall 2005). During the last two decades, a remarkable number of studies have derived gravity models of trade from very different theories of international trade. The foundation used in this article is based on Bergstrand's (1985 and 1989) derivation.

[2] It is important to note that some of these differing effects for shrimp could be due to substances used in its production instead of its processing. A HACCP system cannot control for adverse substances used in production.

Taking account of the economic foundations for the gravity model, this study adds three more adjustment factors, the exchange rate, a dummy variable to identify free trade agreements (FTAs), and a dummy variable for HACCP regulations. Based on Bergstrand's model (1985 and 1989), price effects play an important role in the derivation of the gravity model. Three important price indices cannot be neglected in the price index: transport costs, tariffs and the exchange rate. Bergstrand argued that the real exchange rate should be included in the model when incorporating price effects in cross sectional analysis. Tariffs can be represented by dummy variables indicating the presence of preferential trade arrangements. Finally transport costs can be represented by distance between economic centers of exporting and importing countries.

Soloaga and Winters (2001) and Zarzoz and Lehmann (2002) pointed out that in a purely cross-sectional context, the real exchange rate does not give any information of whether a currency is over or under-valued. Only when a time dimension is considered in the analysis does movement in the exchange rate become relevant. The exchange rate is added in this model specification because a time dimension is incorporated in the analysis. An FTA dummy variable, which has been shown to significantly influence bilateral trade in other research (Baier and Bergstrand 2007; Sun and Reed 2010), is used to represent tariffs. The model specification is:

$$\begin{aligned} \ln EXP_{jt}^{k} &= \alpha_0^{k} + \alpha_1^{k} \ln GDPC_{jt} + \alpha_2^{k} \ln DIST_j + \alpha_3^{k} \ln EXRATE_{jt} \\ &+ \alpha_4^{k} HACCP_t \\ &+ \alpha_5^{k} FTA_{jt} + \varepsilon_{jt}^{k} \end{aligned} \quad (1)$$

where k is the k^{th} category of seafood products. The dependent variable EXP_{jt}^{k} is the dollar value of seafood k that U.S. exports to country j at time t. The disturbance term, ε_{jt}, is assumed to be normally distributed with zero mean and constant variance for all time periods. The descriptions and expected signs of explanatory variables are listed in table 1.

As stated before, the effect of HACCP on U.S. seafood exports could be positive or negative. The view of "standards as catalyst" infers that HACCP requirements provide a comparative advantage for U.S. seafood exports. On the other hand, the "standards as barrier" view implies the additional cost of compliance with HACCP and other food safety standards, which increase the marginal cost of production, inhibit U.S. exports. Li and Saghaian (2011) found that if one concentrates on U.S. seafood exporting markets only, HACCP indeed has a positive impact on the aggregate level of seafood exports to developing countries, while HACCP does not significantly impact seafood exports to developed countries. The hypothesis tested here is:

H1: HACCP enforcement has no effect on U.S. seafood exports of fish, mollusks shellfish and SOM.

Furthermore, different technical standards imposed on various seafood products and inherent hazards contained in each one suggest that food safety regulations may have different effects across seafood products. This hypothesis is also verified by empirical research for the EU, U.S. and Japanese import markets (Nguyen and Wilson 2009). The second hypothesis tested in this article is:

H2: HACCP enforcement has different effects on U.S. seafood exports of fish, mollusks shellfish and SOM.

Equation (1) is a common specification of the gravity model. However, the typical gravity model suffers from two problems, endogeneity and zero-valued observations. The problem comes from unobserved heterogeneity between countries (Anderson and Wincoop 2003; Baier and Bergstrand 2007; Cheng and Wall 2005; Wilson and Otsuki 2003). These unobserved ties between nations may make regional agreements more likely and further impact trade flows.

Table 1. Variable Descriptions and Expected Signs

Variables	Variable Description	Expected Sign
EXP_{jt}	Exports in thousands of US dollars at time t	
$GDPC_{jt}$	Real per-capita GDP of country j in current constant 2000 US dollars at time t	+
$DIST_j$	Geographical distance between country j and U.S. in miles	-
$EXRATE_{jt}$	Exchange rate between U.S. dollar and domestic currency of country j. It is an index with the first year being 100	-
FTA_{jt}	Dummy variable to identify free trade agreement, which equals to 1 if country j belongs to the same Free Trade Agreements with U.S. at time t, and zero otherwise.	+
$HACCP_t$	Dummy variable to identify HACCP enforcement in U.S., which equals to 0 before 1998 and 1 thereafter	To be determined

Thus the estimation is potentially biased because the error term is correlated with other variables. From an econometric point of view, this special effect can be treated as either random (error component approach) or fixed effect (Mátyás 1997). However, most of the existing empirical studies use a fix-effects approach because such models allow for unobserved ties or unspecified factors that simultaneously explain trade between countries (Cheng and Wall 2005). Past research suggests that these unobserved characteristics between countries are best accounted for by using country-specific fixed-effects. In addition to time-invariant fixed effects, fixed effects for bilateral country pairs and time-varying fixed effects for importer and exporter countries are also included to deal with endogeneity problems.

Because the U.S. export market is the focus for this study, bilateral fixed effects are not used and the time varying fixed effects are included as intercept shifters. The fixed-effect gravity model is specified as:

$$\ln EXP_{jt}^{k} = \alpha_0^{k} + \alpha_{jt}^{k} + \alpha_t^{k} + \alpha_1^{k} \ln GDPC_{jt} + \alpha_2^{k} \ln DIST_j + \alpha_3^{k} \ln EXRATE_{jt} + \alpha_4^{k} HACCP_t + \alpha_5^{k} FTA_{jt} + \varepsilon_{jt}^{k} \quad (2)$$

where α_{jt} accounts for unobserved country effects of importing countries and α_t is the time

effect. Since U.S. is the only exporter in this research, the unobserved country effects of exporting country are included in α_t. And the country pair fixed effects are included in α_{jt}.

Another problem comes with zero observations when the double log model is used. Westerlund and Wilhelmsson (2009) point out that OLS estimates of the log-linear model may be both biased and inefficient in the presence of heteroskedasticity when zero value observations are omitted. Many researchers propose a PPML method and find that it performs better than other estimators in the presence of heteroskedasticity (Sun and Reed 2010). Santos Silva and Tenreyro (2009) point out that the PPML estimator is generally well behaved even when the dependent variable has a large proportion of zeros. This article combines the PPML method and fixed effects to deal with these two problems. The final gravity model used for this study is:

$$EXP_{jt}^{k} = EXP(\alpha_0^k + \alpha_{jt}^k + \alpha_t^k + \alpha_1^k \ln GDPC_{jt} + \alpha_2^k \ln DIST_j + \alpha_3^k \ln EXRATE_{jt} + \alpha_4^k HACCP_t + \alpha_5^k FTA_{jt} + \varepsilon_{jt}^k) \quad (3)$$

The PPML method with fixed effects is the benchmark model for this study and it is used to test the two hypotheses by running separate panel regressions for the three seafood categories. The OLS results with fixed effects are included for comparison purposes; it is not always clear that the PPML method is better. A Chow test is used to test whether HACCP effects are the same by seafood product (hypothesis 2).

DATA DESCRIPTION

Panel data from 1989 to 2008 are used for the analysis. Data for 1989 are dropped from the analysis for SOM products because GDP per capita in that year cannot be obtained for several countries, such as Palau and Taiwan. See table 2 for detailed information on the panel data used.

After dropping countries with incomplete data, 57 countries are used for fish products, 34 countries are used for mollusk products, and 61 countries are used for SOM. Although Belgium and Luxembourg were separated after 2000, they are still combined in this analysis.

Annual export values (in thousands dollars) of all three categories of seafood products are used for food and obtained from the Foreign Agricultural Service's Global Agricultural Trade System (GATS).

Fish products refer to aquatic vertebrate animals that lack limbs with digits, the majority of which are finfish. Mollusks are sub-categories of invertebrate shellfish products that are filter-feeding such as clams, mussels, and oysters.

SOM products include the other species of shellfish (crustaceans and echinoderm), such as crab, lobster and shrimp. Since U.S. exports for these three categories involve different destinations, the importing countries chosen for the analysis are not the same among categories. The number of zero observations in the export value data used are 22, 96 and 46, respectively, for fish, mollusks, and SOM.

Data for GDP per capita are obtained from the World Development Indicators and Global Development Finance. Information on distance is obtained from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII). Data for exchange rates are obtained from Penn Trade Tables.

We convert exchange rates into an index form in order to avoid the changing scale among countries; this makes exchange rate changes comparable among countries. Information on Free Trade Agreements is from the WTO's Regional Trade Agreement Lists. Before assigning values for an FTA dummy variable, the effective time of each country's membership is carefully verified, because countries within each FTA group may not join at the same time. FTAs considered in this article include the North American Free Trade Agreement (NAFTA), US – Australia, US – Chile, US – Israel, and US – Singapore.

Table 2. Data Summary

Seafood Categories	Variable	Observation	Mean	Std.	Min	Max
Mollusks	EXP	680	2267.89	7381.43	0.00	76014.00
	GDPj	680	16801.02	12904.11	382.89	72777.72
	DIST	680	8398.89	4295.96	737.04	16371.12
	EXCRATE	680	240.38	1208.15	1.03E-06	10950.00
	HACCP	680	0.55	0.50	0.00	1.00
	FTA	680	0.09	0.29	0.00	1.00
	Zero Observations	96				
Fish[(a)]	EXP	1140	26976.78	106949.10	0.00	1106287.00
	GDPj	1140	13261.45	12045.51	382.89	72777.72
	DIST	1140	7497.06	4134.14	737.04	16371.12
	EXCRATE	1140	174.18	963.93	1.03E-06	10950.00
	HACCP	1140	0.55	0.50	0.00	1.00
	FTA	1140	0.06	0.23	0.00	1.00
	Zero Observations	22				
Shellfish other than mollusks	EXP	1159	11505.34	44372.39	0.00	511550.00
	GDPj	1159	12829.12	12186.22	226.86	72777.72
	DIST	1159	7672.52	4266.98	737.04	16371.12
	EXCRATE	1159	409.52	1945.08	1.03E-06	16977.00
	HACCP	1159	0.58	0.49	0.00	1.00
	FTA	1159	0.05	0.23	0.00	1.00
	Zero Observations	46				

Note: (a): Data of Fish are from 1990 to 2008.

RESULTS AND DISCUSSIONS

Table 3 presents the estimation results for the three categories of seafood with two estimation methods. For each the first column is the typical gravity model specification (model 2) using OLS with time and country fixed effects to control for endogeneity, which excludes zero trade observations. The second column is the PPML estimation with fixed effects (model 3) which includes zero observations to reduce potential bias.

Based on estimated results of the PPML model, the coefficients for the typical gravity variables, such as GDP per capita of the importing country and distance, which are statistically different from zero, have signs that are consistent with expectation. The

coefficient for distance in the estimation of mollusks is positive and the coefficient for GDP in two of the OLS models is negative, but those are not statistically significant. GDP per capita has significant impacts on fish and SOM products in the PPML models, while distance has a statistically significant impact for SOM in the PPML model. The exchange rate coefficient is negative and statistically significant for mollusks and SOM with the PPML model. The variable of FTA is dropped from the PPML model of fish and SOM because of collinearity. For mollusks, the FTA variable has statistically significant and positive effects on U.S. exports for the PPML model, but the impacts on fish and SOM products in the OLS models are negative. Overall, some variation by product is expected since these products have different destinations and harvesting patterns.

Table 3. Gravity Model Estimates of HACCP Impacts on U.S. Seafood Exports of Mollusks, Fish and Shellfish Other than Mollusks

	Fish		Mollusks		SOM	
	OLS with FE	PPML	OLS with FE	PPML	OLS with FE	PPML
ln GDPCj	-1.35 (11.76)	1.01** (0.23)	66.93** (9.27)	0.033 (0.10)	-8.00 (5.86)	0.089* (0.036)
ln Distance	-26.77 (31.18)	-0.23 (0.19)	-64.29** (12.26)	0.15 (0.17)	-37.76 (51.03)	-0.41** (0.16)
ln EXRATE	-13.28 (8.36)	-0.85 (0.69)	13.46** (1.42)	-2.03** (0.32)	-31.62 (21.12)	-1.81** (0.53)
HACCP	-4.89 (7.30)	0.10 (0.44)	-12.29** (2.37)	0.56* (0.25)	37.98 (24.31)	0.11 (0.33)
FTA[(a)]	-2.18* (1.04)	-	-0.08 (0.11)	1.91** (0.31)	-33.47* (15.30)	-
Constant	-40.60 (193.18)	-1.47 (3.37)	-60.80** (23.02)	5.78** (1.54)	440.24 (436.07)	12.52** (1.20)
R^2	0.99	0.14	0.99	0.29	0.99	0.18

Notes: (a): FTA of the fish and SOM PPML model are dropped because of collinearity.
*Significant at 5% level.
** Significant at 1% level.

For the results of fish and SOM, the main changes for the estimates from the OLS model are the different magnitudes of coefficients compared with the PPML model. The only coefficient sign change was for GDP per capita for both products (the coefficient was negative in the OLS results). The coefficients for GDP per capita with the PPML model for these two products are statistically significant and positive, which is consistent with theoretical expectations and previous empirical results. However, the results for mollusks vary between these two models.

As stated before, the results of the PPML model are expected to be more reliable because they avoid the bias problems from using the log model and excluding zero observations. Considering the fact that SOM and mollusks have higher ratios of zero-valued observations than fish, we can draw the conclusion that the results of OLS may be more biased for these seafood categories (where there is a larger portion of zero observations). Thus, the PPML results are likely more suitable in this situation.

This study hypothesizes that everything else equal, the introduction of mandatory HACCP had no significant impact on U.S. seafood exports. The PPML model shows that the HACCP variable has a positive coefficient that is statistically insignificant for fish and SOM products. This result fails to reject the first hypothesis for these two categories. The positive coefficients indicate that mandatory HACCP enforcement does not impede the exports of fish and SOM products. In contrast, the estimated results for mollusks show a different story. The significant and positive coefficient for HACCP infers that mandatory implementation has significantly improved exports of mollusk products.

The U.S. is one of the leading exporters of canned salmon (fish), has substantial exports of crabs and lobster (SOM), and some mollusk exports. It is not surprising to see such different effects of HACCP enforcement on these three kinds of seafood. Theoretically HACCP enforcement could give the U.S. comparative advantage from food safety concerns in world seafood markets.

On one hand, the more stable international demand for fish and SOM may potentially reduce the impacts caused by HACCP implementation. On the other hand, compared with these two categories of seafood, mollusk products have higher inherent riskiness and less stable demand in the international trade market. High inherent risk leads to higher food safety concerns by consumers and less stable demand may potentially increase the advantage of U.S. products after HACCP implementation. These two major characteristics help us understand why more stringent food safety standards have positively (and significantly) affected U.S. mollusk exports.

Differences in technical standards imposed on various commodities suggest that food safety regulations may have different effects across seafood products. This idea is supported by the results of the Chow test for different coefficients on fish and mollusks. The P-value for the Chow test is close to zero; therefore the conclusion is that HACCP has different effects across these three seafood products.

The results in table 3 for HACCP show that mollusk exports are the most sensitive to tighter food safety controls. Exports of fish and SOM indicate similar elasticities and sensitivity to stringent standards. However, mandatory HACCP application only has statistically significant impacts on mollusks exports from the U.S. over the study period. The HACCP coefficient estimates from the PPML model suggest that U.S. mollusk exports increased by 75.1% or about $33.23 million, due to the implementation of HACCP.

Estimates from Nguyen and Wilson (2009) show that tighter food standards significantly reduce imports of shrimp and fish into the U.S. and that shrimp imports are more sensitive to changing standards.

This article presents consistent results when considering the U.S. as the supplier of seafood products instead of a purchaser. For the majority of seafood items analyzed, fish and SOM, the results support the assertion that HACCP standards have not impeded U.S. exports. Moreover, mollusks exports, which have the lowest export value and highest inherent risks, present the most sensitivity to tighter standards.

The results also show that HACCP standards could act as a catalyst for commodities with smaller exported values, particularly for U.S. exports of mollusks, because of the comparative advantage of food safety caused by stricter standard. U.S. exporters have been forced to implement HACCP for these smaller volume export markets, while other competitors with voluntary HACCP standards have not adopted these regulations.

CONCLUSION

Although the effect of HACCP on international trade has been an issue of concern recently, most previous empirical studies have focused on U.S. imports because of food safety concerns; few empirical studies have focused on the impact of HACCP on U.S agricultural exports. This article examines the impacts of HACCP standards on three categories of U.S. exported seafood products: fish, mollusks, and shellfish other than mollusks. A gravity model estimated using the PPML method with fixed effects is adopted for analysis, which allows zero trade observations in the analysis and controls the endogeneity problem caused by unobserved country characteristics. This study finds evidence that enforced HACCP standards have differential effects on the disaggregated categories of exported seafood products. The study also provides OLS estimates with fixed effects for comparison purposes. The results suggest that the PPML method performs somewhat better than the OLS method in the gravity model analysis when a large proportion of zero observations are present in panel data because the PPML results are more in line with expectations.

The PPML results indicate that mandatory HACCP application has positive, but statistically insignificant effects on U.S seafood exports of fish products and shellfish other than mollusks products. These findings are consistent with previous studies in that HACCP introduction should have insignificant effects on seafood exports from a developed country. For the seafood category with the highest inherent risk, mollusk products, a statistically significant and positive effect of HACCP enforcement was found. Exports of mollusks only constitute a small proportion of the total exported value in U.S. seafood export market. This suggests that categories with higher inherent risk and lower trading value are positively influenced (with statistical significance) and show higher sensitivity, while commodities with higher exported value are not significantly influenced and present lower sensitivity. Thus, HACCP standards act as catalyst for seafood with higher inherent risk.

This evidence is from the U.S. export market and may not be indicative of other developed countries that have increased their food safety standards. In order to verify these effects for other countries, it is important for future work to apply similar analyses to seafood export markets, such as the EU countries, and compare the results with this study. More work is needed to determine how stricter food safety standards affect the trading flows of seafood supplied by developed countries.

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MEASURING COMMODITY-SPECIFIC TRADE DETERMINANTS AND EXPORT POTENTIAL: A GRAVITY MODEL OF PAKISTAN'S RICE EXPORTS

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ABSTRACT

Pakistan's milled rice exports to 92 markets during 1991-2010 are analyzed applying an augmented gravity model, treating Pakistan's real GDP and export prices as endogenous, and regressing using Hausman-Taylor estimation technique. Rice is a necessity whose export follows the Heckscher-Ohlin rationale. Real GDP in import markets positively affects demand. Pakistan's real GDP, export prices and the exchange rate affect export supply. Distance negatively affects exports. Historical ties positively affect exports. Raising Pakistan's GDP, improving market access through trade agreements and better marketing would help exploit export potential, earning Pakistan foreign exchange, reducing its trade deficit and improving rural welfare.

JEL codes: F14, F17, C23

Keywords: Pakistan, rice, gravity model, export potential, determinants, panel data

INTRODUCTION

Since its existence in 1947, Pakistan has had a positive trade balance in very few years, mostly in the 1950s. Hence, Pakistan is a trade deficit country that has had a narrow range of export items and few sources of foreign exchange earnings. The major export items include rice, raw cotton and textile manufactures, leather and related products, all of which account for about 76% of the total export earnings during 2000-2010. In these years, almost half of all of Pakistan's exports were comprised by a narrow range of five major export markets that included the USA, the UK, Saudi Arabia, Japan and Hong Kong. Agriculture remains a key

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sector of the economy contributing to about 23% of GDP, employing about 42% of the total employed labor force during 2000-2009, and is the source of most exports (SBP 2010; GOP 2010; Hyder and Mehboob 2006).

Rice is Pakistan's second largest export item after cotton and cotton products and contributes nearly 15% to the country's foreign exchange (GOP 2010, Siddique and Kemal 2002). The major export markets in the Middle East amount to 40% of Pakistan's total exports of milled rice. The major African markets account for another 16% of total rice exports (UN FAO 2012). About 40% of the rice produced is exported due to the relatively low annual per capita domestic consumption of about 10 kg (Anwar 2004). Rice production covers about 20% of the total cropped area under food grains in the country, accounts for almost 6% of the value added in agriculture, contributes to 1.3% of GDP, and employs a number of people who are economically active in its production, domestic marketing and export (GOP 2010).

Given the importance of rice to Pakistan's economy, the identification of factors that affect its international trade and marketing and understanding the factors that can help to exploit market potential is essential. Use of this type of information would help the sector to develop, contribute to foreign exchange earnings, reduce the country's overall trade deficit, and enhance economic growth.

The gravity model is the most popular approach employed to predict the international trade flows (Abler 2007). It is widely used to measure the potential for and factors affecting bilateral trade flows at an aggregate level (e.g. Martínez-Zarzoso and Nowak-Lehmann 2003; Ricchiuti 2004; Brülhart and Kelly 2004; Hatab, Romstad and Huo 2010). However, few studies have attempted to apply it at a commodity-specific level (e.g. Dascal Mattas and Tzouvelekas 2002; Eita and Jordaan 2007; Vollrath et al. 2009) and its application to Pakistan has been very limited (But 2008, Gul and Yasin 2011). This study is an addition to that literature by applying a gravity model to measure the commodity-specific export potential of Pakistan's milled rice using panel data on exports to 92 rice markets for 1991-2010 and to investigate the economic, geographical and cultural factors that affect rice exports. Given the commodity-specific nature of rice, the study analyzes supply-side effects such as Pakistan's GDP, GDP per capita and export prices and, demand-side factors such as income and income per capita in importing countries. Exchange rates and distance to export markets are included in the model to consider macro-financial and geographical factors, respectively, while a cultural factor is included to consider the effect of a common history under British colonization.

The real GDP of Pakistan and export prices are entered into the models as endogenous variables and estimated using the Hausman-Taylor estimation technique. However, pooled, fixed effects and random effects models are also estimated and the results are compared.

AN OVERVIEW OF THE RICE SECTOR OF PAKISTAN

Table 1 presents the data for the area, production, exports and average unit export value of Pakistan's rice. While the area under rice cultivation has varied by 50%, between 1.97 and 2.96 million hectares, production has nearly doubled during 1991-2010, reaching to a maximum of 10.43 million tons (UNFAO 2012). The fluctuations in area and production are primarily due to the lack of timely availability of fertilizer and pesticides, water availability,

inaccessibility to credit to purchase inputs, adverse weather conditions, the effect that unstable farm income has on the timing of sowing, and the ability to respond to external shocks. Moreover, the domestic marketing system is constituted by intermediaries who have buying power relative to the rice producers and who make payments to farmers that are often late. Storage facilities are limited and markets are distant from the production areas. These factors, in turn, affect the farmer's ability to exploit the full production potential (Iqbal et al. 2009, GOP 2010).

Table 1. Pakistan's Rice Area, Production, Export and Prices

Year	Area (mill ha)	Paddy Production (mill tons)	Export Quantity (mill tons)	Export Value (mill $)	Export Price ($/ton)	Average World Price ($/ton)
1991	2.10	4.86	1.20	345.24	286.60	340.35
1992	1.97	4.67	1.51	412.28	272.70	331.64
1993	2.19	5.99	1.03	320.34	310.37	307.23
1994	2.12	5.17	0.98	241.52	245.37	347.62
1995	2.16	5.95	1.85	462.84	249.88	331.63
1996	2.25	6.46	1.60	514.23	321.29	389.14
1997	2.32	6.50	1.77	479.78	271.49	370.51
1998	2.42	7.01	1.97	567.68	287.93	331.20
1999	2.52	7.73	1.79	591.12	330.01	312.00
2000	2.38	7.20	2.02	533.31	264.50	276.18
2001	2.11	5.82	2.42	520.83	214.88	262.41
2002	2.23	6.72	1.68	460.45	273.37	243.34
2003	2.46	7.27	1.82	561.74	308.65	256.03
2004	2.52	7.54	1.82	627.24	344.12	308.64
2005	2.62	8.32	2.89	930.77	321.91	325.51
2006	2.58	8.16	3.69	1150.10	311.79	344.77
2007	2.52	8.35	3.13	1124.07	359.21	407.46
2008	2.96	10.43	2.81	1681.61	598.54	675.31
2009	2.88	10.33	2.75	1894.45	688.52	642.77
2010	2.37	7.24	4.18	2152.81	515.05	594.14

Source: UN FAO, 2012.

Despite the various constraints and inefficiencies in the domestic marketing channel, the volume of exports has steadily increased, having been briefly interrupted in 2000-2002. Exports have increased by more than 300% to 4.13 million tons amounting to USD 2.2 billion, permitted by a slower rate of growth in domestic per capita consumption.

Government Policies

A wide range of government policies and regulations have been enacted, but the intervention was either temporary or has not been implemented to an extent that directly restricted economic behavior. For example there have been restrictions on the movement of rice across regions within the country and bans on the production of certain varieties and sowing in certain areas to reclaim saline lands. Price supports and government procurement programs existed until 2001-02. After 2002 the government's role has been limited to the occasional and irregular announcement of an indicative support price (Salam 2009). This essentially is to create a floor price during the post-harvest period when supply is abundant, but does not replace market-determined prices. The intention is to correct shortcomings in the marketing system (Anwar 2004) such as to curb the market power of intermediaries. There have been no government purchases of rice since 1995-96. Farooq et al. (2001) found a very low response of basmati rice producers to the support prices. Mushtaq and Dawson (2001) also found that the support price policy was ineffective and proposed that it be discontinued. The unit export value of Pakistan's milled rice ranges from $215 to $359 per ton. In most years during 1991-2007 the unit value of Pakistan's rice remained below the world average, showing that Pakistani rice is competitive in the international market. It can also be noted that exports of rice from Pakistan are higher in the years when the unit export prices are less than the world average unit prices and vice versa (UN FAO 2012).

In 1987-88, the government began to allow the private sector to export rice which gave rise to the Rice Exporters Association of Pakistan (REAP) formed in 1988-89 by private exporters. Before this, the Rice Export Corporation of Pakistan (RECP) had a monopoly in the procurement and export of rice. The REAP interacted with the government department for improving the rice exports and established rice quality standards with the cooperation of Pakistan Standards Institution in 1992. It identifies problems in rice exporting such as marketing issues, quality control and barriers in the import of milling machinery etc. and proposed some solutions as well. It also made efforts to improve market access to the EU market (REAP 2010).

Trade policies include export taxes, export subsidies, and tariffs on the imports of milling machinery and other inputs (Salam 2009). During the study period no export taxes were imposed; however, an export subsidy was provided during 2002-04 (WTO 2011). However, on account of high international prices in 2007-08 the government fixed the minimum export prices in April 2008, but was abolished by October 2008 (Salam 2009). Import tariffs on rice were in effect, but were reduced from 15% to 10% on an MFN basis in 1999. Finally, exchange rate policies had been used in Pakistan to achieve export objectives, but by 1982 a managed float was the primary exchange rate regime. There was a brief stint where a multiple exchange rate regime was applied after Pakistan's nuclear tests in 1998 (which resulted in international sanctions). However, since 2000, the current flexible exchange rate has been in place (Hyder and Mehboob 2006).

World Rice Market

Rice is the basic staple food in many countries and of about half of the world's population. Trade in rice on the international market is very thin, with only about 5 to 7% of

the total world production being traded globally (Childs and Hoffman 1999; Razzaque and Laurent 2006; Childs and Baldwin 2010; *Economist* 2011). Wheat trade, by contrast, amounts to about 20% of total world production. The international market rice market is thin because the main global producing countries also tend to be populated by its chief consumers (Wailes 2005), but also because domestic rice markets are highly protected and strictly regulated. This helps to ensure that tastes are inclined to the domestic varieties produced (*Economist* 2011). In Asia, domestic policies basically ensure self-sufficiency. Finally, given that rice comes in many varieties (e.g., long- and short-grain, sticky, fluffy, wild, etc.), it can also be claimed that consumers will prefer that variety that they are used to, rather than relying on imported varieties with different characteristics.

The major exporters of milled rice in the world include Thailand, Viet Nam, Pakistan, India, China, the USA and Italy. However, two exceptional rice trading nations are Pakistan and Thailand, whose domestic consumption is less than 50% of their total production (Childs and Baldwin 2010). This information coupled with Pakistanis low per capita consumption of rice should imply the possibility of meeting increasing world import demand through an expansion of Pakistan's exportable surplus. Price volatility occurs in the international market due to the thin nature of the world market and exporters' and importers' protectionist trade policies such as regulated prices, procurement and government storage, import tariffs, export subsidies and export taxes (Childs and Baldwin 2010, Razzaque and Laurent 2006). However, the restricted nature of so many domestic markets could mean that domestic markets are insulated from international price changes. Some of the principal importers of milled rice comprise Bangladesh, Japan, Iran, Indonesia, Philippines, Saudi Arabia, the UK, the EU and the US.

METHODS AND EMPIRICAL STRATEGY

Gravity Model

The gravity model has performed well when used to analyze international trade flows since the early 1960s, but strong theoretical foundations were not produced until the end of the 1970s. This led to many studies to modify the original Newtonian gravity equation. Among others, Anderson (1979) presented the theoretical foundations of the gravity model by deriving the gravity model from an expenditure system by assuming Armington preferences and considering goods differentiated by the country of origin. Bergstrand (1985) then derived the gravity model in the form of a partial equilibrium sub-system of a general equilibrium model by using the same Armington assumptions. Bergstrand (1989) derived a theoretical gravity model that includes exporter and importer's per capita incomes. Deardorff (1998) employed the Heckscher-Ohlin model to derive the gravity model.

The traditional gravity model includes the income variables of the importing and exporting country, represented by the GDP, and the distance between the two markets, as presented in equation 1:

$$X_{ij} = Y_i^{\beta 1} Y_j^{\beta 2} D_{ij}^{\beta 3} \zeta_{ij} \quad (1)$$

where X_{ij} denotes export from country i to country j; Y_i and Y_j represent the GDP of exporting and importing countries, which are proxies for income variables, respectively; D_{ij} is the distance between the capital cities or economic centers of the respective countries used as a proxy for transportation costs; and ξ_{ij} is an error term.

The present study uses a gravity model under a panel data framework to investigate the factors affecting trade at the commodity-specific level, i.e., Pakistan's export of rice to its principal partners. Panel data specifications of the gravity model are more appropriate than cross-sectional and time-series specifications (Egger and Pfaffermayr 2003, Martínez-Zarzoso and Nowak-Lehmann 2003) because of the model misspecification that can arise under the cross-sectional and time-series approaches. In a cross-sectional specification of a gravity model, the analysis is restricted to one point of time and does not capture the time-variant effects. The time-series specifications, by contrast, do not allow studying the fixed-country pair effects. Moreover, cross-sectional and time-series specifications can affect the sign and magnitude of the effect of the explanatory variables. The problems with the misspecifications establish the basis for the panel specification of the gravity model (Egger 2002, Ricchiuti 2002). Among others Egger (2002), Eita (2008), Egger and Pfaffermayr (2003), Martinez-Zarzoso and Nowak-Lehman (2003), Filippini and Molini (2003) and Mátyás (1997) used panel data to estimate gravity equations and argued that panel data specifications are more appropriate and useful in explaining the bilateral trade flows and determining factors contributing to these trade flows compared to cross-sectional and time-series data.

Empirical Strategy

The model employed here is an augmented form of the basic gravity equation. Cortes (2007) pointed out that additional variables other than basic income and distance variables could be added to improve the basic formulation of the selected gravity equation. Moreover, the addition of variables allows the possibility of adapting the gravity equation to the particular circumstances of the bilateral trade under study. The inclusion of some additional explanatory variables to the basic gravity model helps to better understand the factors that affect Pakistan's rice exports. This augmented gravity model is represented in equation 2:

$$X_{ij} = Y_j^{\beta 1}\, Y_i^{\beta 2}\, PCY_j^{\beta 3}\, PCY_i^{\beta 4}\, P^e_{ij}{}^{\beta 5}\, E_{ij}^{\beta 6}\, D_{ij}{}^{\beta 7}\, CH_{ij}^{\beta 8}\, \zeta_{ij} \qquad (2)$$

where X_{ij} is the tons of milled rice exports from Pakistan (country i) to its j major importing partners (j = 92 export markets); Y_j and Y_i are the real GDP in the importing country and in Pakistan, respectively, measured in million US constant dollars of 2005; PCY_j and PCY_i represents the real per capita GDP of importing countries and Pakistan, respectively, measured in 2005 constant US dollars; P^e_{ij} is the unit export price (USD/ton) for respective import markets at Pakistan's border; E_{ij} is the rupee-foreign currency exchange rate; and D_{ij} is distance, a proxy variable for transport costs; CH_{ij} is a dummy variable for common history intended to capture any effects of shared historical ties that may have led to the development of formal marketing channels, bilateral trade agreements or other political initiatives (i.e., taking on a value of one if the importing country is also a member of the British

Commonwealth and zero otherwise); and ξ_{ij} is the error term which comprises two parts, an individual effects term and the usual error term.

By taking the natural log of equation 2 and separating the individual country effects from the error term, the linear form of the final model to be estimated becomes:

$$\ln X_{ij} = \beta_0 + \beta_1 \ln Y_j + \beta_2 Y_i + \beta_3 \ln PCY_j + \beta_4 PCY_i + \beta_5 \ln P^e_{ij} + \beta_6 \ln E_{ij} + \beta_7 \ln D_{ij} + \beta_8 CH_{ij} + \eta_j + \delta_{ij} \quad (3)$$

where η_j shows the individual country effects and δ_{ij} represents the usual error term. The βs are the parameters to be estimated.

The real income variable (GDP) of the importing countries is intended to capture the demand or absorption effect. The coefficient on the Y_j variable is expected to be positive for normal goods as demand increases with the increase in income for normal goods and negative for inferior goods as demand decreases with the increase in income for these commodities. Pakistan's real GDP is employed to capture the supply effects (production capacity) and is expected to have a positive coefficient, reflecting a larger export supply.

The importer's real GDP per capita is used to determine the type of the product. Its coefficient is expected to have a positive sign in the case of a luxury good and a negative sign in the case of a necessity (Bergstrand, 1989). Rice is expected to be a necessity.

The exporter's per capita income is used as proxy for resource use in the production of crop and trade theory explaining the exports. A negative (positive) sign of the coefficient entails that commodity is labor- (capital-) intensive and resource endowments in the country explain the reason for exports. Among others Bergstrand (1989) employed these four variables as a part of their model specifications.

The unit export price in respective import markets, measured in US dollars per ton at Pakistan's border, P^e_{ij}, is intended to measure the price effect on the decision of exporters regarding the choice of markets. Exporters are inclined to export more to those markets where they obtain a higher price; therefore, this variable is expected to have a positive sign. This variable also partly captures the effects of importer's trade policies such as tariffs. Bergstrand (1985) used export and import unit value indices in his gravity model on aggregate trade flows. Estimating a model without this price variable causes considerable changes in the magnitude and statistical significance of the other coefficients and the performance of the overall estimation and its explanatory power. This suggests that specifying a model of Pakistani rice exports without the unit export prices variable would suffer from the omission of a relevant variable.

The exchange rate is defined as the quantity of Pakistani rupees that must be exchanged to receive one unit of foreign currency in each partner country. The sign of the coefficient is expected to be positive as an appreciation of the exchange rate, i.e. a depreciation in the value of the rupee, reduces the relative cost of rice from Pakistan and should result in stronger import demand. Among others Bergstrand (1985), Martínez-Zarzoso and Nowak-Lehmann (2003), Ricchiuti (2004), Hatab, Romstad and Huo (2010) specified an exchange rate variable in their gravity models.

The proxy variable for transportation costs is measured as the distance, D_{ij}, between capital cities or commercial center and is expected to be negatively related to export.

Common historical ties of British Empire, $CH_{ij,}$ are expected to be positive. The estimation of time-invariant variables in a fixed effects model are estimated in a second step regression with the individual effects as the dependent variable and distance and dummies as explanatory variables. This is estimated as:

$$IE_{ij} = \gamma_0 + \gamma_1 D_{ij} + \gamma_2 CH_{ij} + \upsilon_{ij} \quad (4)$$

where IE_{ij} denotes individual effects; D_{ij} and CH_{ij} are as previously defined; and υ_{ij} is an ordinary error term. One of the factors affecting rice exports from Pakistan during 1991-2010 could be the presence of a large community of people with an origin from Asia, but the lack of detailed population census data on Asian migrants in Pakistan's export markets did not permit the inclusion of such a variable to capture this effect.

Data and Diagnostic Testing

The dataset spans 92 countries that make up about 84% of total rice volume exported from Pakistan, on average, during 1991-2010. The dataset includes high, medium and low income countries and the share of these export markets ranges from negligible to 10% of the total. The broad selection of export markets removes the possibility of selection bias in the sample.

Data for milled rice exports are collected from both UN FAO and UN Comtrade online data bases as reported by both Pakistan and importing countries, but many of the importing countries did not report imports at all or for many of the years during the study period. Hence, data that are used come from the most complete data series which is found in the UN FAO data base as reported by Pakistan. Nevertheless, for some countries, particularly those with negligible import volumes, data are not always reported, which can imply a missing entry or zero trade flows.

To avoid loss of observations and because the model employs a double log functional form, such data points are replaced with a value of 0.0001. Avoiding the loss of observations helped to including more countries and to conduct the IPS unit root test for testing the stationarity of the data.

Data Sources

All trade volume and value data are taken from the UN FAO agricultural trade on-line database (UN FAO 2012). Unit prices are computed from the volume and value data. Real GDP, real GDP per capita and exchange rate data are from the UN CTAD on-line database (UN CTAD 2012). The information on membership of the British Commonwealth is taken from the web pages of the Commonwealth Organization (The Common Wealth 2011). The distance data between the capital cities of Pakistan and the trading partners are collected from Travel Distance Calculator between Cities, under the Chemical-ecology website (Chemical Ecology).

Testing

Prior to estimating the model, it is important to check the stationarity of the variables, particularly that of the dependent variable, to avoid spurious correlation. If the dependent variable is non-stationary then the resulting regression will be spurious and a co-integration test should be performed.

Table 2. Panel Unit Root Test

Variable	IPS				LLC		
	Coeff. of test statistic	Stat. sig.	No. of lags and trend		Coeff. of test statistic	Stat. sig.	No. of lags and trend
X_{ij}	-10.024	***					
Y_j	-2.5093	***	2 with trend				
Y_i	-4.4181	***	4 with trend		-8.2254	***	4 with trend
PCY_j	2.8495		1				
PCY_i	-4.7724	***	4 with trend		-9.8786	***	trend
P^e_{ij}	-9.2924	***					
E_{ij}	-6.7784	***	1 with trend				

Notes: ***/**/* denotes rejection of the null hypothesis at 1%/5%/10% level respectively.
Source: Author's calculations

The IPS test developed by Im, Pesaran and Shin (2003) and the LLC test developed by Levin, Lin and Chu (2002) are unit root tests performed to check the stationarity of dependent variable as well as independent variables. The IPS test allows the autoregressive parameters to vary across countries and also for individual unit root processes. It is computed by combining the individual countries' unit root tests to come up with a result that is specific to a panel. It has more power than the single-equation Augmented Dickey Fuller (ADF) test (Eita and Jordaan 2007; Eita 2008; Levin, Lin and Chu 2002; Hatab, Romstad and Huo 2010). The null hypothesis is that all series contain a unit root and the alternative is that at least one series in the panel does not have a unit root. This test can be applied to an unbalanced panel, one that does not have an observation of all the cross sections' elements for all the years, e.g., the values of the dependent variable, Pakistan's rice exports to its principal markets, are missing for some years for some countries. The LLC test is used for balanced panel data only, using a null hypothesis of a unit root and an alternative hypothesis that all panels are non-stationary. It assumes that the autoregressive parameters are common across countries (Eita and Jordaan 2007; Eita 2008; Levin, Lin and Chu 2002; Hatab, Romstad and Huo 2010).

The results of the stationarity tests are reported in table 2. The dependent variable has an unbalanced panel and an IPS test is conducted. The results of this test show that the dependent variable, the natural log of the volume of rice exports from Pakistan to its partner countries, is stationary. This implies that the co-integration test is not required and the ordinary least squares method can be used to estimate the gravity model represented by equation 3.

Only the natural logs of Pakistan's real GDP and the real GDP per capita variables are balanced panels. Therefore, both the IPS and LLC tests were applied to test their stationarity.

The natural log of the real GDP variable becomes stationary after including a trend and four lag terms in both tests, while the log of real GDP per capita becomes stationary after including a trend and four lag terms in the IPS test and by only including a trend in the LLC test. The other variables are unbalanced panels, so only the IPS test is performed for them. The natural log of real GDP of importing countries becomes stationary after including the trend and two lag terms while the natural log of GDP per capita of the importing countries is a non-stationary variable. The natural log of the exchange rate is also a stationary variable with a trend and one lag term.

Model Identification

Panel data permit the construction of the Hausman-Taylor model, the fixed-effects model, random-effects model, and a pooled regression. The main problem with the pooled model is that it assumes a common intercept for all the countries and does not allow for heterogeneity of countries. It does not estimate country-specific effects and assumes that all countries are homogenous (Dascal, Mattas and Tzouvelekas 2002). An F-test is performed to make a choice between the pooled regression and the fixed-effects model having the null hypothesis of common intercept for all the cross sections versus an alternative hypothesis of the presence of individual effects (Dascal, Mattas and Tzouvelekas 2002; Hatab Romstad and Huo 2010). A Breusch-Pagan Langrange Multiplier (LM) test is performed to choose between the pooled regression and the random-effects regression with the null hypothesis that the variance across all cross sections is zero, i.e., no panel effects (Dascal, Mattas and Tzouvelekas 2002; Hatab, Romstad and Huo 2010). Either the fixed effects or the random effects are used to measure the individual country effects and a choice between them is needed to know which one yields consistent results. The main distinction between the fixed and random effects models is that a random effects model assumes that individual effects and regressors are not correlated, while a fixed effects model would allow this correlation. For example, in the context of this study, the individual effects of a country such as good weather conditions can increase the production of rice in an importing country, reducing the net import volume required, which affects one of the dependent variables in the model. A Hausman specification test is applied to test this correlation (Egger 2000). Basically, the Hausman test distinguishes the differences between estimates of the fixed and random effects model. The null hypothesis is that the difference is not systematic and if the null hypothesis is rejected then it means that coefficients of both models are significantly different. In other words, there is correlation between regressors and individual effects. Under the rejection of null hypothesis, estimates from fixed effects model are consistent while estimates from random effects model are not consistent. The Hausman-Taylor model is used because it is a hybrid of the fixed and random effects model that allows the correlation among regressors and individual effects, estimates the time invariant variables such as distance and dummy variables (e.g., historical ties), and treats some variables as endogenous (e.g., the real GDP of Pakistan and unit export prices variables).

RESULTS AND DISCUSSION

Panel data are employed for the reasons described in section 3.2 regarding the appropriateness of this specification relative to cross-sectional and time-series specifications. In table 3, the results of the gravity model are reported for the estimation of equation (3) under a Hausman-Taylor model, a fixed effects (FE) model, a random effects (RE) model and a pooled model. Robust standard errors are used for the estimation. Regarding the selection of the model, the coefficient value of the F-test is 22.18, which is statistically significant at the 1% level. Hence, the null hypothesis of a common intercept across all the countries is rejected, implying that individual effects are present and the FE estimation technique is more appropriate relative to the pooled regression model

Table 3. Gravity Model Estimated Results

Variables and test statistics		Pooled model		RE model		FE model		Hausman-Taylor	
		Coeff.	Stat sig	Coeff.	Stat sig	Coeff.	Stat sig.	Coeff.	Stat sig.
Y_j		0.26	***	0.34	***	1.34	*	0.39	***
Y_i		2.25	**	3.56	***	3.13	**	3.65	***
PCY_j		-0.33	***	-0.49	***	-1.42	**	-0.55	***
PCY_i		-2.07		-3.89		-3.82		-4.04	***
P^e_{ij}		1.13	***	1.07	***	1.06	***	1.06	***
E_{ij}		-0.09	***	0.04		0.08	*	0.06	*
D_{ij}		-0.92	***	-0.94	**			-0.97	***
CH_{ij}		0.90	***	1.02	***			1.03	*
Constant		-3.49		-5.97		-12.37	***	-5.79	
Wald chi2				3408.38	***			13185.61	***
Number of obs.		1749		1749		1749		1749	
[a]F test		4020	***			502	***		
R-square	Within			0.88		0.88			
	Between			0.84		0.69			
	Overall	0.87		0.86		0.79			
LM		3405	***						
Hausman test						33.73	***		
[b]F test						22.18	***		

Note: ***, **, * represent statistical significant at 1%, 5%, and 10% level, respectively.

[a] F test for overall model fit.

[b] F test for choice between fixed effects and pooled regression.

Source: Author's calculations.

The coefficient value of the LM-test is 3405 with zero probability of accepting the null hypothesis at a 1% level of significance. Thus, the null hypothesis of no panel effects is rejected, which also implies that the pooled regression model is not appropriate. The Hausman specification test, applied to choose between the FE and RE models and the results of the test show that the null hypothesis is rejected as the value of the chi square statistic is 33.73 with zero probability of accepting the null hypothesis. The statistical significance level of this coefficient is 1%. Hence, the coefficients of the FE model are consistent and robust. Eita (2008), Ricchiuti (2004) and Dascal (2002) each applied a gravity model to panel data to determine the factors affecting exports and found that the FE model was more appropriate than either a pooled or random effects model. The values of within, between and overall R-squares are reported. The overall R-square values for all the models are about 80% or above implying a good fit of the model specification.

The results of the coefficients in the four models presented are the same in terms of their sign, in general, and similar in their level of statistical significance. This is an indication of consistency in the relationship between dependent and independent variables. The exceptions are that the real per capita GDP of Pakistan is only significant in Hausman-Taylor estimates and the exchange rate is only insignificant in RE model estimates. All variables that are statistically significant have the expected signs, although there is some variation in the level of significance.

In the FE model, the time-invariant variables such as distance and common historical ties cannot be estimated directly; however, the Hausman-Taylor model has the advantage of directly estimate them. Moreover, the real GDP of Pakistan is likely to be endogenous because exports can also affect GDP and unit export prices are also likely to be endogenous as they are the equilibrium prices that depend on excess supply (Pakistan's exports) and excess demand in the international market. Another advantage of the Hausman-Taylor estimation technique is to estimate the models considering the endogeneity of the model. As a result of the potential endogeneity and time-invariant variables included in the model, the implications and insights behind the results are from those of the Hausman-Taylor model.

The positive coefficient on Y_j, the real GDP in the importing country, shows that rice is a normal good. The value of the income elasticity is 0.39, suggesting that a 1% increase in importer's income results in a 0.39% increase in Pakistan's rice exports.

The coefficient on Y_i, the real GDP of Pakistan, is positive as expected and significant at the 1% level of significance. The coefficient is relatively elastic and its value indicates that a 1% increase in real GDP results in an increase in rice exports of 3.65%. Hatab, Romstad and Huo (2010) computed a similar income elasticity of 5% for Egypt in their study on determinates of total Egyptian agricultural exports. This positive and elastic coefficient implies that rice exports are sensitive to domestic supply (production capacity); hence, economic growth and greater production of rice (contributing to 1.3% of GDP) can stimulate rice exports. On the other hand, a supply shock such as a drought can adversely reduce the exports.

The coefficient on importers GDP per capita is negative as expected, illustrating that rice is a necessity rather than a luxury product, and is statistically significant at the 1% level of significance. The coefficient on Pakistan's GDP per capita is negative as expected and statistically significant at the 1% level of significance. The negative sign suggests that rice is a labor-intensive commodity. Ali and Flinn (1989) also stated rice to be a labor-intensive crop. This finding further suggests that rice exports are explained by the H-O factor

endowment theory. In other words, there is an argument that Pakistan's rice sector enjoys an international comparative advantage and specialization in rice production to increase rice exports should result in an efficient allocation of resources (land and labor) to enhance economic growth.

The coefficient on the unit export price is positive as expected and statistically significant at the 1% level of significance. The price elasticity is 1.06 (unitary elasticity) indicating that a 1% increase in the export price of rice at an export market increases rice exports from Pakistan to that market by about 1%. The exporter's decision regarding the choice of an export market responds closely to price, i.e., that more is exported to markets where a higher price is obtained.

The coefficient on the exchange rate variable is positive illustrating that 1% depreciation in the value of the rupee leads to an increase in rice exports of 0.06%. During the period of the study the country shifted from a managed exchange rate regime to a more flexible regime, but the rupee depreciated by about 26%, which had a positive effect on the country's rice exports. The coefficients on distance and historical ties have expected signs and are statistically significant at the 1% and 10% level of significance, respectively. The coefficient on the measure of distance is negative, suggesting that increased transport costs negatively affect Pakistan's export. The sign of the coefficient on historical ties is positive, which is reasonable to expect because marketing/trade linkages in regions that were once part of the British Empire should serve existing trade relations and facilitate exports of rice to such markets as Australia and the UK. Time invariant variables in the fixed effects model are estimated in a second stage regression as describes in section 3.2 and the results are given in table 4. The coefficients on distance and historical ties variables are statistically significant at the 1% level of significance using robust standard errors and the signs are as expected.

Table 4. Second Stage Regression for Time Invariant Variables

Explanatory Variables	Coefficient	Robust standard errors	Statistical Sig.
Distance	-1.21	0 .10	***
Common wealth	1.49	0.11	***
Constant	9.96	0.93	***
R- squared	0.12		***

Notes: ***/**/* statistical significant at the 1%, 5%, and 10% level, respectively.
Source: Author's calculations

Export Potential

The country-specific effects show the factors which are unique to each country but which are not included in the estimation of the gravity model. The results in table 5 show that there are unobservable unique characteristics in some countries which promote rice exports from Pakistan, e.g., to Afghanistan, Australia, Bahrain, Indonesia, Iran and Kenya, UAE, the USA and the UK, countries with positive country-specific effects. However, other results suggest that there are characteristics that are not observable and discourage rice exports from Pakistan, e.g., to Argentina, Bangladesh, Philippines, and Sweden, countries with negative country-specific effects.

Table 5. Individual Effects by HT Estimates

Country	Mean	Country	Mean	Country	Mean
Afghanistan	1.62	Guinea	1.78	Philippines	-0.51
Angola	-0.73	Guinea-Bissau	2.32	Poland	-0.41
Argentina	-1.82	Haiti	0.06	Portugal	-1.02
Armenia	-1.38	Hungary	-1.08	Qatar	2.80
Australia	0.70	Iceland	-0.53	Romania	-1.65
Austria	-2.70	Indonesia	0.61	Russian Federation	-1.26
Azerbaijan	-1.82	Iran	3.14	Rwanda	-1.68
Bahrain	2.39	Iraq	0.16	Saudi Arabia	2.99
Bangladesh	-0.57	Ireland	-0.86	Sierra Leone	-0.10
Belarus	-1.63	Italy	-0.43	Singapore	0.33
Belgium	1.09	Japan	-1.70	Somalia	-0.09
Benin	1.74	Jordan	0.49	South Africa	2.17
Brunei Darussalam	-0.70	Kenya	2.98	Spain	-0.92
Bulgaria	-1.81	Kuwait	2.91	Sri Lanka	0.90
Canada	-0.32	Lesotho	-1.48	Sweden	-0.67
Chile	-0.52	Liberia	-0.85	Switzerland	0.35
China. Hong Kong SAR	-0.56	Libya	-1.82	Syrian Arab Republic	-1.19
Congo	1.72	Lithuania	-0.27	Togo	2.87
Côte d'Ivoire	3.74	Madagascar	3.06	Tunisia	-0.69
Cyprus	-2.36	Malaysia	0.89	Turkey	-0.87
Dem. Rep. of the Congo	-2.05	Maldives	-1.12	Turkmenistan	-3.39
Denmark	-1.19	Mauritania	0.74	Uganda	-1.55
Djibouti	0.77	Mauritius	2.31	United Arab Emirates	4.54
Egypt	-2.42	Morocco	-0.43	United Kingdom	0.81
Finland	-2.99	Mozambique	0.15	Tanzania	1.90
France	-0.05	Netherlands	0.89	USA	1.58
Gambia	1.57	New Zealand	-0.75	Uzbekistan	-4.26
Georgia	-1.98	Niger	-0.17	Yemen	1.85
Germany	-0.38	Norway	-0.30	Zambia	-2.16
Ghana	0.35	Oman	2.80	Zimbabwe	-1.11
Greece	-0.51	Peru	-0.29		

Source: Author’s calculations.

Two main approaches have been used in literature to measure the export potential under a gravity model: the within-sample approach (e.g. But 2008; Eita 2008; Gul and Yasin 2011) and out-of-sample approach (e.g. Brülhart and Kelly 2004). The gap between the actual and predicted values in the within-sample approach measures the exploited or unexploited export potential. Egger (2002) criticized this approach by saying that this gap reflects residuals and misspecification of the model. In the out-of-sample approach, the model is estimated on a reference group and the coefficients obtained are used on the actual data of concerned country/countries to predict potential, and the actual values are compared with these predicted values. However, it is assumed that this potential will prevail if the concerned country/countries would behave like the reference group, or whether trade would be more liberalized or integrated. It is very difficult to find a reference group and impose such an assumption in rice trade as rice is a highly protected crop through importer's and exporter's policies and rice is traded thinly on the international market. Therefore, a within-sample approach is used to identify the potential markets for Pakistan's milled rice. However, both the FE and HT models were used to predict potential markets and these markets are very similar. Predictions are made by including the individual effects that capture the unobserved heterogeneity due to country-specific characteristics among the partner countries and are expected to be better than when excluding them.

The coefficients of the estimated model in equation (4) are used to predict the potential within the sample markets. This potential prevails if the exports are determined by the variables of the model. A different model specification might generate different results. The potential-to-actual export ratios, which are averaged over 1991-2010, are calculated and presented in tables 6 and 7. A ratio with a value greater than one indicates the existence of an unexploited potential. Unexploited potential is predicted within the existing markets because it is relatively easy to capture greater market share than to enter into a new market. However, the data set covers a wide range of countries, those with negligible import volumes and those which account for a large share of Pakistan's rice exports. Capturing potential in markets with a low share of imports could be somewhat similar to entering into a new potential market. However, the intention is not to shift export from existing markets to new or potential markets, but rather to maintain the current markets and concentrate on marketing to countries where there is unexploited potential.

There is high unexploited export potential in 49 export markets out of the 92 countries (indicated with * in tables 6 and 7) included in the sample, such as Argentina, Austria, Bangladesh, Benin, Georgia, Ghana, Hungry, Indonesia, Japan and the Philippines. The potential market development will depend on, among other factors, Pakistan's existing share in the total rice imports of the importing countries, importers' share in the total export of rice from Pakistan and on the preferences of consumers in those countries and their share in the total world rice import. The shares for the potential markets are given in table 8.

Among the 49 countries with potential, 13 are the members of the EU. Each of these countries have a low share of the total rice exported by Pakistan, between 0-2%, and Pakistan's exports also accounted for a low share of their total rice imports, ranging between 0-13% (UN FAO 2012). The EU-wide tariff on rice is 175 EUR/ton (WTO 2013); however, concessionary access to the EU was granted to Pakistan in 2002 for three years. Autonomous trade preferences were given to Pakistan in 2012 due to heavy floods in 2010 and 2011 which covers about 27% of all Pakistan trade with the EU.

Table 6. Market Potential for Rice Exports

Country	Mean	Country	Mean	Country	Mean
Afghanistan	0.47	Guinea*	4.52	Philippines*	12.53
Angola	0.56	Guinea-Bissau*	1.64	Poland*	1.88
Argentina*	2.08	Haiti	0.64	Portugal*	1.12
Armenia	0.49	Hungary*	1.83	Qatar	0.38
Australia	0.38	Iceland*	1.48	Romania*	2.45
Austria*	1.81	Indonesia*	9.08	Russian Federation*	6.83
Azerbaijan	0.70	Iran	0.49	Rwanda	0.90
Bahrain	0.38	Iraq*	7.01	Saudi Arabia	0.40
Bangladesh*	6.80	Ireland*	1.24	Sierra Leone*	3.47
Belarus*	1.85	Italy*	5.05	Singapore	0.58
Belgium	0.61	Japan*	1.65	Somalia*	1.52
Benin*	2.49	Jordan*	1.46	South Africa	0.66
Brunei Darussalam*	1.05	Kenya	0.40	Spain*	1.56
Bulgaria*	1.64	Kuwait	0.39	Sri Lanka*	1.23
Canada	0.58	Lesotho*	1.61	Sweden*	1.02
Chile*	1.65	Liberia*	2.07	Switzerland *	2.48
China. Hong Kong SAR	0.67	Libya	0.90	Syrian Arab Republic	0.93
Congo	0.96	Lithuania*	2.57	Togo*	1.72
Côte d'Ivoire	0.73	Madagascar*	1.88	Tunisia *	2.29
Cyprus	0.69	Malaysia	0.65	Turkey*	1.31
Democratic Republic of the Congo*	3.07	Maldives	0.54	Turkmenistan*	1.03
Denmark	0.46	Mauritania*	1.46	Uganda*	1.49
Djibouti	0.44	Mauritius	0.56	United Arab Emirates	0.40
Egypt	0.74	Morocco*	3.83	United Kingdom	0.41
Finland	0.72	Mozambique*	2.03	Tanzania	0.66
France	0.92	Netherlands	0.90	USA	0.51
Gambia	0.51	New Zealand*	2.22	Uzbekistan	0.79
Georgia*	0.55	Niger*	2.14	Yemen	0.52
Germany	0.54	Norway	0.55	Zambia*	2.97
Ghana*	4.70	Oman	0.38	Zimbabwe*	1.33
Greece*	1.36	Peru	0.59	Total	1.71

Source: Author's calculations. * Markets with high unexploited export potential.

Table 7. Predictions Employing Fixed Effects Model

Country	Mean	Country	Mean	Country	Mean
Afghanistan	0.51	Guinea*	4.66	Philippines*	12.81
Angola	0.56	Guinea-Bissau*	1.79	Poland*	1.88
Argentina*	1.81	Haiti	0.64	Portugal*	1.16
Armenia	0.45	Hungary*	1.76	Qatar	0.38
Australia	0.38	Iceland*	1.49	Romania*	2.42
Austria*	1.60	Indonesia*	9.39	Russian Federation*	6.48
Azerbaijan	0.65	Iran	0.53	Rwanda	0.90
Bahrain	0.43	Iraq*	6.81	Saudi Arabia	0.45
Bangladesh*	7.31	Ireland*	1.28	Sierra Leone*	3.33
Belarus*	1.53	Italy*	5.21	Singapore	0.60
Belgium	0.62	Japan*	1.51	Somalia*	1.50
Benin*	2.71	Jordan*	1.46	South Africa	0.71
Brunei Darussalam*	1.01	Kenya	0.43	Spain*	1.49
Bulgaria*	1.68	Kuwait	0.42	Sri Lanka*	1.19
Canada	0.57	Lesotho*	1.71	Sweden*	1.02
Chile*	1.72	Liberia*	2.17	Switzerland	2.47
China. Hong Kong SAR	0.64	Libya	0.85	Syrian Arab Republic	0.84
Congo	0.94	Lithuania*	2.92	Togo*	1.94
Côte d'Ivoire	0.83	Madagascar*	1.85	Tunisia *	2.09
Cyprus	0.63	Malaysia	0.64	Turkey*	1.28
Democratic Republic of the Congo*	2.83	Maldives	0.51	Turkmenistan*	0.90
Denmark	0.44	Mauritania*	1.59	Uganda*	1.34
Djibouti	0.46	Mauritius	0.58	United Arab Emirates	0.54
Egypt	0.68	Morocco*	3.65	United Kingdom	0.41
Finland	0.67	Mozambique*	1.91	Tanzania	0.70
France	0.93	Netherlands	0.92	USA	0.51
Gambia	0.56	New Zealand*	2.15	Uzbekistan	0.68
Georgia*	0.53	Niger*	2.39	Yemen	0.51
Germany	0.56	Norway	0.54	Zambia*	2.78
Ghana*	4.91	Oman	0.41	Zimbabwe*	1.25
Greece*	1.38	Peru	0.59	Total	1.72

Source: Author's calculations.

* Markets with high unexploited export potential

More importantly, the EU announced its new generalized system preferences (GSP^+) that will be implemented on January 1, 2014. Pakistan can qualify for this scheme provided that it would be able to prove its seriousness in the implementation of international human rights, labor rights and environment and good governance conventions.

Pakistan's rice exports qualify under GSP^+ and the government of Pakistan has been making efforts for this access (The Nations 2012). Market access under GSP is different from the autonomous trade preferences in that it covers all products except arms and ammunitions and is expected to be of greater importance for EU-Pakistani trade (The EU delegation to Pakistan 2012).

The Philippines, Japan and Indonesia are included among the largest importers of rice in the world having 4.5%, 2.5% and 4.9% share in the total world rice imports, but Pakistan's exports captured only 1.8%, 3.5% and 3% of their imports, respectively. These exports accounted for about 1% of total rice exports from Pakistan (UN FAO 2012). The applied MFN tariff on rice in Philippine is 50% while in Indonesia and Japan imposed non-advalorem duty amounted to 450 Rs/Kg and 342 yn/kg, respectively (WTO 2013). Some other potential import markets where rice exports face high applied MFN tariffs are Morocco with 156%, Turkey with 45%, Tunisia with 36% and Uganda levies a 75% or 200USD per metric ton duty (WTO 2013). Many of the export markets of developing countries for which Pakistan's rice has an export potential have applied tariffs ranging from 5 to 16% (WTO 2013). This restricted market access, and each of those markets accounted for less than 2% of Pakistan's rice exports (UN FAO 2012). Developing bilateral trade agreements to improve South-South market access and better marketing efforts to reduce transport costs are a means of exploiting the market potential and increase overall exports.

On the other hand, there is no applied MFN tariff in Bangladesh, Brunei Darussalam, Iceland, Jordan, Lesotho Madagascar and New Zeeland. Pakistan captured between 0 and 30% of these market's total rice import during 1991-2010 (UN FAO 2012). Bangladesh is among the largest consumers as well as producers of rice in the world and its imports account for about 3% of the world total, but those imports only accounted for 2.5% of Pakistan's rice exports (UN FAO 2012). Better marketing practices are the means to exploit market potential in these markets. With regard to adopting better marketing efforts and establishing bilateral agreements, Government should cooperate with exporters such as sending delegations of exporters and government officials for promotional purposes and negotiating with importers and officials in the partner countries. Importers and delegations from the partner's countries can also be hosted.

Government should devote attention to improving yield per hectare through technological improvement by encouraging research and development as Pakistan's yield per hectare, 2862 kg/ha, is lower than the world average yield per hectare, 3856 kg/ha during 1991-2010, and much lower compared with Australia's yield of 8479 kg/ha and the USA's of 6980 kg/ha. Even regional competitors had higher yields: Indonesia's was 4429 kg/ha while Bangladesh, Malaysia, Philippines and Sri Lanka had rice yields above 3000 kg/ha during the same period (UN FAO 2012). Moreover, Abedullah et al. (2007) found that rice producers in Pakistan were about 91% technically efficient and there was less room to increase rice productivity through improving resource use efficiency given existing seeds and technology. Hence, technological improvement through research and development was argued to be a requirement for the rice sector to increase production, reducing cost of production and making rice prices more competitive in the international market.

Table 8. Market Shares during 1991-2010 (%)

Countries	Share in world rice Imports	Importer's Share in Pak rice exports	Pak Exports share in total rice import of importing countries
Argentina	0.040	0.001	0.320
Austria	0.180	0.037	2.450
Bangladesh	2.780	2.514	12.990
Belarus	0.100	0.013	2.240
Benin	1.230	0.779	5.660
Brunei Darussalam	0.130	0.028	1.340
Bulgaria	0.110	0.078	7.310
Chile	0.350	0.007	0.200
Dem. Rep. of the Congo	0.410	0.063	1.620
Georgia	0.020	0.012	3.050
Ghana	1.220	0.579	6.720
Greece	0.060	0.071	11.750
Guinea	0.970	1.169	10.720
Guinea-Bissau	0.260	0.361	12.750
Hungary	0.160	0.050	2.520
Iceland	0.000	0.002	5.080
Indonesia	4.900	2.006	2.740
Iraq	3.090	1.023	3.060
Ireland	0.050	0.062	9.690
Italy	0.380	0.443	8.280
Japan	2.500	0.075	3.590
Jordan	0.480	0.625	14.260
Lesotho	0.040	0.110	6.490
Liberia	0.490	0.055	0.780
Lithuania	0.040	0.150	8.890
Madagascar	0.490	2.231	33.840
Mauritania	0.310	0.157	4.480
Morocco	0.030	0.259	
Mozambique	0.740	2.156	12.010
New Zealand	0.120	0.077	4.550
Niger	0.510	0.139	4.640

Table 8. (Continued)

Countries	Share in world rice Imports	Importer's Share in Pak rice exports	Pak Exports share in total rice import of importing countries
Philippines	4.490	1.145	1.840
Poland	0.360	0.220	4.720
Portugal	0.420	0.078	2.470
Romania	0.280	0.315	12.300
Russian Federation	1.330	0.409	2.860
Sierra Leone	0.610	0.649	13.650
Somalia	0.390	0.666	10.920
Spain	0.440	0.144	2.940
Sri Lanka	0.510	1.894	45.210
Sweden	0.230	0.220	6.940
Switzerland	0.320	0.341	9.980
Togo	0.280	1.405	31.340
Tunisia	0.060	0.073	10.270
Turkey	1.050	0.327	2.240
Turkmenistan		0.006	33.870
Uganda	0.160	0.158	7.930
Zambia	0.050	0.043	9.370
Zimbabwe	0.110	0.041	3.720

Source: UN FAO, 2012.

Furthermore, government should improve the quality standard of the crop by educating the producers, exporters and other market players about sanitary and phytosanitary measures and technical requirements by the partner's countries. This will reduce the probability of possible rejection at the customs point as happened in the past and increase the probability of more orders.

SUMMARY AND CONCLUSION

A gravity model of 92 export markets of Pakistan's milled rice is estimated using panel data to determine factors affecting exports of rice from Pakistan during 1991-2010. An effort is made to determine in which countries there is unexploited export potential as a means to identify country-specific factors that could lead to increased marketing efforts, political responses such as the pursuit of bilateral trade agreements or preferential market access arrangements, and other economic actions that can improve Pakistan's competitiveness in the existing markets. The real GDP of Pakistan and unit export prices are modeled as endogenous

variables using the Hausman-Taylor estimation technique for panel data. Both of these variables have the expected positive sign and are statistically significant at the 1% level. The real GDP of Pakistan is strongly elastic (3.56) on export supply while price elasticity is unitary. Pakistan's production capacity should be enhanced to exploit potential. The yield per hectare in Pakistan is less than the world average and compared with other rice producers in the region. In this regard timely sowing and availability of irrigation water and other essential inputs should be ensured to the rice farmers. Easy and timely access to credit to buy inputs is also important to sow the crop in time and to increase yields and production. The government should devote attention to technological improvements by encouraging research and development. Rice availability for export can also be increased by reducing post-harvest losses that amount to about 16% (Khan and Khan 2010) through improved post-harvest management practices.

The real GDP of importing countries is also found to be a significant determinant of exports of Pakistan's rice. This result suggests that greater specialization in rice, all else the same, could boost income and welfare in rice producing regions of the country. The negative and statistically significant coefficient on Pakistan's real per capita GDP illustrates that rice exports are labor-intensive and follows the H-O explanation of trade, strengthening the case for greater specialization in rice production.

The exchange rate is also found to be positively and significantly affecting rice exports from Pakistan. The distance between partner countries was used as a proxy of transportation costs is also statistically significant having a negative effect on trade and common British historical ties have positive and significant effect on rice exports from Pakistan. The poor infrastructure in developing countries, e.g., in African markets, could be a factor that limits Pakistan's short-term ability to exploit potential in those markets.

There is unexploited potential of Pakistan's rice exports in emerging and developed economies that can be exploited through enhancing production capacity (GDP), establishing bilateral trade agreements with importing countries and better marketing efforts. Particularly, with regard to exploit potential in the EU markets government should make every effort to qualify for GSP^{+} through implementing international human rights, labor rights and environment and good governance conventions, the pre-requisite for qualifying for GSP^{+}. Furthermore sanitary and phyto-sanitary (SPS) measures should also be adopted to avoid problems at customs points and facilitate trade.

The exploitation of this export market potential would increase the production activity, marketing activity, storage activity, processing and export activity that will ultimately increase the incomes and livelihoods of all these people. An increase in rice exports will also help in reducing the trade deficit of the country and earn more foreign exchange, which will help in financing the country's imports and paying its foreign debt. Such kind of analysis can be replicated for commodity exports of other countries particularly treating GDP and price variables as endogenous and these variables are expected to play a similar role.

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A DYNAMIC MONTHLY DEMAND MODEL OF U.S.-PRODUCED SOFTWOOD LUMBER WITH A FUTURES MARKET LINKAGE

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ABSTRACT

In this paper we estimate a dynamic demand model of U.S. produced softwood lumber using a cointegrated vector autoregression model. We find that demand for U.S.-produced lumber responds to prices of softwood lumber, housing starts, and lumber prices in the futures market, and that various trade measures against Canadian softwood lumber imports have boosted this demand. These results suggest that U.S. lumber producers and consumers could use price information from futures markets to manage price risks and adjust their production/consumption activities and that U.S. producers' political actions have paid huge dividends.

JEL codes: C32, L66, G13, Q18

Keywords: softwood lumber demand, cointegrated vector autoregression, hedging, softwood lumber war, lumber futures

INTRODUCTION

As softwood lumber is the largest single category of forest products output in the United States, its demand and supply are of special interest to both private entrepreneurs and public policy-makers. For example, to the extent that softwood lumber in U.S. markets is primarily sourced in the U.S. and Canada, it is not surprising to see that U.S. producers have lobbied for

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restrictions on Canadian lumber imports and that the two countries have engaged in a long-lasting softwood lumber trade war (Zhang 2007). The various trade-restrictive measures on Canadian lumber imports historically and currently, as well as the market structure for softwood lumber, characterized by inelastic demand and supply, collectively render lumber prices volatile in the U.S. (Zhang and Sun 2001). Thus, understanding the dynamics of demand for U.S. produced lumber is helpful for many U.S. lumber producers to make their production decisions and U.S. consumers to adjust their consumption.

Herein, the estimated U.S. softwood lumber demand model differs from previous estimated models (e.g., Uri and Boyd 1990; Adams et. al. 1992) in three ways: (a) our demand is estimated with monthly data, while most previous work used annual data; (b) we focus on U.S.-sourced lumber, while previous work emphasized annual U.S. demand for softwood lumber from all sources (U.S. production and imports); and more importantly (c) we test for and incorporate an empirical link between current demand for U.S.-produced lumber and the lumber futures market, whereby producers and consumers may use prices of lumber futures to adjust their production and consumption activities. In addition, we demonstrate the cointegrated VAR model's policy-analytic usefulness in empirically assessing the positive impacts that various trade restrictions measures have had on demand for U.S.-produced softwood lumber. Since we examine the success with which some of these trade measures accomplished their purpose and augmented supply and demand of U.S.-sourced softwood lumber, we focus on quantities of U.S. produced lumber. The next section presents the demand model for U.S. produced lumber, followed by estimation methods, data and results. The final section concludes.

A Dynamic Demand Model for U.S.-Produced Lumber

As Uri and Boyd (1990) stated, the demand for softwood lumber at the regional level in a given period is often expressed as a Cobb-Douglas function:

$$Q_L = \mu\, P_L^{\alpha}\, P_s^{\beta}\, H^{\gamma}\, M^{\delta} \tag{1}$$

or

$$\ln Q_L = \ln \mu + \alpha \ln P_L + \beta \ln P_s + \gamma \ln H + \delta \ln M + \varepsilon \tag{2}$$

where Q_L is quantity demanded for softwood lumber, P_L is lumber price, P_S is price of a substitute good, H is housing starts, M is maintenance, remodeling, and repairing activities; μ (or $\ln \mu$), $\alpha, \beta, \gamma,$ and δ are parameters to be estimated, and ε is an error term. Often the quantity of softwood lumber demanded in previous periods is also included. At the national level, other demand models such as the end-use approach (Adams et al. 1992) and product diffusion approach (Spelter 1985) have been used. Again, all previous demand studies have used annual data and irrespective of where the lumber is produced.

Our interest in this paper is monthly demand for U.S. produced lumber. Demand of lumber substitutes is highly inelastic in such short-term (monthly) horizons so that the term, $\gamma \ln P_s$, is close to zero($\gamma \ln P_s \to 0$). Further, the maintenance, remodeling, and repairing

activities are highly correlated with housing starts. Thus, U.S. producers may consider price expectations, expressed in the lumber futures prices, as an indicator of demand in the near future. Thus, we have

$$Q_L = \mu P_L^{\alpha} P_F^{\omega} H^{\gamma} \quad (3)$$

where P_F is the price of lumber futures and ω is a parameter to be estimated. Here, P_L and P_F may be seen as prices of close substitute lumber products: the currently valued lumber priced at P_L that would have a negative exponent ($\alpha < 0$) and its time-differentiated substitute delivered at a later date and priced at P_F that would have a positive coefficient ($\omega > 0$).

Equation 3 is the basic model of this paper. Should α and ω be statistically identical, but with opposite signs (i.e., $\alpha = -\omega$), we would have

$$Q_L = \mu \left(\frac{P_L}{P_F}\right)^{\alpha} H^{\gamma} \quad (4)$$

or

$$\ln Q_L = \ln \mu + \alpha \ln P_L - \alpha \ln P_F + \gamma \ln H + \epsilon \quad (5)$$

Obviously, demand for U.S. produced lumber is affected by the various trade restriction measures placed on Canadian lumber imports. Hence we used various dummy variables to account for the effects of important and potentially market-influencing events. This model was estimated with time series data using a cointegration approach (cointegrated VAR model).

ESTIMATION METHODS AND DATA

The Cointegration Approach and Data

As is well known, economic time series often fail to meet conditions of weak stationarity (also known as stationarity and ergodicity) required of valid inference. In some cases, applying regression to time-ordered data generate biased estimators (Granger and Newbold 1986, p. 1-5). On the other hand, while often individually non-stationary, such series can form vectors with stationary linear combinations, whereby the series move in tandem and in a stationary manner as a group known as an error-corrected cointegrated system (Johansen and Juselius 1990).

Based on Equation 5, we found monthly data for the following endogenous variables (denoted by parenthetical labels) with which to conduct this study:

- U.S. softwood lumber production (Q_L) in millions of board feet. These data were obtained from Western Wood Products Association and Southern Forest Products Association (G. Andrew 2012; V. Barabino, 2012. Pers. Comm.).

- U.S. housing starts (H) in thousands of units, not seasonally adjusted (U.S. Census Bureau 2012).
- U.S. wholesale price of softwood lumber (P_L): This is the U.S. producer price index or PPI for softwood lumber in the lumber and wood products group of PPIs, Series no. WPU0811. This variable represents current U.S. softwood lumber price.
- Price of Softwood Lumber Futures (P_F): This is the average monthly settlement price of the CME Group's Random Length Lumber Futures contract that trades in volumes of 110,000 board feet of random length (8 to 20 feet) softwood 2-by-4s.[1] P_F is the average of softwood lumber futures 45 days forward from the current pricing point, P_L, above.[2]

Modeled in natural logarithms, our data are shown to be non-stationary or integrated of order 1. An estimation period of January, 1992 through May, 2012 (1992:01 – 2012:05) was chosen because previous U.S. softwood lumber production data are not available at the monthly level.

Following Juselius and Toro (2005) and Juselius (2006, chs. 1-4), we examined the logged levels and differences to assess the data's non-stationarity properties. Such examinations led to formulation of specification implications of these properties that utilize inherent stores of information to avoid compromised inference, and in some cases, biased estimates (Granger and Newbold 1986). Incorporating statistically supported specification implications in turn results in a statistically adequate underlying VAR model (and algebraically equivalent unrestricted VEC) with which the cointegrated properties of the four endogenous variables can be exploited.

The Underlying Statistical Model: The Levels VAR and Unrestricted VEC Equivalent[3]

Sims (1980) and Bessler (1984) note that a VAR model posits each endogenous variable as a function of k lags of itself and of each of the system's remaining endogenous variables. The above lumber-related variables render the following 4-equation model in lagged levels:

$$\begin{aligned} X(t) = {} & a(1,1)*Q_L(t-1) + \ldots + a(1,k)*Q_L(t-k) + \\ & a(2,1)*H(t-1) + \ldots + a(2,k)*H(t-k) + \\ & a(3,1)*P_L(t-1) + \ldots + a(3,k)*P_L(t-k) + \\ & a(4,1)*P_F(t-1) + \ldots + a(4,k)*P_F(t-k) + \\ & a(c)*CONSTANT + a(T)*TREND + a(s)*SEASONALS + \gamma(t) \end{aligned} \quad (6)$$

where $X(t) = Q_L(t)$, $H(t)$, $P_L(t)$, and $P_F(t)$. The asterisk denotes the multiplication operator; t

[1] The chosen roll methodology on the Bloomberg terminal prices the front month contract with a roll into the next nearest contract on the first business day of the front month contract's expiration month.

[2] The average estimate that P_F prices a position at an average horizon of 45 days forward of P_L arises from a number of factors. The 45-day average estimate uses the assumptions that (i) a monthly average price presents approximately half a month (15 days), (ii) the contract lists every other month, and (iii) average settlement occurs about 15 days into the delivery month. Hence, the following summation arises: 15+15 or 15+30+15. The 45-day average arises from taking an average of the latter two possibilities.

[3] This section draws heavily on Johansen and Juselius (1990) and Juselius (2006).

refers to current time period; and $\gamma(t)$ is a vector of white noise residuals. The a-coefficients are ordinary least squares regression estimates with the first parenthetical digit denoting the four endogenous variables as ordered in X(t)'s definition, and the second reflecting the lagged value. The lag structure, k=3, was suggested from the application of Tiao and Box's (1978) lag search procedure. The a(c) denotes the intercept generated on a vector of unity values, while a(T) is the coefficient generated on a time trend or TREND. Equation 6 also includes a vector of 11 centered seasonal variables and a number of other binary variables discussed below.

It is well known that Equation 6, known as a levels VAR, with a lag order-k can be equivalently written more compactly as an unrestricted vector error correction (unrestricted VEC) model (Juselius 2006, p. 59-63; Johansen and Juselius 1990):

$$\Delta x(t) = \Gamma(1)*\Delta x(t-1) + \ldots + \Gamma(k-1)*\Delta x(t-k+1) + \Pi*x(t-1) + \Phi D(t) + \varepsilon(t) \quad (7)$$

The endogenous variable number, p, is 4. The $\varepsilon(t)$ are white noise residuals, the delta is the difference operator, while the x(t) and x(t-1) are p by 1 vectors of the endogenous variables in current and lagged levels. The $\Gamma(1), \ldots, \Gamma(k-1)$ terms are p by p matrices of short run regression coefficients, and Π is a p by p long run error correction term to account for endogenous levels. The $\Phi D(t)$ is a set of deterministic variables, including an array of binary (dummy) variables that will be added to address stationarity issues and policy and market events. The error correction (EC) term is decomposed as follows:

$$\Pi = \alpha*\beta' \quad (8)$$

The α is a p by r matrix of adjustment coefficients (r is the number of cointegrating relationships or the reduced rank of Π discussed below). The β is a p by r vector of cointegrating parameters.

The error correction or EC term retains the levels-based and other long run information: linear combinations of non-differenced and individually I(1) levels variables (under cointegration); permanent shift binaries to capture more enduring effects of policy/market events (presented below); and a linear trend. The term $[\Gamma(1)*\Delta x(t-1) \ldots \Gamma(k-1)\Delta x(t-k+1), \Phi D(t)]$ collectively comprises the model's short run/deterministic component (hereafter denoted short run component) that includes the permanent shift binaries in differenced form, observation-specific outlier binaries (introduced below), and seasonal binaries.

Having followed Zhang (2007), Nagubadi et al. (2009) and Majumdar, et al. (2011), along with market knowledge and expertise, we initially restricted the following non-differenced permanent shift binary variables to the levels-based error-correction space to account the long run effects of seven important and potentially market-influencing events:

- NAFTA: This binary is defined for the January, 1994 implementation of the North American Free Trade Agreement (NAFTA) and takes a value of unity for the 1994:01 – 2012:05 period and zero otherwise.
- URUGUAY: This binary is defined for the January, 1995 implementation of the Uruguay Round Trade Agreement and takes a value of unity for the 1995:01 – 2012:05 period and zero otherwise.

- SLA96: This binary accounts for the first U.S.-Canada softwood lumber agreement. The binary takes a value of unity during 1996:04 – 2001:03 when the U.S. imposed an export tax-rated quota system on imports of Canadian-sourced lumber, and of zero otherwise.
- SLA06: This binary accounts for the second U.S.-Canada softwood lumber agreement in force during the 2006:10 – 2012:05 period when Canada agreed to a price-adjusted TRQ on U.S.-bound Canadian softwood lumber shipments. The variable takes a value of unity during this period and of zero otherwise.
- ADCVD: This variable captures the effects of U.S.-imposed firm-specific and annually-varying anti-dumping and countervailing duties imposed during the 2001:08 – 2006:09 period. The variable takes a value of unity during the latter period and zero otherwise.
- RECESS_2001: This binary is defined for the economic recession that occurred during the 2001:03 – 2001:11 period during which the variable is valued at unity and at zero otherwise.
- RECESS_0709: This binary is defined for the economic recession that occurred during the 2007:11 – 2009:06 period during which the variable is valued at unity and at zero otherwise.

ESTIMATION RESULTS

We followed Juselius' (2006, ch. 6) method of identifying and including extraordinarily influential effects of month-specific events through specification of "outlier" binaries. When a potentially includable outlier was identified with a "large" standardized residual, an appropriately specified variable was included in differenced form as part of Equation 7's short run component, and retained if a battery of diagnostics (discussed below) moved favorably to suggest enhanced specification.[4]

Table 1's battery of diagnostic values for the levels VAR (and its unrestricted algebraic VEC equivalent) before and after efforts focusing on enhanced specification suggest clear benefits to such efforts.

The trace correlation, a goodness of fit indicator, increased 84% to 0.644. While serial correlation was initially a likely issue, the finally estimated levels VAR after specification efforts generated evidence that serial correlation was no longer an issue. While initial evidence strongly rejected the null of no heteroscedasticity before specification efforts, the

[4] An observation-specific event was judged as potentially "extraordinary" if its standardized residual exceeded 3.0 in absolute value. Such a rule for outliers was designed based on the effective sample size of 242 observations using the Bonferoni criterion: INVNORMAL $(1\text{-}1.025)^T$ where T=242 and INVNORMAL is a function for the normal distribution that returns the variable for the cumulative density function of a standard normal distribution (Estima 2007). The Bonferoni variate had an absolute value of 3.7. Having realized that there were some month-specific events with potentially extraordinary effects with absolute standardized residual values of about 3.0, we opted to follow recent research and chose a more conservative Bonferoni absolute value criterion of 3.0 rather than 3.7 (Babula and Rothenberg 2012). Observations with absolute standardized residual values of 3.0 or more were thereby considered as potential outliers, and we specified an appropriately defined variable for relevant observations for the sequential estimate procedure. Ten binaries were ultimately included. Due to space limitation considerations, we do not report the binaries as they are part of the estimated model's short run component that is not a focus of this study on long run cointegration relationships. The binaries are available from the authors on request.

finally restricted model after specification efforts suggested that heteroscedasticity was likely not an issue.

Doornik-Hanson (D-H) values test the null that the estimated model's residuals behave normally. The D-H values for the estimated system improved notably such that the system of estimated residuals ultimately achieved strongly normal behavior. The univariate D-H values suggest that ultimately, evidence at the five percent significance level was insufficient to reject the null of normally behaving residual estimates for all four equations.

Finally, Table 1 suggests that the finally estimated and statistically adequate model displayed skewness and kurtosis indicators that fell within literature-established ranges.

Table 1. Mis-specification Tests for the Unrestricted VEC: Before and after Specification Efforts

Test and/or equation	Null hypothesis and/ or test explanation	Prior efforts at specification adequacy	After efforts at specification adequacy
Trace correlation	system-wide goodness of fit: large proportion desirable	0.350	0.644
LM Test for serial correlation (lag 2)	Ho: no serial correlation by lag-2. Reject for p-values of 0.05 or less	29.6 (p=0.02)	7.3 (p=0.97)
ARCH, lag 2	Ho: No heteroscedasticity. Reject for p values of 0.05 or less	254.1 (p=0.006)	222.8 (p=0.13)
Doornik-Hansen test, system-wide normality	Ho: modeled system behaves normally. Reject for p-values below 0.05.	15.8 (p=0.05)	6.7 (p=0.57)
Doornik-Hansen test for normal residuals (univariate)	Ho: equation residuals are normal. Reject for p-values at or below 0.05		
ΔQ_L		5.12 (p=0.08)	0.70 (p=0.71)
ΔP_L		5.5 (p=0.062)	4.94 (0.08)
ΔP_F		2.02 (p=0.36)	1.01 (p=.60)
ΔH		3.01 (p=0.02)	3.49 (p=0.17)
Skewness(kurtosis) univariate values	Skewness: ideal is zero; "small" absolute value acceptable kurtosis: ideal is 3.0; acceptable range is 3.0-5.0.		
ΔQ_L		-0.35 (3.14)	-0.13 (2.9)
ΔP_L		0.34 (3.49)	0.33 (3.41)
ΔP_F		0.02 (3.33)	0.14 (3.06)
ΔH		0.01 (3.44)	-0.036 (3.48)

Cointegration: Testing For and Imposing an Appropriate Reduced Rank

The endogenous variables are shown below to be non-stationary. Juselius (2006, p. 80) notes that cointegrated variables are driven by common trends and stationary linear combinations called cointegrating vectors or CVs. The Π-matrix in Equation 8 is a p by p

(here 4 by 4) matrix equal to the product of the two p by r matrices: β of error correction estimates that under cointegration combine into r < p stationary CVs of the four individually non-stationary endogenous variables, and α of adjustment coefficients (beta, alpha estimates, respectively). Under cointegration, the rank of β'x(t) is reduced despite the non-stationarity of x(t)'s four series.

The EC space's reduced rank has traditionally been selected based on the widely-applied trace tests (Johansen and Juselius 1990). However, Juselius and Toro (2005), Juselius and Franchi (2007), and Juselius (2006, ch. 8) strongly recommend against a sole reliance on the trace test results in determining the reduced rank r < p, and in turn the number of cointegrating vectors that error-correct the system. More specifically, they suggest that determination of reduced rank (r) should consider other relevant sources of evidence. Thus, our determination of r is a three-tiered process that considers three sources of relevant evidence: the traditionally consulted nested trace tests, patterns of α-estimate statistical significance in relevant CVs, and patterns of characteristic roots in companion matrices (Juselius 2006, ch. 8).

All three sources of evidence suggest that r could be as low as 1 and as high as 3, with most evidence suggesting that r is likely 1.

Table 2 provides nested trace test results. A strict reading of these results suggests that evidence at the five percent significance level is sufficient to reject Table 2's first three hypotheses, and is insufficient to reject the fourth, suggesting that r ≤ 3. Given the nested nature of these four trace tests, they suggest that r = 3. However, evidence only marginally rejected the third hypothesis that r ≤ 2. Such indicates that the appropriate number of error-correcting CVs may be smaller than 3, perhaps 2 or less.

The patterns of adjustment coefficient or α-estimate significance further suggest that r is not only less than 3, but is likely 2 or less. A CV that actively participates in, and that should be considered part of, the EC mechanism should display a high number of statistically significant alphas. When many of a CV's α-estimates are statistically significant, then including that CV in the EC space is justified since the CV is contributing to the model's explanatory power. When many of the α-estimates in a CV are not statistically significant, Juselius (2006, p. 141-143) notes that including that particular CV in the EC mechanism would likely not improve the explanatory power of the model; may invalidate inference; and likely should be excluded from the cointegration space.

The patterns of pseudo-t values on the three CVs from the rank-unrestricted VEC model suggest that CV1 contributes most to the model's explanatory power; CV2 contributes the second-highest levels of explanatory power; and that the third CV contributes little and should perhaps be excluded from the EC process. This is because of the four α-estimates generated on the four endogenous variables in each CV: three were significant in CV1; two were significant in CV2; and only 1 was significant in CV3.[5] This evidence concerning α-estimate significance suggests that the EC mechanism should include CV1 and possibly CV2, and should not include CV3, suggesting that r is 1 or 2 rather than 3.

[5] Due to space considerations, the alpha estimates, pseudo t-values and other results from the rank-unrestricted VEC model are not reported, and are available from the authors on request. An α-estimate is deemed statistically non-zero at the five percent significance level if its absolute pseudo-t value is 2.6 or more (Juselius 2006, p. 142). More specifically for this paper's model, the following were the statistically significant pseudo-t values generated by the CVs: -3.1 on Q_L, -2.7 on P_L, and 3.6 on P_F in CV1; 6.0 on Q_L and 2.8 on P_F in CV2; and -4.4 on H in CV3.

Table 2. Nested Trace Tests and Test Statistics

Null Hypothesis	Trace Value	95% Fractile	Result
Rank or $r \leq 0$	134.84	78.06	Reject null that $r \leq 0$
Rank or $r \leq 1$	81.21	57.17	Reject null that $r \leq 1$
Rank or $r \leq 2$	42.23	40.13	Reject null that $r \leq 2$, although marginally
Rank or $r \leq 3$	14.61	26.85	Fail to reject that $r \leq 3$

Notes: As recommended by Juselius (2006), CATS2–generated fractiles are increased by 8*1.8 or 14.4 to account for the eight previously discussed deterministic variables that were restricted to lie within the cointegration space. As recommended by Juselius (2006, ch. 8) and programmed by Dennis (2006), trace values are corrected with Bartlett's small sample adjustment.

The third source of rank-relevant evidence is patterns of the characteristic roots under alternative reduced ranks that suggest r is likely 1 and not 2 or 3. Generally, if the chosen r is appropriate, then the companion matrix under r should generate (p – r) unit roots, and the (p-r+1)st root should be substantially below unity. Should the (p – r + 1)st root be near-unity, then r should likely be reduced (Juselius 2006, ch. 8). The following summary results clearly suggest that not only is the appropriate reduced rank less than 2 or 3, it is likely even smaller, that is r=1:[6]

- Under r = 3, there was (p – r) = (4-3) or 1 unit root with the second root having been 0.96 that is nearly unity. This suggests that r=3 should be reduced.
- Under r = 2, there were (p – r) = (4-2) or two unity roots with the third being 0.83, a value deemed near enough to unity to suggest that r=2 may also be reduced.
- Under r = 1, there were (p – r) = (4-1) or three unit roots with the fourth of 0.68 far enough below unity to suggest that r=1.

Based on the three sources of above-cited references, we conclude that the EC space's reduced rank is more likely 1 than 2 or 3 and we restricted the model for r=1 with a single CV error-correcting the system.

Hypothesis Tests on the Three Unrestricted Cointegrating Relations

One begins with the unrestricted CV (not reported here) that emerged from Johansen and Juselius' (1990) reduced rank estimation of Equation 7 after having imposed a rank of r=1 on the EC space. A sequence of hypothesis tests were then conducted on the EC space; the statistically supported hypotheses were imposed; and the restriction-ridden model was re-estimated with the Johansen and Juselius' (1990) reduced rank estimator to generate the finally restricted cointegrating relation that error-corrects the system and that is presented and analyzed below. Hypothesis tests on the betas take the form:

$$\beta = H*\varphi \tag{9}$$

[6] Due to space considerations, the authors have summarized and have not reported the companion matrices and related results under 1, 2, and 3. These results and matrices are available from the authors on request.

Above, β is a p1 by r vector of coefficients included in the cointegration space,[7] and H is a p1 by s design matrix, with s being the number of unrestricted or free beta coefficients. The φ is an s by r matrix of unrestricted beta coefficients. The hypothesis test value or statistic is:

$$2\ln(Q) = T^{*}\sum [(1-\lambda_i^{*}) / (1-\lambda_i)] \text{ for } i= 1 (=r) \quad (10)$$

Asterisked (non-asterisked) eigenvalues (λ_i , i = 1) are generated with (without) the tested restrictions imposed.

The first group consists of four system-based and rank-dependent stationarity (unit root) tests on the four endogenous variables. Juselius (2006), Juselius and Toro (2005), and Juselius and Franchi (2007) recommend this approach over univariate unit root tests (e.g. Dickey-Fuller and Phillips-Perron tests) for such multivariate models as ours. The four unit root tests were conducted in CATS2 (Dennis 2006). Evidence suggested that all four endogenous variables are non-stationary or I(1) in logged levels.[8]

The second group of tested hypotheses contains those that emerged and/or were suggested by (a) values of the estimated CV's parameter estimates, (b) market/industry knowledge and expertise, and (c) economic and econometric theory. It is well known from Sims (1980) that the unrestricted levels VAR of Equation 6 that underlies Equation 7 is a reduced form one, where estimated relations reflect a mix of demand- and supply-side elements without clear structural interpretations. Further, these reduced form relations encompass an intertwined mix of influences of long run and short run components. The advantage of dichotomizing Equation 6 into Equation 7's long run EC component and its short run component is to permit researchers to focus on the long-run component's equilibrium or cointegrating relationships in Equation 8 and to work economic/econometric theory and market knowledge into Equation 8's estimation through imposition of statistically supported restrictions obtained from hypothesis tests. In so doing, long run theoretical relationships are illuminated and separated from short run influences, and economic rationalization of Equation 8's relationships may become clearer than in prior work that did not so-dichotomize the model. As well, such dichotomization of long run and short run effects, as well as due diligence in imposing statistically supported hypothesis test restrictions, may render a finally restricted CV whose parameter values vary from those in prior literature whose methods did not have the benefit of their models' dichotomization into long run and short run components.

The following five restrictions arose from (a) – (c). They were tested and strongly accepted by the data using Equations 9 and 10 and were imposed on the EC space that was then re-estimated using Johansen and Juselius' (1990) reduced rank estimator:[9]

[7] The p1 equals 12: it is the sum of p=4 endogenous variables plus the eight deterministic variables (previously presented) that were restricted to lie in the cointegration space.

[8] More specifically, Equation 9 is re-written as $\beta^{c} = [b,\varphi]$. Let p1 be the new dimension of 12 to reflect the four endogenous variables and the eight deterministic variables restricted to lie in the EC space. The β^{c} is a p1 by r or 11 by 3 matrix with one of the variable's levels restricted to a unit vector and b is a p1 by 1 or 12 by 1 vector with a unity value corresponding to the variable the stationarity of which is being tested. The φ is a p1 by r-1 matrix that vanishes under r=1 since (r-1) is zero. Given the rank of 1, the test values and parenthetical p-values for the four stationarity tests are as follows with the null of stationarity rejected for p values below 0.05: 26.3 (0.000008) for Q_L; 34.96 (0.00000012) for P_L; 28.2 (0.000003) for P_F; and 28.4 (0.000003) for H.

[9] The Chi-square test value (5 degrees of freedom) using the Bartlett small sample correction programmed in CATS2 by Dennis (2006) was 8.97 and had a p-value of 0.11. Thus, evidence at the five percent significance level was insufficient to reject the five restrictions.

- $\beta(P_L) = -\beta(P_F)$. The reasoning and importance of this test is highlighted below.
- Zero restrictions on the β-estimates on the binaries defined for the Uruguay Round agreement, the two recessions, and time trend. The issue of multicollinearity of these non-trend binaries with other temporally concurrent permanent shift binaries ultimately included in the finally restricted CV [Equation 11] is addressed below as a reason why the data accepted these restrictions.

What resulted is the finally-restricted cointegrating relationship provided in Equation 11 as a monthly U.S. demand for softwood lumber.

$$\begin{aligned} Q_L = {} & \underset{(-7.10)}{-1.25*(P_L - P_F)} + \underset{(4.3)}{0.30*H} - \underset{(-1.34)}{0.09*NAFTA} + \underset{(1.85)}{0.10*SLA96} \\ & + \underset{(3.00)}{0.16*ADCVD} + \underset{(2.88)}{0.19*SLA06} \end{aligned} \quad (11)$$

The parenthetical values below the estimated coefficients are pseudo t-values. The absolute critical value to test that the CV β-estimate is statistically zero is 2.6 at the 5% significance level (Juselius 2006, p. 142).[10]

INTERPRETATION AND USEFULNESS OF U.S.-PRODUCED SOFTWOOD LUMBER DEMAND MODEL

As expected of a demand relation, the quantity of U.S. softwood lumber (Q_L) is negatively related to its price, P_L. As we used a cointegrated VAR approach, our elasticity of demand is a long-run elasticity. It is thus not surprising that our elasticity estimate (-1.25) is much higher than those presented in the literature (e.g., Uri and Boyd 1990; Adams et al. 1992).

Perhaps more interestingly, such demand is positively and equally dependent on futures price that prices a closely-substitutable (and time-differentiated) futures lumber position an average of 45 days forward. Insofar as data were modeled in natural logarithms, Equation 11's price difference term implies that U.S. softwood lumber demand depends on the relative softwood lumber/futures price, such that the emergent demand takes the form of Equation 4. This implication is reinforced by the term's notable statistical strength: The term's pseudo-t value (-7.1) far exceeds the ±2.6 critical values at the 5% significance level (Juselius 2006, p. 142).

At first glance, Equation 11's P_L/P_F term may suggest that concurrently equal movements of the two prices could or would be mutually offsetting with no effect on softwood lumber demand. However, such a precise offset is unlikely, since the modeled softwood lumber and futures prices do not define (and are not intended to define) the CME Group's Random Length Lumber contract's underlying basis. Rather, P_L is a nationally-surveyed PPI intended to capture national softwood lumber price trends, and is not the contract-specific cash price

[10] Juselius (2006, p. 142) notes that these pseudo-t values are not Student t-values and as a result, the critical values for the hypothesis concerning Equation (11)'s β-estimates are not the same as Student-t critical values.

used to settle the CME Group's contract that in turn generates P_F. And while the two prices are expected to qualitatively move in tandem, there is no hard expectation that a related event or policy shock should generate equal percent changes in the two prices.

Nonetheless, softwood lumber priced concurrently at its own price and priced forwardly at P_F are highly substitutable products that are differentiated by time. The above lumber/futures price relation results are therefore consistent with U.S. softwood lumber demand that is negatively related to its own current price (P_L) and positively related to the price of its close substitute priced forwardly at P_F. Hence, Equation 11 is that log linear form of the previously discussed Cobb-Douglas demand in Equation 3, and more specifically Equation 4 where demand is a function of the P_L/P_F ratio.

Risk-managing activity, including hedging, is likely under Equation 11's P_L/P_F price term. As softwood lumber price rises relative to futures price, demand for softwood lumber at the current pricing point, P_L, becomes relatively more expensive than at the futures pricing point, P_F, at an average time-stamp of 45 days forward. As P_L/P_F consequently rises, there is a willingness of some agents to postpone demand and allocate some of their total demand towards the relatively cheaper futures pricing point some 45 days forward through taking positions with the CME Group's softwood lumber contract.

Likewise, as softwood price declines relative to futures price, demand for lumber at the current pricing point, P_L, becomes relatively cheaper than at the P_F point some 45 days ahead. As P_L/P_F declines, there is a P_L-induced increase in current demand that may be offset by a decline in demand at the futures price 45 days ahead, as agents hedge through position-taking on the CME Group contract. Finally, it is important to note that policies or events that induced effects on P_F have similarly reasoned effects on softwood lumber demand through changes in the relative softwood lumber/futures price.

Observed data associated with notably pronounced movements in lumber price, futures price, relative P_L/P_F price, and CME Group lumber contract trading volumes seem consistent with the above reasoning and analysis of Equation 11's lumber/futures price term. One well-known instance occurred during the 10 months ending March, 1993 when softwood lumber rose 43% and futures price soared even more, such that the softwood lumber price ratio fell by about 20%.[11]

As demonstrated in Figure 1, the resulting 20% drop in relative lumber/futures price rendered demand for U.S. softwood lumber cheaper at the current P_L pricing point than at P_F, the pricing point some 45-days forward. This relative price ratio decline was concurrently met with a notable 38.3% escalation in the trading volume of CME Group's random length lumber contract as reflected by the monthly averages in the contract's daily trades, particularly after November, 1992.

Although Figure 1 provides daily trades (both long and short positions combined) and does not provide levels of open interest, this rise in trading activity in response to sharp movements in the relative lumber/futures price ratio likely included hedging activity along with some speculative trading.

[11] Reasons for the pronounced lumber price increases included enhanced lumber demand from a then-recovering economy's increased residential construction, a reduction in timber supplies from Pacific Northwest forests due to environmental concerns, and from allegations of heightened levels of trader speculation (Gorte 1993; Bianco 2012).

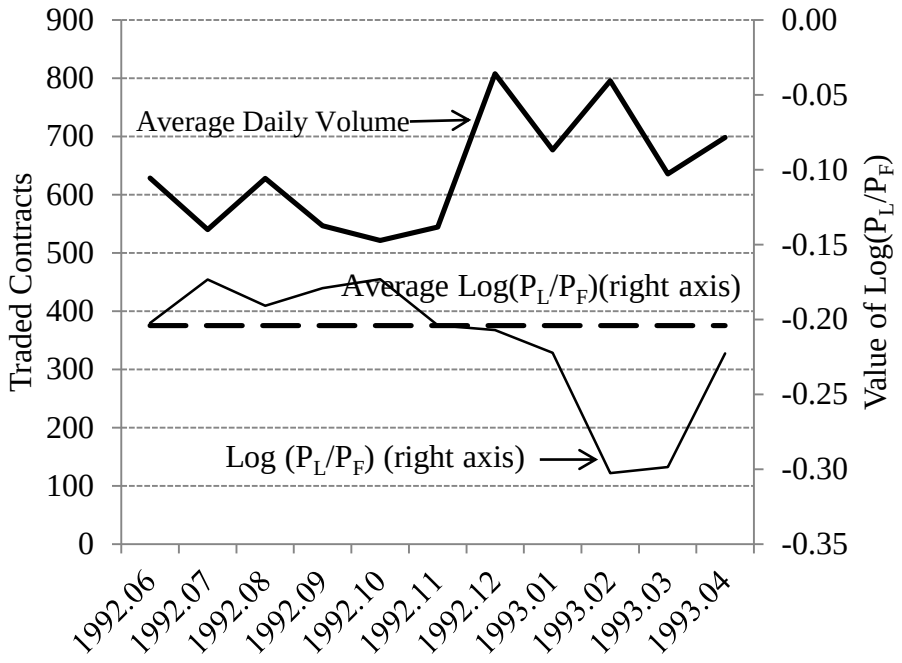

Figure 1. Relationship between Lumber Futures Trading Volumes and the Relative Softwood Lumber/Futures Price: 1992:06 – 1993:04.

Estimated Effects of Specific Policies/Events

Since this study's cointegrated VAR model was estimated in natural logarithms (logs), interpreting coefficient estimates generated by binary (or dummy) variables follow Halvorsen and Palmquist's (1980) well-known method (Babula and Rothenberg 2012). The Halvorsen and Palmquist (HP) values calculated for the β-estimates generated by binary variables indicate, on average, the percentage by which the dependent variable (Q_L in Equation 11) is above (for positive β-estimates) or below (for negative β-estimates) during the binary's period of definition than during sub-periods of the sample when the binary's defining event was not in force.[12] The HP values provide an important avenue of the cointegrated VAR model by which policy-analytic results may be obtained.

Recall that the seven permanent shift binary variables that were initially restricted to lie in the EC space had the following definition periods: NAFTA, 1994:01 – 2012:05*; URUGUAY, 1995:01 – 2012:05*; SLA96, 1996:04 – 2001:03; SLA06, 2006:10 – 2012:05*; ADCVD, 2001:08 – 2006:09; RECESS_2001, 2001:03 – 2001:11; and RECESS_0709, 2007:11 – 2009:06.[13] These seven sub-periods of binary variable definition clearly overlap,

[12] As noted in Halvorsen and Palmquist (1980), for log/log estimations such as ours, one takes "e," the base of the natural logarithm; raises it to the power of the binary's β-estimate; subtracts 1.0; and then multiplies the result by 100 to render he noted HP value for that estimated coefficient.

[13] The periods of binary variable definition ending with May, 2012 are asterisked. May, 2012 values were the most recent available at the point of model estimation, and this date serves as the end of the estimation period and is not the end of the subsample for which the binaries are defined.

and in some cases, entire sub-periods of binary definition are included in those of other binaries.

As such, these initially included permanent shift binaries likely generated highly collinear coefficients, insofar as all seven coefficients were picking-up concurrent influences. The most obvious example involved the sub-periods defined for NAFTA (1994:01 onward) and URUGUAY (1995:01 onward): β(NAFTA) initially captured all influences captured by β(URUGUAY).

Such collinearity among binaries is likely responsible for the acceptance of zero restrictions on the beta estimates for URUGUAY and the two recessions during implementation of the hypothesis tests, and perhaps for the seemingly low significance levels suggested by low absolute pseudo-t values on Equation 11's NAFTA and SLA96 coefficients that may well, in reality, be statistically non-zero.[14] Of the four remaining permanent shift binaries that the hypothesis test results suggested should remain, the ADCVD and SLA06 variables generated positive and significant coefficients. Yet NAFTA and SLA96 generated pseudo t values that suggested insignificance. We decided to retain NAFTA to compare with results of other commodity trade studies (e.g., Babula and Rothenberg 2012) where it is shown to be significant and to retain SLA96 to compare with results of other studies on softwood lumber (e.g. Zhang 2006). And as Zhang (2006) notes, including the final year of SLA96 which were expected to expire might have caused the insignificance.

Equation 11's ultimately included four permanent shift binaries generated β-estimates that, through HP values, suggested the following effects on U.S. demand for domestically produced lumber:

- Implementation of NAFTA resulted in U.S. demand levels for softwood lumber that were, on average, not significantly different from the treaty's 1994 implementation. This is consistent with our expectation because softwood lumber was excluded from the U.S.-Canada Free Trade Agreement which became NAFTA (Zhang 2007).
- Similar to Zhang (2006), the first SLA in 1996 resulted in demand for U.S. softwood lumber that was, on average, 10% higher than when SLA96 was not in force.
- The U.S. antidumping and countervailing duty orders that were imposed on certain imports of Canadian-sourced softwood lumber appeared effective in augmenting U.S. demand for its own softwood lumber. The HP value on β(ADCVD) suggests that such demand was, on average, 17.4% higher than during the sample periods when the orders were not in force. This finding is consistent with Nagubadi and Zhang (forthcoming).
- The second softwood lumber agreement established in 2006 appeared effective insofar as HP value on β(SLA06) suggests that U.S. demand for its own lumber was about 21% higher than sub-samples prior to the agreement's implementation. We must relegate to future research how much of a net effect this is, insofar as RECESS_0709's defined sub-period falls entirely within that of the SLA06. This finding is consistent with Nagubadi and Zhang (forthcoming).

[14] More specifically, the entire URUGUAY sub-period is enveloped into that of NAFTA. The RECESS_0709 sub-period is included completely in the sub-period of SLA06, while RECESS_2001 overlaps partially with the sub-periods of ADCVD. Further, for the four coefficients ultimately included in Equation 11, the sub-period of ADCVD (2001:08 – 2006:09) overlays with the defined sub-period of NAFTA (1994:01 – 2012:05).

CONCLUSION

In this paper we use the cointegration approach to establish a demand model for U.S. produced softwood lumber that displays noticeable statistical strength. Our model is consistent with economic theory and robust under various diagnostic tests. Our results show that the demand for U.S.-produced lumber responds to current lumber prices, futures lumber prices, and housing starts. Further, various trade restriction measures on Canadian lumber imports have been successful and have had positive impacts on demand for U.S.-produced softwood lumber.

The results suggest that demand for U.S.-produced softwood lumber is related to a ratio of current to futures prices as noted within the Cobb-Douglas form in Equations 3 and 4, or alternatively, to both current and futures prices but in opposite ways. Softwood lumber priced currently and forwardly can be taken as closely substitutable lumber products differentiated by time. U.S. producers could use this relationship to manage price risks and to adjust their short-run production plans. Similarly, lumber buyers could hedge their consumption activities. Finally, the forest economist profession, which has not paid much attention to futures markets in the literature, may glean substantial amounts of useful information and insights on market relationships by studying lumber prices in the futures market -- for example, relationships among the lumber/futures price ratio and contract trading volumes from hedging and from speculative trades.

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EXPORT-LED GROWTH AND TERMS OF TRADE VOLATILITY IN THE EAST AFRICAN COMMUNITY TRADE BLOC

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ABSTRACT

The export-led growth hypothesis is examined for five East African Community trade bloc countries using panel co-integration methods. Results indicate that exports have a positive and significant effect on exports-adjusted GDP in the long- and short-run horizons. In addition, an increase in terms of trade volatility has a negative and significant impact on GDP. The bulk of exports are primary commodities which are vulnerable to high terms of trade volatility. This increases the probability of reversing the gains from export-led growth. These countries should emphasize policies that lead to an increase in the share of value-added commodities in total exports.

JEL classification: C23, F43, O13, O50

Keywords: trade, export-led growth, terms of trade volatility, East Africa

INTRODUCTION

Export-led growth theory postulates that promoting exports and achieving export expansion leads to better resource allocation, creating economies of scale and production efficiency through technological development, capital formation, and employment generation. It also relaxes current account pressures by increasing the country's external earnings and attracting foreign investment (The World Bank, 1993). Greater theoretical agreement on the premise of export-led growth has emerged following the success of the free-market and the outward-oriented policies of the East Asian Tigers. This has been compared to the poor

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performance of Latin American economies that followed inward-oriented policies and import substitution. The export-led growth hypothesis has also shaped the policies of international organizations, the international banking community, The World Bank, and the International Monetary Fund (Medina-Smith, 2001).

Yet, the expanding empirical literature has shown mixed results concerning export-led growth, particularly with regard to whether or not exports spur economic growth. Time series studies have used either a single- or multi-country framework to find support for the theory (Gupta, 1985; Rana, 1985; Nandi and Biswas, 1991; Khan and Saqib, 1993; Ghartey, 1993; Bahmani-Oskooee and Alse, 1993; Bhat, 1995; Khan et al., 1995; Al-Yousif, 1997; Ghatak and Price, 1997; Anwar and Sampath, 2000; Ahmed et al., 2000; Kemal et al., 2002; Sanjuàn-Lòpez and Dawson, 2010). Similarly, several cross-section studies provide support for the export-led growth hypothesis (Kravis, 1970; Michaely, 1977; Bhagwati, 1978; Balassa, 1985; Tyler, 1981; Kavoussi, 1984; Gonclaves and Richtering, 1986; Ram, 1987; Heitger, 1987; Fosu, 1990; Lussier, 1993). Multi-country studies report mixed results (Jung and Marshall, 1985; Darrat, 1986, 1987; Chow, 1987; Bahmani-Oskooee et al., 1991; Dodaro, 1993; Kwan et al., 1996; Dutt and Ghosh, 1996; El-Sakka and Al-Mutairi, 2000). Some case studies have rejected the export-led growth hypothesis (Mutairi, 1993; Boltho, 1996; Ahmed and Harnhirun, 1996; Xu, 1996). On balance, most of these studies support the export-led growth hypothesis, whether for primary or manufactured commodities.

This paper shows empirically that growth of exports is not a sufficient condition for economic growth. Reliance on primary commodities to spur economic growth has pitfalls, such as the potential for the reversal of growth due to increases in terms of trade volatility. Panel data for the East Africa Community (EAC) trade bloc is used to investigate the effects of terms of trade volatility on country-level growth. Our focus is on primary commodity export price volatility as a driver of the relatively high terms of trade volatility experienced by developing countries such as those in the EAC.

TERMS OF TRADE VOLATILITY

The economic relationship between trade and development does not guarantee that trade will automatically lead to economic growth in developing countries, especially those that predominantly rely on exports of primary commodities. Cashin et al. (2000) show that primary commodity prices are highly volatile and the effects of their volatility tend to persist over time. Fatima (2010) also indicates that unfavourable terms of trade may lead to sluggish growth in country exports and investments, ultimately slowing the rate of GDP growth. Conversely, an improvement in terms of trade may lead to improved growth and investment (Bleaney and Greenaway, 2000). Our focus is on the fact that many developing countries rely on primary commodity exports and these countries tend to experience relatively high terms of trade volatility, which has the potential to seriously disrupt GDP growth (Broda and Tille, 2003).

There is increasing evidence of a negative relationship between specialization in the production and export of primary products and economic growth. Sachs and Warner (1997) indicate that the 1970 share of primary commodity exports in GDP has a negative and significant effect on growth for 83 countries during 1965-1990. Sala-i-Martin (1997) reports that the 1970 share of primary commodity exports in total exports is negatively correlated

with growth based on alternative regression specifications. Mendoza (1997) uses data for 40 industrial and developing countries to find that terms of trade volatility has a large adverse effect on economic growth. These results are robust to the addition of other key growth determinants based on Barro's growth-regression framework (Barro, 1991).

Baxter and Kouparitsas (2000) show that terms-of-trade fluctuations are twice as large in developing countries when compared with developed countries. They attribute this to the fact that developing countries predominantly rely on primary commodity exports, whose prices are more volatile than those of manufactured goods. Given the inelastic demand, it is expected that primary commodities will experience greater price volatility. In addition, these countries have a high degree of openness where sharp swings in the terms of trade affect a large share of their output. Mendoza (1995) and Kose (2002) show that terms-of-trade changes can account for up to half of the output volatility in these countries. Developing countries are also highly exposed to terms-of-trade volatility because they have little control of their export prices, as world markets dictate the prices of the goods they export. In contrast, developed countries exert substantial influence on their export prices (Broda 2004). Therefore, terms of trade shifts in developing countries are exogenous to these economies.

East Africa Community Trade Bloc

The motive of this study is to contribute to the discussion of economic growth policy in developing countries generally, and specifically in the case of the EAC trade bloc partner states, which have not received prior research attention. The EAC was revived in 2000 with the mission of improving the quality of life of the people in the region through increases in: competitiveness, value-added production, trade, and investment. Implementation of this mission is to occur during 2011–2020, so research at this stage in the process can be instrumental in shaping development policy in the EAC.

Significant trade expansion has occurred in the EAC trade bloc during the past decade in response to establishment of a customs union. Intra-EAC trade grew by 40% during 2005-9. Uganda's exports to Kenya increased from US$ 15.5 million to US$172 million during 2004-9, and Tanzania's exports to Kenya increased from US$ 95.5 million to US$ 300 million during the same period (Ministry of the East African Community, 2011). It is expected that further growth in intra-regional exports will be facilitated by the Common Market, which was formed in 2010. This projected increase in trade and investment among the partner states is expected to improve the prospects for economic growth and development in the EAC. Since the revival of the EAC trade bloc in 2000, the composition of trade has been dominated by primary goods with a small fraction being processed products. And the industrial share of GDP has remained relatively stagnant between 2000 and 2011 for all the partner states. This implies that there has been little value addition within the manufacturing sectors of the partner countries (Ministry of the East African Community, 2011). Prolongation of this situation runs counter to the fundamental objectives of the EAC trade bloc - to enhance trade and foster economic growth and development. It is not clear that specializing in primary commodity exports guarantees that trade will achieve economic growth and development.

Since the bulk of the exports from the five EAC states are primary commodities with little value-added, we focus on the effects of terms of trade volatility on output for these countries. We examine the export-led growth hypothesis for the East African Community

trade bloc countries of Uganda, Kenya, Rwanda, Tanzania and Burundi using panel data co-integration techniques. We propose to show that export expansion leads to increased output, but terms of trade volatility has a countervailing negative and significant effect on output in the East African Community trade bloc.

To improve on previous research we use the export-led growth hypothesis and terms of trade volatility effects on GDP to determine if growth in primary commodity exports in developing countries is a necessary, but not sufficient, condition for economic growth and development. We also use a simple analysis to show that foreign direct investment inflows into the EAC region reduce the negative effect of terms of trade volatility. This is in part due to the fact that one quarter of the investment inflows in the region go into the manufacturing sector where value addition is affected. In addition, we use both panel data and country-specific analysis to test for consistency of these results. These panel data techniques are different from the cross-sectional and time-series methods that have been employed in previous studies. We use an extended dataset that spans 1970-2008 for testing the export-led growth hypothesis and the effect of terms of trade volatility on GDP.

METHODS

Panel data are assembled for GDP, exports, and terms of trade for the five EAC countries during 1970-2008 from the IFS yearbooks of the IMF and World Bank tables (The World Bank, 2011). Given that exports are a component of GDP, we subtract exports from GDP to derive the exports-adjusted GDP (AGDP) series. This allows us to isolate the effect of exports on the rest of the economy. The AGDP measure allows us to test the export-led growth hypothesis and examine the relationship between exports and AGDP. The data are expressed in constant 1990 prices.

Panel Unit Root Tests

We use a panel unit root test proposed by Levin *et al.* (2002), denoted LLC, which allows for heterogeneity of the intercepts across members of the panel. We also use the test proposed by Im *et al.* (2003), denoted IPS, which allows for heterogeneity in the intercepts and the slope coefficients. Both tests are constructed by averaging individual augmented Dickey-Fuller (ADF) t-statistics across cross-section units (Dickey and Fuller, 1979).

The LLC test is for the null hypothesis that each individual time series in the panel is integrated, where the alternative hypothesis is that all individual time series are stationary. The test is based on the pooled ADF equation

$$\Delta y_{it} = X'_{it}\alpha + \delta y_{it-1} + \sum_{L=1}^{p_i} \beta_{ij} \Delta y_{it-L} + \varepsilon_{it} \quad (1)$$

where a common $\delta = \rho - 1$ is assumed, X_{it} represents the exogenous variables in the models, including any fixed effects or individual trends, and ρ_i is the required country specific degree of lag augmentation to make the residuals white noise as determined by the conventional step-

down procedure. The null hypothesis is $\delta = 0$ under the assumption that $\delta_i = \delta$ for all i is tested against the alternative hypothesis that $\delta < \delta_i$ for all i. The test is based on a technique that removes autocorrelation as well as deterministic components.

The panel specification for the IPS test is

$$\Delta y_{it} = X_{it}^{'}\alpha + \delta y_{it-1} + \sum_{L=1}^{p_i} \beta_{ij} \Delta y_{it-L} + \varepsilon_{it} \tag{2}$$

where all variables are defined as in (1). However, in this case X_{it} also includes time dummy variables to account for cross-sectional correlation that could result from common shocks affecting all countries in the panel. The null hypothesis is $\delta = 0$ for all i (i.e., all series have a unit root) and is tested against the alternative that $\delta_i < 0$ for $i = 1, 2, \ldots, N_1$ and $\delta_i = 0$, for $i = N_1 + 1, N_2 + 2 \ldots N$. On the assumption that the N cross-section units are independently distributed, the t-statistic can be computed as an average of the individual ADF t-statistics,

$$\bar{t}_{NT}(p_i) = \frac{\sum_{i=1}^{N} t_{iTi}(p_i)}{N}, \tag{3}$$

where $t_{iTi}(p_i)$ is the t-statistic for testing that $\delta_i = 0$ in each individual ADF regression. In a further step, the t-bar statistic is standardized so that it converges to a standard normal distribution as N increases. A key strength of the IPS test is that δ_i is allowed to differ across countries and only a fraction of panel members is required to be stationary under the alternative hypothesis.

PANEL CO-INTEGRATION TESTS

The second step is to analyze the panel data properties for existence of co-integration among the GDP and exports series. The available techniques for panel co-integration tests are in essence an application of the Engel and Granger (1987) co-integration analysis. As in the analysis of single time series, these approaches test the estimated residuals for stationarity. We use the panel data methods of Kao (1999) and Pedroni (1995), which provide different statistics for this purpose, yet both assume homogenous slope coefficients across countries. Kao tests the residuals $\hat{e}_{it}$ of the OLS panel estimation by applying DF- and ADF-type tests where the residuals are written as in (4) and (5), respectively.

$$\hat{e}_{it} = \hat{e}_{it}\rho_{it-1} + \upsilon_{it} \tag{4}$$

and

$$\hat{e}_{it} = \hat{e}_{it}\rho_{it-1} + \sum_{j=1}^{p} \phi_j \Delta \hat{e}_{it-j} + \upsilon_{it}. \tag{5}$$

The hypothesis of no co-integration, $\rho = 1$, is tested against the alternative hypothesis that the residuals are stationary, $\rho < 1$. The OLS estimate of ρ can be written as in (6),

$$\hat{\rho} = \frac{\sum_{i=1}^{N}\sum_{t=2}^{T} \hat{e}_{it}\,\hat{e}_{it-1}}{\sum_{i=1}^{N}\sum_{t=2}^{T} \hat{e}_{it}^{2}} . \tag{6}$$

To minimize the space devoted to the technical aspects of the different panel co-integration methodologies, we show only the Kao methodology. Although we do not discuss other methodologies, we use the results from the Pedroni residual panel co-integration and the Johansen-Fisher panel co-integration tests to check for consistency of the results.

Estimation of the VAR Model

To investigate the long-run co-integration relationship we apply the VAR model, since it is assumed that exports and AGDP exhibit a two-way causal relationship. In its simplest form (without lagged terms) the panel VAR is estimated as in (7) and (8)

$$\mathrm{AGDP}_{\mathrm{it}} = \eta_{\mathrm{it}} + \delta D_{it} + \beta X_{it} + \varepsilon_{it}, i = 1,...N, t = 1,..., T \tag{7}$$

$$\mathrm{X}_{\mathrm{it}} = \eta_{\mathrm{it}} + \delta D_{it} + \beta AGDP_{it} + \varepsilon_{it}, i = 1,...N, t = 1,..., T \tag{8}$$

where η_{it} is the intercept, D is a vector of country specific dummies to capture fixed effects, X_{it} represents exports, and AGDP is exports-adjusted GDP. To simplify notation we write the short-run co-integration VAR as

$$\Delta Y_{\mathrm{t}} = \alpha_1 + \sum_{i=1}^{m} \beta_{1i} \Delta Y_{t-i} + \sum_{i=1}^{n} \lambda_{1i} \Delta X_{t-1} + \sum_{i=1}^{r} \delta_{1i} ECT_{t-1} + e_t \tag{9}$$

$$\Delta X_{\mathrm{t}} = \alpha_2 + \sum_{i=1}^{m} \beta_{2i} \Delta X_{t-i} + \sum_{i=1}^{n} \lambda_{2i} \Delta Y_{t-1} + \sum_{i=1}^{r} \delta_{2i} ECT_{t-1} + e_t \tag{10}$$

where ΔY is the change in AGDP, ΔX is the change in exports, and ECT is the error correction term.

Panel Corrected Standard Error Model

We examine the relationship between terms of trade volatility (TOTV) and output (GDP) for the five EAC countries by estimating the panel corrected standard errors equation

$$\mathrm{GDP}_{\mathrm{it}} = \alpha_{\mathrm{it}} + \delta t_{it} + \beta TOTV_{it} + \varepsilon_{it}, i = 1,...5, t = 1,...,T \quad (11)$$

where t is the unit step time trend. The hypothesized sign on the β coefficient is negative. Terms of trade volatility is estimated using the simple GARCH(1,1) model (Bollerslev, 1986; Engle and Ng, 1991; Bollerslev, Chou and Kroner, 1992; Andersen and Bollerslev, 1998). The GARCH specification allows for the conditional variance to be dependent on past information, which is expected to induce variability over time.

RESULTS

Tests for the existence of unit roots in AGDP and exports cannot be rejected and these series are nonstationary in level form (Table 1). However, first differencing of the series shows that the null hypothesis is rejected for both variables. Similar results are obtained for the ADF-Fisher Chi-square statistic; the ADF-Choi Z-statistic, the Phillips Peron-Fisher Chi-square statistic, and the Phillips Peron-Choi Z-statistic. These additional test results are available upon request. Panel diagnostic results indicate that the terms of trade volatility variable (lnTOTV) is integrated of order one. These results are found to be consistent across all panel methods.

Table 1. Panel Unit Root Tests

	Levin *et al.* (LLC) test		Im *et al.* (IPS) test	
Variable	Levels	First Difference	Levels	First Difference
lnAGDP	1.342	-5.812	2.623	-3.265
	(0.910)a/	(0.000)	(0.996)	(0.001)
lnExports	0.669	-10.013	1.096	-12.075
	(0.748)	(0.000)	(0.864)	(0.000)
lnTOTV	1.926	-10.386	3.603	-10.578
	(0.973)	(0.000)	(0.999)	(0.000)
lnGDP	2.448	-4.988	4.059	-4.351
	(0.993)	(0.000)	(0.999)	(0.000)

a/ p-values are in parenthesis.

The methods of Kao (1999) and Pedroni (1995) are used to test for co-integration of AGDP and exports. Results in Table 2 indicate that the null hypothesis of no co-integration between AGDP and exports is rejected at the 1% level using the Pedroni method and at the 5% level using the Kao method. Similar results are obtained using the combined Johansen-Fisher panel co-integration test and are available upon request. The results reported in Table 3 indicate that there is co-integration between lnGDP and lnTOTV using the Kao residual co-integration test and the Johansen-Fisher panel co-integration test. The null hypothesis of no co-integration between lnGDP and lnTOTV is rejected.

Impact of Exports on Adjusted GDP

The estimated panel long-run VAR model indicates that exports have a positive effect on AGDP (Table 4). Using the coefficient on the lagged exports variable ($\ln X_{(t-1)}$), the estimated export elasticity of adjusted GDP indicates that a 1% increase in exports leads to a 0.078% increase in AGDP for the panel. Our main interest is the effect of exports on adjusted GDP and, while the data are not disaggregated into agricultural and nonagricultural exports, the bulk of exports in all five EAC countries are agricultural. These results are consistent with those obtained by Sanjuan-Lopez and Dawson (2010) for developing countries. They show that the agricultural export elasticities of GDP for developing countries range between 0.073 - 0.091%. The country dummies in Table 4 simply capture the fixed effects.

Table 2. Panel Tests for Cointegration of lnExports and lnAGDP (N = 195)

Pedroni Residual Panel Cointegration Test:		
Bartlett kernel		
	t-Statistic	p-value
Panel v-Statistic	5.697	0.000
Panel rho-Statistic	-3.015	0.001
Panel PP-Statistic	-3.403	0.000
Panel ADF-Statistic	-0.078	0.469
Quadratic spectral kernel		
	t-Statistic	p-value
Panel v-Statistic	5.510	0.000
Panel rho-Statistic	-3.365	0.000
Panel PP-Statistic	-3.577	0.000
Panel ADF-Statistic	-0.078	0.469
Kao Residual Panel Cointegration Test:		
Bartlett kernel		
	t-Statistic	p-value
ADF	-1.842	0.033
Quadratic Spectral kernel		
	t-Statistic	p-value
ADF	-1.974	0.024

Table 3. Panel Tests for Co-integration of lnTOTV and lnGDP (N = 195)

Kao Residual Panel Cointegration Test Results: Bartlett kernel

	t-Statistic	p-value
ADF	1.609	0.054

Johansen-Fisher Panel Cointegration Test:

No. of CE(s)	Trace Stat.	p-value	Max-Eigen Stat.	p-value
None	22.820	0.011	21.740	0.017
At most 1	9.139	0.519	9.139	0.519

Exports have a positive influence on AGDP in the long run model and the effect is bidirectional, so that AGDP has also a positive effect on exports. This confirms the export-led growth hypothesis. It is worth noting that the hypothesis is supported even though the bulk of the exports from the EAC bloc countries are primary products, which contain little or no added value through further processing.

Table 4. Long Run Panel VAR Results for lnExports and lnAGDP

Variable	lnAGDP	lnExports
Constant	2.845 (3.935) a/	-3.206 (-1.397)
lnAGDP(t-1)	0.903 (11.9334)	0.530 (2.206)
lnAGDP(t-2)	-0.100 (-1.340)	-0.112 (-0.472)
lnX(t-1)	0.078 (3.314)	0.582 (7.845)
lnX(t-2)	-0.015 (-0.656)	0.127 (1.709)
DUga	0.208 (3.579)	-0.275 (-1.492)
DKen	0.227 (2.996)	-0.075 (0.309)
DTan	0.148 (3.629)	-0.363 (-2.809)
DRwa	0.212 (3.414)	-0.205 (-1.039)
DBur	-0.054 (-1.995)	-0.159 (-1.841)
Trend	0.005 (3.915)	2.01E-05 (0.005)
Adj. R-squared	0.993	0.968
S.E. equation	0.072	0.228
F-statistic	2662.9	563.4
Log likelihood	230.4	16.7
N	185	185

a/ t-statistics are in parenthesis.

Country-level VAR models are reported in Table 5. Only part of the country VAR is shown where the AGDP is the dependent variable. The results are consistent with those of the panel method. Results for all five EAC countries show that exports have a positive and significant effect on AGDP. The coefficient of interest is the first order lag of lnExports. We assume the effect of exports on current AGDP in any given year, t, is stronger in the previous year (t-1) than two years previous (t-2). In the model for Kenya the coefficient on lnExports(t-2) is negative and significant, but our interest is in the effect of lnExports(t-1). These results provide a test for consistency with the results obtained from the panel analysis. They show that economic growth occurs, even if it is primary commodity-led as in the East Africa Community trade bloc. The panel short-run error correction VAR model indicates that the primary commodity export growth elasticity of AGDP growth is positive and significant (Table 6). In effect a 1% increase in export growth yields a 0.044% increase in AGDP growth across the five EAC countries. We are interested in the effect of exports on AGDP both in the long- and short-run since all the variables are integrated of order one. Granger causality tests are run to test for the existence of bidirectional causality between AGDP and exports. The null hypothesis of no Granger causal relationship between exports and AGDP in both directions is rejected at the 5% and the 1% levels of significance. Overall, the results for Granger causality tests indicate that a two-way relationship exists between exports and AGDP in both the long-run and short-run. We find that exports Granger-cause AGDP and vice versa.

Table 5. Country-Specific Results for Long Run Impact of Exports on AGDP (Dependent Variable = lnAGDP)

	Uganda	Kenya	Tanzania	Rwanda	Burundi
lnAGDP(-1)	0.714	1.253	0.929	0.533	0.847
	(10.009)	(6.453)	(12.244)	(3.018)	(11.457)
lnAGDP(-2)	-	-0.380	-	-	-
	-	(-2.049)	-	-	-
lnExports(-1)	0.099	0.145	0.033	0.181	0.079
	(4.356)	(1.886)	(4.046)	(1.781)	(1.732)
lnExports(-2)	-	-0.169	-	-	-
	-	(-2.158)	-	-	-
Constant	4.198	3.336	0.926	6.535	1.677
	(3.330)	(1.224)	(0.583)	(2.360)	(1.245)
Trend	0.010	0.005	0.002	0.008	0.002
	(4.043)	(1.055)	(0.599)	(2.360)	(1.109)
Adj. R-Sq.	0.988	0.993	0.997	0.857	0.948
S. E.	0.055	0.032	0.021	0.128	0.053
F-stat	1004.5	1032.9	4332.4	74.7	226.4
Log-likelihood	58.3	78.0	95.0	26.3	59.6
N	38	37	38	38	38

a/ t-statistics are in parentheses.

Table 6. Short Run Panel VAR Results for lnExports and lnAGDP

Error Correction Model	D(lnAGDP)	D(lnExports)
CointEq1	-0.056 (-2.000) a/	0.416 (4.957)
Constant	0.013 (0.526)	0.236 (3.246)
D(lnAGDP(t-1))	0.034 (0.450)	0.162 (0.705)
D(lnAGDP(t-2))	-0.074 (-0.978)	0.273 (1.204)
D(lnExports(t-1))	0.044 (1.772)	-0.189 (2.531)
D(lnExports(t-2))	0.035 (1.466)	-0.162 (-2.266)
DUga	0.039 (1.301)	-0.290 (-3.256)
DKen	0.010 (0.430)	-0.107 (-1.502)
DTan	0.041 (1.223)	-0.344 (-3.426)
DRwa	0.029 (1.029)	-0.222 (-2.658)
DBur	-0.020 (-0.771)	-0.138 (-1.748)
Adj. R-sq.	0.042	0.218
S.E.	0.074	0.224
F-stat.	1.782	5.981
Log likelihood	217.9	19.6
N	180	180

a/ t-statistics in parenthesis.

Impact of Terms of Trade Volatility on Overall GDP

Long run and short run effects from terms of trade volatility on overall GDP are estimated using panel corrected standard error (EGLS) models with fixed effects. We use the GARCH method to estimate the commodity terms of trade volatility. The predicted squared residuals from the two-stage regression model of the terms of trade variable are taken as the conditional variance or volatility.

We find that the terms of trade volatility variable has a negative and significant long run effect on overall GDP (Table 7). A 1% long run increase in terms of trade volatility decreases overall GDP by 0.265%. These results are consistent in both the fixed effects and random effects model specifications. This negative effect on GDP has the potential to reverse the positive growth effects on GDP brought about by export expansion. Results in the short run model show that a 1% increase in terms of trade volatility decreases overall GDP growth by 0.048% (Table 8). Also, terms of trade volatility has a negative and significant effect on exports (results are available upon request).

These results are consistent with those obtained by Cavalcanti *et al.* (2012). They show that the negative effect of commodity terms of trade volatility on GDP per capita growth is more pronounced in countries where there is heavy reliance on primary commodity exports rather than manufactured goods and services. They attribute this effect to the diversified nature of exports from the latter group of countries. That is, countries with a diversified basket of exports, especially manufacturing and/or service-sector goods, are expected to grow faster and be better insured against price volatility. These results are also consistent with Hausmann et al. (2007) who show that countries that export goods from relatively high productivity activities, especially manufacturing, are less vulnerable to the negative effects from terms of trade volatility.

Attracting foreign direct investment (FDI) into the EAC region indirectly mitigates the negative effect of terms of trade volatility. In Table 7 the introduction of FDI inflows into the model reduces the long-run negative effect of terms of trade on overall GDP from 0.265% to 0.223%.

Table 7. Long Run Effect of Terms of Trade Volatility on GDP with Panel EGLS-Fixed Effects (Dependent Variable = lnGDP)

Variable	Without FDI	With FDI
Constant	21.173	21.318
	(364.336) a/	(385.150)
lnTOTVt	-0.265	-0.223
	(-16.649)	(-14.053)
lnFDIt-1	-	0.021
		(5.236)
Adj.R-sq.	0.963	0.973
S. E.	0.188	0.158
F-stat.	573.3	617.9
Prob(F-stat.)	0.000	0.000
N	112	103

a/ t-statistics in parenthesis.

Table 8. Short Run Effect of Terms of Trade Volatility on GDP with Panel EGLS-Fixed Effects (Dependent Variable = DlnGDP)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	0.024	0.003	6.984	0.000
DlnTOTV	-0.048	0.013	-3.682	0.000
ECT(t-1) a/	0.202	0.082	2.457	0.016
ECT(t-2)	-0.213	0.082	-2.603	0.010
Adjusted R-sq.	0.276			
S. E.	0.079			
F-stat.	6.490			
Prob(F-stat.)	0.000			
N	102			

a/ ECT = the error correction term.

Table 9. Long Run Effect of Terms of Trade Volatility on Overall GDP (Dependent Variable = lnGDP)

Variable	Uganda	Kenya	Tanzania	Rwanda	Burundi
lnTOTV	-0.104	-0.126	-0.194	-0.191	-0.026
	(-3.010) a/	(-2.720)	(-3.170)	(-1.290)	(-1.240)
Constant	0.0955	22.658	21.890	21.092	20.579
	(6.920)	(26.140)	(35.940)	(43.470)	(114.380)
Adj. R-Sq.	0.994	0.997	0.999	0.992	0.999
S. E.	0.056	0.033	0.028	0.161	0.047
F-stat.	420.05	595.79	1525.30	2.73E+04	1.44E+04
D-W stat.	0.312	0.726	0.764	1.771	1.176
N	20	26	17	27	22

a/ t-values in parentheses.

We obtain similar results in the short-run model specification (available upon request). Here we interpret the mitigating effects of FDI on the impact of terms of trade on overall GDP as due partly to the fact that FDI inflows play a key role in the production of value added export commodities which are less prone to high terms of trade volatility. These FDI inflows into the EAC are in the form of transfer of new technologies, managerial skills, stimulation in the establishment of micro, small and medium enterprises and employment opportunities

For example, in Uganda the manufacturing, construction, electricity, gas and water, transport, communication and storage sectors constituted 65% of FDI inflows during 2006-2009. In Tanzania, the manufacturing, transportation, construction, and agriculture sectors received 62% of total FDI inflows in the same period (Ministry of the East African Community, 2011).

Country-level analysis is performed to evaluate the country-specific effects of terms of trade volatility on overall GDP. The Prais-Winsten AR(1) model results are reported in Table 9. Country-level results are consistent with the panel data analysis. While all effects are

negative, these effects are statistically more significant among the three larger economies of Uganda, Kenya and Tanzania, than for Rwanda and Burundi. A plausible explanation for this difference is the effect of omitted variables since we regress lnGDP on lnTOTVol only without a time trend variable.

We test for existence of long run bidirectional causality between the overall GDP and terms of trade volatility for the EAC panel. The Granger causality tests indicate that the null hypothesis (overall GDP does not Granger-cause terms of trade volatility) cannot be rejected. However, the converse (terms of trade volatility does not Granger-cause overall GDP) is rejected at the 10% level of significance. Similar results are obtained in the short run analysis. Both sets of test results show that a one-way causal relationship exists from the direction of terms of trade volatility to overall GDP.

CONCLUSION

Results from this study reinforce the view that the EAC stands to benefit from increased export growth within and outside the trade bloc. An increase in exports, whether comprised of primary products or not, leads to an increase in output. Thus, one of the key determinants of economic growth in the region is the expansion of exports. Yet, developing countries that predominantly rely on primary commodity exports to spur economic growth face the challenge that terms of trade volatility has negative effects on that growth. In the five EAC states primary commodities form a large fraction of total exports. These commodities have little or no value-added and are prone to high terms of trade volatility, which has a significant negative impact on both GDP and export revenue. A high level of terms of trade volatility has the potential of reversing the gains from export-led growth.

The EAC countries would benefit from putting more emphasis on capital investments that lead to an increasing share of value-added exports to boost economic growth, especially manufactured products based on agro-processing industries.

This implies a need to expand the export base by increasing the share of manufactured commodities for export. Diversification away from primary commodities toward other value-added exports would tend also to lower the vulnerability of the EAC economies to commodity terms of trade volatility and increase economic growth in the region. Given that these countries lack technology and skills to transition from primary commodity exports to manufactured goods, there is need for attracting more foreign direct investment to speed up the transformation process.

We conclude that infusion of foreign direct investment into the region will indirectly reduce the negative effect of terms of trade volatility due to an increase in the share of value added export commodities, which are less prone to commodity price volatility.

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THE RESPONSE TO CLIMATE VARIABILITY AMONG FARM FAMILIES IN NORTHERN GHANA

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ABSTRACT

This study examines the effect of human capital on the adoption of coping mechanisms to extreme climatic conditions (drought, flood, and bushfires) by farm households in the Bawku West district of Ghana. Results indicate that literacy level, membership in a farm organization, and access to credit had positive and significant impacts on adaptation to drought. Similarly, source of seeds for planting, and household income had positive significant influence on adaptation to flood. Adaption to bushfire was positively influenced by radio ownership, and farm size. The main effect of the climatic extreme events on households were found to be destruction of crops, livestock and buildings; food and water shortage; poor yield or harvest and limited fields for livestock grazing.

Keywords: climatic conditions, coping mechanisms, drought, flood

JEL Classification Codes: Q54, Q56, O13.

INTRODUCTION

This paper explores climate change vulnerabilities and coping strategies employed by farming communities in Northern Ghana to alleviate the negative impact of potential extreme events as drought, flood and bushfires. The general goal of the study is to clearly understand the level of vulnerability of households in the Bawku West of Ghana to climate change, and how they cope with climate variability. The specific objectives are to analyse the determinants of coping mechanisms used by households in responses to climate change and climate variability, and identify the effect of climate risk encountered by farming households.

The impact of climate change vulnerability varies globally. However, the adverse effect of climate change is particularly devastating in developing regions, especially sub-Saharan

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Africa (Kandji et al., 2006) as a result of rapidly declining precipitation levels, increasing temperatures, low adaptive capacity, high dependence on natural resources, inability to detect the occurrence of extreme hydrological and meteorological events due to low technology adoption (Kurukulasuriya et al., 2006), limited infrastructure, illiteracy, lack of skills, low management capabilities, weak institutions and information (UNFCCC, 2007), and the absence of comprehensive national adaptation policy among others. According to the IPCC (2007), vulnerability is defined as "the degree to which an environmental or social system is susceptible to or unable to cope with, adverse effects of climate change, including climate variability and extremes" (McCarthy et al., 2001). The scope of vulnerability of Africa to climate change is disquieting, with one third of African people already living in drought–prone areas. Overexploitation of land resources including forests, increases in population, desertification, and land degradation were identified as additional constraints for African countries to cope with climate variability (UNDP, 2006).

Temperatures are expected to rise fastest in Africa and a decline in rainfall volume is also anticipated. According to the IPCC (2007), sub-Saharan Africa is likely to experience increases in both minimum (1.8^{o}C) and maximum (4.7^{o}C) temperatures. Minimum and maximum precipitation levels are also likely to change by -9% and 13% respectively (Christensen et al., 2007). These factors, coupled with the volatile nature of the socio-political economy/environment of the continent, places it at a higher risk level. Many African countries already battle with poverty, low agricultural productivity, and other environmental-related issues without climate change. An added impact of climate change is critical to the economic development of the region. The region is lagging in the development of public infrastructure, and in strengthening the capacity of existing institutions to mitigate climate change.

The impact of climate change on agricultural productivity in low-income countries is relatively severe compared to other sectors of their economy and the magnitude of this impact is expected to either remain same or intensify (Pearce et al., 1996; McCarthy et al., 2001; Tol, 2002). The widespread debate and increasing global concern on climate related issues, especially in Africa, is partly drawn from this assertion. There has therefore been a mounting fear as to how agriculture-dependent sub-Saharan economies cope with climate extremes and climate variability. To this end, the unanswered question on climate change related issues about Africa is: ''will African agriculture survive climate change?''(Kurukulasuriya et al., 2006). Though there have been mixed predictions on the impact of climate change on African agriculture, it is established that African countries cannot veer off the impact of climate change and climate variability on the economic well-being of their growing population and expanding food demand. A general consensus points to declining net revenues with warming and decreasing precipitation levels for dry land crops and livestock production in the region (Kurukulasuriya and Mendelsohn, 2006). Cereal yields in tropical regions are projected to decline markedly due to climate change vis-à-vis comparable temperate regions. Domestic per capita food production in sub-Saharan Africa declined by 10% between 1985 and 2005. Hence the current food production in the region is not meeting the needs of the rising African populace (UN Millennium Project, 2005). The Ghanaian economy is also forecasted to suffer severe economic consequences from climate change: Ghana's economy essentially depends on climate-sensitive sectors such as agriculture, forestry, and hydroelectric energy. Northern Ghana is considered to be particularly vulnerable to climate change, primarily drought and flood because of the relatively low precipitation levels, higher temperatures, subsistence

based farming, higher poverty level, poor infrastructure, high illiteracy rate and limited access to information compared to the other regions of Ghana.

The poverty level ranges between 70 and 90%, the highest in Northern Ghana (GSS, 2004) and temperature levels also likely to increase the most in the Northern, Upper East and Upper West regions of Ghana, by 2.1 to 2.4 ^{o}C by 2050 (World Bank, 2010). Though precipitation forecast for the entire country shows a cyclical pattern over the next half century, Northern Ghana is predicted to be relatively drier (World Bank, 2010). Estimates from the climate baseline trends for Ghana in the fourth assessment report of IPCC reveals an alarming impact of climate change in altering the climatic pattern in Ghana. The average number of hot days and hot nights increased by 48 and 73 days per year, respectively, between 1960 and 2003. The average number of cold days and night decreased by 3.3% and 5.1% of days respectively in the same period. This trend indicates the gradual alteration of Ghana's weather pattern as a result of the changing climate in the country (McSweeney et al., 2012).

The current contribution of agriculture to Ghana's total GDP is projected to decline between 3 to 8 percent by 2050. A major contributory factor to this decline has been closely linked to unfavorable projected climatic conditions that are likely to have adverse effect on agricultural productivity, predominantly in the north of Ghana. The main diet in most Ghanaian homes constitutes mostly cereals – millet, sorghum, maize, and rice – 70% of which are produced in the north of Ghana (World Bank, 2010). A decrease in production and/or yield of these commodities as a result of climate change would worsen the already alarming threat of food security, particularly in the Northern sector and severely affect the economic development of the region. Decades of data show a decrease in yield and production whenever the northern part of Ghana, particularly, experiences any adverse agro-climatic change such as flood and drought. The ripple effect has always been food shortage, higher prices for agricultural commodities and other products produced from agricultural raw materials, not only in the northern regions, but the country as a whole. Though the focus of this paper concentrates on the relationship between climate change and agriculture, other sectors of the economy, directly or indirectly related to agriculture are also impacted such as the health, service and industry sectors that thrive on agriculture.

The survey for this study (table 1) was conducted near the end of 2008, almost a year after several towns and villages in the north of Ghana were severely hit by the worst flood ever since the 1980's. Although the impact of this flood was most deleterious in Northern Ghana, virtually every single country in West Africa including Sudan and Chad was hard hit. This flood event was ranked by the Dartmouth Flood Observatory (DFO) as one of the three most devastating flood events in the world that year (Tschakert et al., 2009). The 2007 flood season (July to September) was preceded by a long period of drought (January to May). Such extreme wet periods and accompanying flooding are anticipated to increase by 20% in the next decades in West Africa (Christiansen et al., 2007).

This paper examines both reactive and proactive measures that farm households use in response to climate. Proactive in the sense that the yearly weather pattern of Northern Ghana always has a period of drought which is usually considered a "normal" condition though the severity and length of the drought period differs yearly. It is assumed that households in this area already have adopted some measures to adapt to such recurring events. Reactive measures are used to cope with climatic extreme events that are atypical to the region such as flood. A good understanding of the aftermath effect of climate change on the livelihood of

farming households, possible coping measures employed, and factors influencing the choice of a specific coping strategy to climate change will enhance policies towards tackling the challenges that climate change poses to farming communities.

Table 1. Distribution of Sampled Villages

Area Council	Villages Interviewed	No. Villages	No. Households Interviewed
Binaba-Kusanaba	Binaba-Natinga		16
	Kusanaba	24	16
Zebilla	Yarigu		16
	Ankpaliga		16
	Zebilla-Natinga	51	16
Sapelliga	Komaka		16
	Kare-Natinga		16
	Sapelliga-Zongo	28	16
Gbantongo	Gbantongo		16
	Kamega Central	17	16
Tanga-Timonde	Tanga Natinga		16
	Tanga-Gbandame	12	16
Tilli-Widnaba Zongoyire	Widnaba-Natinga	8	16
	Zongoyire-Natinga	19	16
	Bulinga		16
Total		152	240

Source: Author's compilation from household survey, 2008.

Review of Literature

Climate change is predicted to have undesirable consequence on agricultural production and food security in sub-Saharan Africa (Boko et al., 2007). This impact, however, is expected to vary spatially across and within countries in the region (and across socio-economic groups). Areas with high climate-sensitive agricultural production systems due to their over reliance on rain-fed subsistence agriculture have been identified as the most vulnerable to climate change. In Ghana, agriculture continues to provide employment and livelihood for a large proportion of the labor force, despite its declining contribution to total GDP. Agricultural production is predominantly subsistence or small scale and productivity is already low though farmers are understood to be efficient but poor (Schultz, 1964). Increases in productivity are realized primarily through addition of new lands to cultivation. Fewer advances in technology, combined with changing climate, make the agricultural sector highly vulnerable.

Climate change is expected to impact agricultural productivity in Sub- Saharan Africa, especially cereal production. Sagoe (2006) indicated an impact on root and tuber production by climate change in Ghana. The CROPSIM-cassava and CROPGRO (ARGRO980)-tanier models were used to generate growth and yield in cassava and cocoyam, respectively, in years 2020, 2060 and 2090 given expected changes in climate. A decline in cassava productivity is expected in 2020, 2050 and 2080 by 3%, 13.5%, and 53%, respectively. Cocoyam

productivity will decline by 11.8%, 29.6%, and 68% by the 2020s, 2050s and 2080s respectively (Sagoe, 2006). The Crop Environment Resource Synthesis (CERES) model has also been used to assess the impact of climate change on cereal production in Ghana. In a report by the Netherlands Climate Assistance Programme on women's livelihoods and vulnerability to climate change in Ghana, yield changes in maize and millet were estimated using the CERES model. Maize yield in the Transition zone is anticipated to decrease by 6.9 percent in the year 2020, however no change in millet yield is expected because millet is more drought tolerant and, therefore, insensitive to temperature rise.

Antwi-Agyei et al. (2011) provided a comprehensive map of vulnerability in crop production to climate change, particularly drought, for all the regions in Ghana and some selected districts across the country. This section draws heavily from their analysis. They used a three-stage method (crop yield sensitivity index, exposure index and crop drought vulnerability index) to determine the vulnerability of crop production (specifically maize at the regional level, and sorghum and millet at the district level) to drought. The crop (or maize) yield sensitivity indices for all the ten regions showed the Upper East and Upper West regions as the most sensitive regions to drought. In terms of adaptive capacity to drought, the three regions in the northern sector: the Northern region, Upper West and Upper East, were identified to have the lowest capacity to cope with drought. These regions invariably were noted as the most vulnerable to drought in Ghana. Their results are in agreement with several studies, which designate the northern sector of Ghana as the most vulnerable region of Ghana.

EMPIRICAL MODEL

A binary logit model (BLM) was used to identify and quantify the determinants of coping mechanisms used by households in responses to climate change and climate variability. The standard form of the logit model is given as (Greene, 2003):

$$Pr(y_i = 1) = exp(x_i'\beta)/1 + exp(x_i'\beta) \quad (1)$$

where x_i' is a vector of explanatory variables that influence the choice of a given coping strategy, and β is the vector of parameters to be estimated. The variable y_i is a random variable, and represents the adoption of a given measure by a household if y_i = 1. Each household is faced with the decision to adopt or not adopt a given coping measure. The dependent variables were all collected in the survey as binomial (0-1) variables. The choice of each measure is assumed to depend on a number of socioeconomic characteristics (age, gender, marital status, household size, literacy level of household head, farm income), asset characteristics (radio ownership, mobile phone ownership, size of farmland), resource availability (access to electricity, access to formal/informal credit, farmer-to-farmer extension), and other factors (source of seed for planting, area or locality, effect of climatic events on households). The empirical model is specified as:

$$Y_i = \beta_0 + HHCHAR_i'\beta_1 + ASSET_i'\beta_2 + RESOURCE_i'\beta_3 + OTHER_i'\beta_4 + \varepsilon_T \; \forall i = 1,15 \quad (2)$$

where $Y_i =$ coping measure i,; $HHCHAR$ = household characteristics; $ASSET$ = asset characteristics; $RESOURCE$ = resource availability; $OTHER$ = other factors; ε_T = random

error term, and the β_s' are parameter estimates. The study identified 15 coping measures (dependent variables) used by households in the study area in responses to three major climate extreme events – drought, flood and bushfires (table 2).

Table 2. Household Coping Mechanism under Extreme Climatic Conditions

Extreme Event	Percent Affected		Coping Strategy	Households (%)
Drought	2007	2008	Early planting	17.4
	37.9	39	Plant drought resistant or early yielding crops	10.8
			Did nothing	49.7
			Plant more trees and cover crops	12.8
			Irrigation practices	6.1
			Food storage	3.0
			Early planting	2.0
Flood	44.6	48.7	Stop farming or building in low areas, waterways	21.0
			Construction of or improve drainage system	9.2
			Did nothing	52.3
			NGO or government aid	6.7
			Modern building technique	8.7
Bushfires	14.4	15.4	Improve farm management practices	61.0
			Fire prevention education	28.7
			Did nothing	10.3

Source: Author's compilation from household survey, 2008.
Note: N = 195.

The method of maximum likelihood is used to estimate the parameters of the binary logit model. Assuming the observed dependent variable, y, follows a Bernoulli distribution with N independent observations, then the likelihood function for household *i* is given by:

$$L = \prod_{i=1}^{N} \mathrm{F}(X_i'\beta)^{y_i} \, (1 - \mathrm{F}(X_i'\beta))^{\,1-y_i} \tag{3}$$

where $F(X_i'\beta)$ is a logistic distribution function. Taking the natural log of the likelihood function yields the log likelihood function and depicted as:

$$In\ L = \sum_{n=1}^{N} [y_i \mathrm{InF}(X_i'\beta)(1 - y_i)\mathrm{In}(1 - \mathrm{F}(X_i'\beta))] \tag{4}$$

Table 3. Description and Measurement of Explanatory Variables Used in Regression Model

Household Characteristics		
Age 19-39	1 if household head age is 19-39 years; 0 otherwise	+/-
Age 40.69	1 if household head age is 40-69 years; 0 otherwise	+/-
Age 70+	1 if household head age is 70 years or more; 0 otherwise	+/-
Gender	1 if the household head is a male and 0 if female	+/-
Household size	Number of family members living together	+/-
Literacy level	1 if head of household is literate; 0 otherwise	+
Farm income	Measured in Ghana Cedi (GH¢)	+
Asset Characteristics		
Radio ownership	1 if household have ownership of radio; 0 otherwise	+
Mobile phone ownership	1 if household have ownership of mobile phone; 0 otherwise	+
Size of farmland	Acres of farmland	+/-
Resource Availability		
Access to electricity	1 if a household head has *access to electricity;* 0 otherwise	+
Access to credit	1 if a household head has *access to credit;* 0 otherwise	+
Farmer-to-farmer extension	1 if household head is member of an FBO; 0 otherwise	+
Other Factors		
Area council BZ	1 if located in Binaba-Kusanaba and Zebilla; 0 otherwise	+/-
Area council SG	1 if located in Sapelliga and Gbantongo; 0 otherwise	+/-
Area council TT	1 if located in Tanga-Timonde and Tilli-Widnaba; 0 otherwise	+/-
Area council Z	1 if located in Zongoyire area council; 0 otherwise	+/-
Effect	1 if had effect from drought, flood or bushfires; 0 otherwise	+
Source of seed	1 if household head use own seed: 0 otherwise	+/-

Marginal effects are calculated for each estimated coefficient. The Wald test statistic, the Score (or Lagrange Multiplier) test statistic and the likelihood ratio (LR) test statistic are used to validate the models (Wooldridge, 2002).

Household size was measured by the number of family members living together (table 4). Some studies show that households with large family size are more likely to adopt and use more labor-intensive adaptive or coping measures because they have a large labor pool (Croppenstedt et al., 2003; Deressa et al., 2005; Dolisca et al., 2006; Nyangena, 2007; Anley, et al. 2007; Birungi, 2007). The other possibility is that households with a large family may be forced to divert part of the labor force to off-farm activities to generate more income and

decrease the demands on food consumption (Mano and Nhemachena, 2006; Tizale, 2007; Yirga, 2007). The impact of household size on the choice of a coping strategy is ambiguous.

Table 4. Selected Household Demographics

Age	*19 to 39 years*	30.3	
Age	*40 to 69 years*	53.3	
Age	*70 years >*	15.9	
Gender *male*		86.7	
Material for wall	*Mud/mud bricks*	90.2	
Material for wall	*Cement/sandcrete*	8.8	
Material for roof	*Mud*	4.1	
Material for roof	*Thatch*	58	
Material for roof	*Wood*	2.6	
Material for roof	*Metal sheet*	33.7	
Household size			5.86
Income			$2844 (2008USD)
Land size			7.76 acres
Literate		25.6	
Livestock ownership		88.7	
Access to formal/informal credit		38.0	
Access to extension		23.6	
Access to electricity		12.8	

Source: Author's compilation from the household survey, 2008. Note: N = 195.

Gender of household head takes the value of 1 if the household head is a male and 0 otherwise. It is argued that male household heads are relatively risk averse and have more access to information, land and other resources relative to female-headed households (Asfaw and Admassie, 2004; Tenge and Hella, 2004; Bryan et al., 2011) particularly in the developing world hence are more likely to adopt certain practices than female household heads (Marenya and Barrett, 2007). According to Quisumbing et al. 2011, African women have reduced access to critical resources (land, cash and labor), which often weakens their ability to carry out labor-intensive agricultural innovations. On the other hand, some research

has shown a relatively higher level in adopting certain coping measures by female-headed households (Dolisca et al., 2006; Nhemachena and Hassan 2007; Bayard et al., 2007).

The *age of the household head* was grouped into 3 categories: 19-39 years, 40-69 years, and greater or equal to 70 years (table 4). The empirical literature on the influence of age has been varied. While some reveal a positive significant effect of age on adoption (Bayard et al. 2007; Deressa et al., 2005), others have shown otherwise (Dolisca et al., 2006; Nyangena, 2007; Anley et al., 2007, Hassan and Nhemachena, 2008). Other studies have also shown age as significant variable on household's adoption decision (Zhang and Flick, 2001; Bekele and Drake, 2003).

The *literacy level* is a dummy variable of 1 if head of household is literate and 0 otherwise was used for this study. The expectation is that the literacy level of household head significantly influences adoption decisions on certain adaptation or coping measures as has been shown empirically (Daberkow and McBride 2003; Maddison, 2006; Dolisca et al., 2006; Anley et al., 2007; Tizale, 2007; Ibrahim et al., 2011). The expenditure of each household was used as a proxy for household *farm income* and measured in Ghana Cedis (GH¢). This variable is a measure of wealth, and reflects the ability of a household to cope with risk. Some studies show a positive correlation between income and adoption (Knowler and Bradshaw, 2007; Ibrahim et al., 2011). This study postulates that farm income increases household's ability to adopt certain coping strategies to climate change.

The *size of farm land* is an important asset in rural households and is a function of the available economic resources to the household. The farm size variable is defined as acres of farmland. Following the results from Daberkow and McBride (2003), there may be a critical lower limit on farm size that prevents smaller farms from adapting given the uncertainty and the fixed transaction and information costs associated with innovation. Households with smaller farms are less likely to adopt innovations with large fixed transaction and/or information costs. However, a later study by Bradshaw et al. (2004) found that farm size had both negative and positive effects on adoption. The expected result of this study is therefore an empirical question.

Ownership of radio and *ownership mobile phone* is expected to provide more timely access to information on climate situation of their locality and improve technologies or practices available for mitigation. The study assumes that any household head that is member of any *Farmer Based Organization (FBO)* will have access to extension services. Access to information on new and improved agricultural practices, is critical to the ability of farmers particularly in developing nations to cope with climate change and variability. Such information is easily accessible to farmers through extension services. Some empirical research indicates a positive relationship between extension education and adoption behaviors of farmers (Anley et al., 2007; Nhemachena and Hassan, 2007; Yirga, 2007; Fosu-Mensah et al., 2010). This study explores the hypothesis that membership in an FBO gives access to extension information and increases the chances of a farmer adopting certain coping strategies to climate.

In low-income areas such as Bawku West District, the ability of households to adopt certain cost intensive climate change coping mechanisms – purchase of improved crop varieties, fertilizers and relocating to different farm sites due to flood – will be contingent on the availability and accessibility of credit facilities. Several studies postulate a positive relationship between access to credit and adoption behavior (Pattanayak et al., 2003; Nhemachena and Hassan, 2007; Ibrahim et al., 2011; Gbetibouo 2009). Similarly, this study

also hypothesizes a positive relationship between *access to formal/informal credit* and adoption. Few studies have investigated the influence of source of seed for planting on the choice of climate change coping strategies. If a household use own seed for planting, the value 1 is assigned and 0 if otherwise, to capture to the *source of seed for planting* variable. It is anticipated that depending on the source of seed for planting by a household, it would be likely to adopt certain coping measures or not. The direction of influence is however uncertain.

Area Councils are included (table 3) to capture differences in precipitation and temperature. Households that reported to have experienced changes in climate do not correspond to households who were actually affected by the impact or effect of such climatic change. Some households indicated to have experienced flood, drought or bushfire events but reported no effect from such conditions. To control for any non-item response bias that might have occurred as a result of the data collection process, the effect variable is included in the binary logit model. The *effect* variable takes a value of 1 if households experienced the impact of climatic event (flood, drought, and bushfires) and 0 if otherwise. A positive relationship between effect and household adoption decision is expected.

DATA OVERVIEW

The study was conducted in the Bawku West district located in the north-eastern part of the Upper East Region of Ghana. The district stretches over an area of 1,070km^2. The 2010 census approximates the population of the district to be 94,034 with a population density of 87.88 persons per square kilometer. Agriculture is the mainstay of the district's economy employing more than 80% of the working population in the district. Major crops cultivated in the district include millet, rice, sorghum and maize. The study area falls within the Sudan savanna agro-ecological zone which forms part of the semi-arid areas of Ghana. The area has a unimodal rainy season lasting 4-6 months (May to October) and a long dry period of 6-8 months (November to April) in a year. The average annual rainfall for the area varies from 900 mm to 1150 mm and temperatures are high, averaging about 28.5^{o}C annually. The maximum length of growing period for rain-fed crops in the district is less than 60 days (Atta-Quayson, 1995). The area is characterized by severe drought during the dry season, particularly from December to March. Average monthly rainfall levels recorded during these periods are below 5 mm. The natural vegetation consists predominantly of short drought and fire-resistant deciduous trees interspersed with open savanna grassland. Some environmentally unfriendly farming practices including land clearing for farming, fuel wood harvesting, overgrazing, annual routine bushfires, and poor conservatory and animal husbandry practices have led to loss of the vegetative cover in the study area.

The primary data used in this study were obtained from a household survey conducted in the 2007/2008 production season in the Bawku West district of Ghana (table 1). Fifteen out of the 152 villages in the district were sampled and surveyed. Sixteen (16) households were interviewed in each village sampled. Nonetheless, some of the households were omitted due to either data inconsistency or incompleteness. This makes the number of households included in the estimation analysis equal 195 instead of 240. The towns and/or villages sampled fall within the same agro ecological zone (Sudan savanna) with near similar precipitation and temperature pattern. In sampling the villages and households, a combination

of both purposive and random sampling techniques were employed respectively. Both qualitative and quantitative data techniques were also adopted for data collection and analysis. At least one village was sampled from each of the seven area councils in the district. The household survey generated information on demographic (age, gender, adult literacy, household size, etc.), resource (access to electricity, access to formal/informal credit, etc.), assets (radio and mobile phone ownership, etc.), economic (farm sizes, farm income, etc.), and incidence of different extreme events or shocks (drought, flood and bushfires) on households in the Bawku West district. The survey used both open- and closed-ended questions to solicit information from respondents. The dependent variables are the 13 coping strategies identified that were used by households in the event of extreme climatic conditions – five in the event of drought, five for flood and three for bushfires (table 2), and the independent variables are summarized in table 3.

Male household heads constitute 86.7 percent of the respondents sampled and interviewed (table 4). Out of the 80 percent who are married, 77.6% are monogamous marriages, and the remaining 22.4% are polygamous marriages. The age distribution of respondents depicts a rightward or positively skewed normal distribution. Fifty-three percent of household heads fall within the age group of 40 to 69 years, 30 percent are between the ages of 19 to 39 years, and nearly 16 percent are 70 years and above. The literacy level of sampled respondents is slightly higher than the regional average, with 25.6 percent capable of reading and writing.

The size of land owned by households ranges from 0.5 to 40 acres, with an average land holding of 7.76 acres. The survey results demonstrate that at least some land is owned by all respondents, as reported in table 4. Additional open-ended survey questions, not reported here, showed that many of the survey respondents also worked on land other than that owned.

A majority of households (88.7%) owned livestock, probably to plough on farms or sever as a source of food security, collateral for loans and or prestige. The average expenditure of households, used as a proxy for income is GH¢3009, almost $2844 (2008USD) per year. The result indicates that, on average, more than half of households live above the poverty line of $1.50 a day. This might not be the case, since data on income show few outliers that weighed heavily on the average income level. Income levels are heavily concentrated at the right tail of a normal distribution curve. With this level of income and the predominant agricultural economy of the study area, it is no surprise that less than 13 percent of households have access to electricity. Access to formal/informal credit and farmer-to-farmer extension service are also limited to only 38 percent and 24 percent of sampled households, respectively. The survey did not investigate the causes and consequences of why certain farmers have access to credit and others do not.

The data for the study were collected in the aftermath of a prolonged drought followed by a devastating flood condition in the district and the entire Upper East region, which occurred during the 2007 and 2008 production seasons. These conditions brought severe economic hardship on the people and more than 61 percent indicated suffering severe food shortage as a result. Given that the field research for the study was conducted in the aftermath of the 2007/2008 extreme climatic events, respondents were asked whether their households were impacted in any way. Table 2 shows an increasing trend of households affected by extreme climatic conditions. Bushfires affected 14.4% of respondents in 2007 and 15.4% in 2008. The proportion of drought affected households appreciated slightly from 37.9% in 2007 to 39% in 2008. It is not surprisingly that more households felt the impact of the flood in both years –

44.6% in 2007 and 48.7% in 2008 – than any of the other climatic conditions. The incidence of the flood came as unexpected and most communities were not prepared for such worst case scenario (table 2). Coping strategies identified could be placed under two distinct categories: inward-looking and outward-looking. Inward-looking strategies require households to rely on their internal resources and outward-looking, on external resources such as community, government and or non-governmental support (Mingione, 1987). The implementation of either type of strategy might require either monetary or non-monetary resources (Snel and Staring, 2001).

The possibility of collinearity was investigated with the use of pairwise correlation coefficients for all independent variables, and variance inflation factors (VIF) in each binomial regression. The correlation coefficients were all below 0.5, and the VIF analysis found no potentially degrading collinearity among all of the included explanatory variables.

RESULTS: COPING STRATEGIES FOR FLOODS

Table 5 shows the effect of flood on the 91 sampled households affected by flood. More than 36 percent reported destruction of their farm or farm produce including maize, millet, rice, sorghum and cowpea. While some farmers reported that their harvested crops (including seeds) were washed away by the flood others had their farms flooded and crops that were still not harvested got destroyed.

Crops that were able to withstand the flood produced poor yields as indicated by 5.5% of households. The flood in 2007 revealed the vulnerability of buildings of households which are primary constructed with weak building materials like mud and thatch. All or part of buildings owned by twenty two percent of respondents collapsed. The number of rooms of partly damaged homes ranged from one to six. This rendered some of the inhabitants' homeless for a period, but for the intervention of government and non-governmental organizations. For 17.6 percent of households, both their crops and homes were destroyed. The impact of the flood resulted in 8.8 percent of households which experienced severe food shortage. Others (3.3%) had a triple impact of flood on their livelihood: destruction of crops, livestock and buildings.

Tables 6 and 7 show the parameter estimates and marginal effects, respectively, from the binary logit regression (BLR) for each of the coping strategies for floods. Efforts were made to include the same variables for each of the models estimated. However, the problem of partial separation was encountered in estimating two models. The access to electricity, effect of flood and area TT (Tanga-Timonde and Tilli-Wadnaba area councils) variables correctly predicted the dependent variable (NGO or government aid) and were dropped. The likelihood ratio statistic for all the models are highly significant, an indication of their strong explanatory power.

Evidence from the model estimations as shown in Tables 6 and 7 suggest that, the set of significant explanatory variables varies across the different coping measures in terms of significant levels and signs. The study found out that access to electricity is significant and positively influenced adoption of improved drainage systems, but negatively influenced the decision to stop farming in lowland areas in other to cope with floods. This implies that the probability of households with access to electricity to select an improve drainage system as a coping measure to floods is 0.142 greater than households without electricity. The probability

to stop farming in lowland areas is 0.251 lower for households with access to electricity than households without access to electricity.

Table 5. Effect of Flood on Households

	Percent
Destroyed crops only	36.3
Decline in crop yield	5.5
Destroyed house only	22.0
Destroyed crops and livestock	3.3
Destroyed crops and house	17.6
Destroyed livestock and house	3.3
Destroyed crops, livestock and house	3.3
Food shortage	8.8

Source: Author's compilation from household survey, 2008. Note: N = 91.

Being a member of an FBO decreased the likelihood of no adaptation by 0.146 but increases the probability of resorting to modern building techniques by 0.123. Seed source is a significant determinant of no adaptation, modern building techniques and reliance on NGO or government aid. Farmers that depend on government or NGOs as their major seed supplier for planting are likely to do nothing in the event of floods. Also, the probability of such households depending heavily on government support during floods is likely to upsurge by 0.07. Household heads within the ages of 40-69 years are less likely to depend on external support compared to household heads between the ages of 19 to 39 years in order to cope with floods. The result shows a negative significant effect of age range 40-69 years on the decision to depend on NGO or government aid for adaptation. The probability of non-dependence on external support decrease by 0.07 for farmers aged between 40-69 years than those aged between 19-39 years.

Household size positively and significantly influences dependence on external support to cope with floods and the probability for such dependence increases by 0.018 with one additional household member.

Table 6. Parameter Estimates of Logit Model of Coping Strategies for Floods

Variables	Stop farming in lowland areas		Improve drainage system		Did nothing		Modern building technique		Ngo or govt aid	
Coeff.	Std. Err	Coeff.	Std. Err	Coeff.	Std. Err	Coeff.	Std. Err	Coeff.	Std. Err	
Literacy	0.706	0.494	0.361	0.875	-0.436	0.438	-0.874	0.899	1.152	1.184
Radio ownership	-0.257	0.439	0.357	0.778	0.324	0.368	-0.295	0.826	-0.120	0.781
Mobile phone ownership	-0.098	0.541	0.103	0.802	0.257	0.444	0.353	0.756	-1.705	1.3954
Access to electricity	**-1.825****	0.821	**2.403*****	**0.788**	-0.587	0.549	1.935	1.496	----	----
FBO	0.301	0.503	0.023	0.800	**-0.738***	**0.441**	**2.411*****	0.988	0.959	1.122
Seed source	0.647	0.472	0.134	0.742	**-0.598***	**0.368**	**3.080****	1.506	**-1.937****	0.843
Age X	0.324	0.692	0.922	1.201	-0.243	0.534	1.916	1.502	-0.400	1.125
Age Y	0.530	0.639	0.856	1.024	-0.445	0.474	1.162	1.472	**-1.736***	1.016
Gender	0.997	0.751	-0.596	0.967	-0.355	0.542	-1.703	1.262	0.506	1.582
Household size	-0.118	0.092	0.078	0.146	-0.082	0.073	0.046	0.177	**0.449*****	0.154
Income	**1.708*****	0.581	-0.494	0.601	**-0.839****	**0.387**	1.516	1.005	**-1.586****	0.892
Area Z	-0.896	0.798	1.423	1.460	-0.354	0.573	1.556	1.411	1.001	1.136
Area BZ	-0.077	0.516	**1.947****	**0.843**	**-0.956****	**0.416**	0.071	1.032	**1.771***	1.047
Area TT	0.253	0.587	1.544	1.127	-0.039	0.488	----	---	---	----
Effect	**-0.850****	0.423	**-2.025*****	**0.839**	**-0.599***	**0.344**	**3.965*****	1.287	---	----
Access to credit	-0.010	0.438	-0.503	0.689	-0.391	0.352	0.952	0.935	0.408	0.872
Farm size	-0.053	0.039	-0.042	0.062	**0.059****	**0.029**	0.010	0.077	**-0.250****	0.118
Constant	-7.190	1.931	-2.761	2.165	4.737 1.310	-14.88	4.214	0.807	2.673	
No observation	195	195			195		195		195	
Log likelihood	-83.407	-40.994			-113.377		-32.200		-27.711	
LR chi square	31.08	38.07			43.34		51.03		34.74	
Pseudo R2	0.1571	0.3171			0.1604		0.4421		0.3853	
Prob>chi 2	0.0195	0.0024			0.0004		0.0000		0.0016	

Source: Author's compilation from household survey, 2008. Note: *, ** and *** represent significance at 10%, 5% and 1% respectively.

Table 7. Marginal Effects of Logit Model of Coping Strategies for Floods

	Stop farming in lowland areas		Improve drainage system		Did nothing		Modern building technique		Ngo or govt aid	
Variables	dy/dx	Std. Err	dy/dx	Std. Err	dy/dx	Std. Err	dy/dx	Std. Err	dy/dx	Std. Err
Literacy	0.097	0.067	0.021	0.052	-0.086	0.086	-0.044	0.045	0.046	0.048
Radio ownership	-0.035	0.060	0.021	0.046	0.064	0.073	-0.015	0.042	-0.004	0.032
Mobile phone ownership	-0.013	0.074	0.006	0.047	0.051	0.088	0.017	0.038	-0.069	0.057
Access to electricity	**-0.251****	0.109	**0.142*****	0.044	-0.116	0.108	0.098	0.075	----	----
FBO	0.041	0.069	0.001	0.047	**-0.146***	0.085	**0.122*****	**0.045**	0.039	0.045
Seed source	0.089	0.064	0.007	0.044	**-0.118***	0.071	**0.156****	0.074	**-0.078****	0.034
Age X	0.044	0.095	0.054	0.071	-0.048	0.106	0.097	0.074	-0.016	0.046
Age Y	0.072	0.087	0.050	0.061	-0.088	0.093	0.059	0.074	**-0.070***	0.041
Gender	0.137	0.102	-0.035	0.057	-0.070	0.107	-0.086	0.063	0.020	0.065
Household size	-0.016	0.013	0.004	0.009	-0.016	0.014	0.002	0.009	**0.018*****	0.006
Income	**0.235*****	0.076	-0.029	0.036	**-0.166****	0.076	0.077	0.050	**-0.064***	0.036
Area Z	-0.123	0.109	0.084	0.086	-0.070	0.113	0.079	0.071	0.040	0.046
Area BZ	-0.010	0.071	**0.115****	0.049	**-0.190****	0.078	0.003	0.053	**0.072***	0.042
Area TT	0.034	0.081	0.091	0.067	-0.007	0.097	----	---	---	----
Effect	**-0.117****	0.056	**-0.119****	0.050	**-0.119***	0.067	**0.201*****	**0.059**	---	----
Access to credit	-0.001	0.060	-0.029	0.041	-0.077	0.069	0.048	0.047	0.016	0.035
Farm size	-0.007	0.005	-0.002	0.004	**0.011****	0.006	0.001	0.004	**-0.010****	0.005
No observation	195		195		195	195	195			

Source: Author's compilation from household survey, 2008. Note: *, ** and *** represent significance at 10%, 5% and 1% respectively

As expected, income negatively influences the decision of no adaptation and dependence on external support. On the other hand, decision to stop farming in lowland areas has a positive significant relationship with income.

Wealthier households mostly have large amount of assets in the community and are therefore more likely to find some measures to mitigate the effect of climate change on their assets. Given that the decision to stop farming in lowland areas is risky, only wealthier households are likely to adopt such measures. As indicated by the results, households in area BZ (Binaba-Kusanaba and Zebilla area councils) are more likely to adopt improve drainage system and depend on NGO or government support but less likely to do nothing in the event of flood compared to households in area SG (Sapelliga and Gbantogo area councils). Living in Binaba-Kusanaba and Zebilla increase the probability of selecting improve drainage system or external support by 0.115 and 0.07 respectively.

Large farm size positively influenced no adaptation, with a probability of 0.01 and negatively influences dependence on external support with a probability of 0.010 with an additional unit of farmland. The results show that adoption decision is strongly influenced when households experienced the impact of floods (such as destruction of crops, livestock or house). Surprisingly, the probabilities of adopting improved drainage systems and discontinue farming in lowland areas falls if households experienced any effect from flood by 0.117 and 0.119 respectively. The intuition for this result could be attributed to the not so many lowland areas in the district and most of these farmers already may not have farms in lowland areas. The probability of selecting modern building techniques as an adaptive measure to floods increased by 0.202 if households were impacted or experienced a loss of some sort caused by floods. It may not be possible to stop farming or improve drainage without moving.

RESULTS: COPING STRATEGIES FOR DROUGHT

A majority of respondents (73) recounted having experienced several impacts from drought as shown in Table 8. Poor yield or harvest was reported by 67 percent of the 73 households affected by drought. Most farmers in the district usually cultivate their land after the first rain. A delay in the rains as a result of drought resulted in poor crop yield and harvest. Grasslands for livestock grazing dried up which caused the death of several animals. Likewise, some surveyed households indicated their farm crops wilted and subsequently dried up. Nearly three percent of drought affected households encountered severe water shortage since most water sources (rivers and streams) got dried up.

The occurrence of drought conditions is seen as a "normal" phenomenon in the district due to the climatic pattern there. However, the intensity of the drought periods differ yearly and households' have in the course of time developed measures to enable them not only cope with such situation but also adapt to its impact. Six coping strategies were identified as households' responses to drought events in the Bawku West district (table 2). Table 2 shows these strategies include irrigation or dry season farming (6.1%), food storage (3%), planting more trees or cover crops (12.8%), planting drought resistant or early yielding crops (10.8%), early planting (17.4%) and no adaptation (49.7%). These strategies predominantly require the reliance on households' internal resources or factors as opposed to seeking external support.

A large number of households (49.7%, table 2) had no adaptation strategy to drought. While this might seem high, a number of factors could be attributed to this result. First off,

dry periods (or drought periods) for the region span from November to April (or November to June in extreme drought situations) annually and their occurrences are seen as normal circumstances. Most households have integrated the other coping strategies into their normal daily activities and don't see them as otherwise. For others, drought conditions have some spiritual inclination and their only coping measure is to pray to God. They offer sacrifices to deities during certain times of the year for protection.

Table 8. Effect of Drought on Households

	Percent
Poor yield or harvest	67.1
Destruction of crops and livestock	30.1
Water shortage	2.8

Source: Author's compilation from household survey, 2008.
Note: N = 73.

Drought regression models are presented in table 9, and marginal effects in table 10. The likelihood statistics indicates a high level of significance for all the models, as such all the models have a strong explanatory power. Here again, the problem of partial separation was encountered in estimating two of the models – models with drought resistant and irrigation practice as dependent variables – so the variables gender and area BZ (Binaba-Kusanaba and Zebilla councils) were subsequently dropped. The results from the binary logit regression model for coping strategies for drought show that most of the explanatory variables influence adaptation to drought situations. Exceptions are radio ownership, mobile phone ownership and access to electricity, that have no significant influence on adoption decisions.

A key result is the effect of literacy on adaptation to climate change, as literacy promotes the use of early planting measures to cope with drought. This shows the importance of human capital to the decision to adapt to climate which is in sync with T. W. Schultz's (1954) assertion of the importance of human capital for agricultural productivity. Household heads that are able to read and write have a 0.167 probability higher than those who cannot read or write in adopting early planting strategies.

In Africa, women are primarily responsible for food security, provision of potable water and energy for household use. As such female household head are more likely to engage with at least one coping measure to climate change to reduce the time burden needed to carry out responsibilities (such as the length of time it takes to get clean and portable water) in the event of drought. However, the estimates show that female household heads are more likely to result to no adaptation to cope with drought. Being male reduces the probability of doing nothing by 0.193. The probable reason could be that females have relatively limited access to information, resource and are less educated. The ability to adopt any of the other coping strategies for drought requires these critical resources (education and access to information).

Table 9. Parameter Estimates of the Logit Model of Coping Strategies for Drought

Variables	Early Planting		Drought resistant		Did nothing		Tree planting		Irrigation Practices	
	Coeff.	Std. Err	Coeff.	Std. Err	Coeff.	Std. Err	Coeff.	Std. Err	Coeff.	Std. Err
Literacy	**1.454*** **	0.550	-0.254	0.739	-0.474	0.443	0.232	0.798	0.214	0.894
Radio ownership	-0.600	0.515	0.881	0.787	0.345	0.367	-0.317	0.646	-0.691	0.837
Mobile phone	0.306	0.558	-0.877	0.772	0.095	0.441	0.275	0.834	0.172	0.856
Access to electricity	-1.258	0.805	0.030	1.039	-0.022	0.539	1.390	0.943	0.124	1.318
FBO	-0.818	0.650	0.040	0.870	0.099	0.450	**2.017** **	0.854	-0.423	1.213
Seed source	**1.447** **	0.599	1.477	0.964	-0.607	0.380	**-2.031*** **	0.712	1.900	1.242
Age X	0.426	0.741	**2.520** **	1.389	-0.860	0.552	0.300	1.015	15.94	1364.823
Age Y	0.066	0.700	2.059	1.323	-0.682	0.493	-0.847	0.872	15.37	1364.823
Gender	-0.682	0.673	----	---	**-0.978***	0.540	0.965	1.178	1.237	1.54205
Household size	-0.150	0.107	**-0.314** **	0.155	0.022	0.070	**0.421** **	0.139	0.089	0.150
Income	**-0.741***	0.457	**2.143** **	1.111	0.334	0.356	-0.629	0.729	0.030	0.740
Area BZ	-0.331	0.574	18.02	2593.97	**-1.265*** **	0.433	**3.122*** **	1.084	---	---
Area Z	-0.892	0.809	15.84	2593.971	-0.761	0.568	**2.471** **	1.281	1.675	1.093
Area TT	-0.167	0.616	16.14	2593.971	-0.740	0.501	**2.041***	1.257	**2.474** **	**1.095**
Effect	-0.008	0.495	**1.220***	0.711	-0.449	0.371	-0.538	0.689	1.058	0.888
Access to credit	**1.119** **	0.476	0.238	0.714	-0.511	0.360	-0.842	0.718	1.228	0.833
Farm size	0.032	0.034	-0.116	0.115	**0.111*** **	0.035	**-0.537*** **	0.156	-0.129	0.104
Constant	0.473	1.578	-28.03	2593.974	0.765	1.156	-1.924	2.408	-22.55	1364.826
No. observation	195		195		195		195		195	
Log likelihood	-71.875		-36.798		-112.466		-41.490		-31.910	
LR chi Square Pseudo R2	36.71 0.203		59.65 0.448		45.39 0.168		66.37 0.444		26.34 0.292	
Prob>chi2	0.004		0.001		0.001		0.000		0.049	

Source: Author's compilation from household survey, 2008.

Note: *, ** and *** represent significance at 10%, 5% and 1% respectively.

Table 10. Marginal Effects of Logit Model of Coping Strategies for Drought

Variables	Early planting		Drought resistant		Did nothing		Tree planting		Irrigation practices	
	Coeff.	*Std. Err*	*Coeff.*	*Std. Err*	*Coeff.*	*Std. Err*	*Coeff.*	*Std. Err*	*Coeff.*	*Std. Err*
Literacy	**0.167*** **	0.060	-0.015	0.044	-0.093	0.087	0.015	0.054	0.009	0.042
Radio ownership	-0.069	0.059	0.053	0.047	0.068	0.072	-0.021	0.043	-0.032	0.039
Mobile phone	0.035	0.064	-0.052	0.046	0.018	0.087	0.018	0.056	0.008	0.040
Access to electricity	-0.144	0.091	0.001	0.063	-0.004	0.106	0.093	0.062	0.005	0.061
FBO	-0.094	0.074	0.002	0.053	0.019	0.089	**0.136** **	0.054	-0.019	0.056
Seed source	**0.166** **	0.067	0.089	0.056	-0.119	0.073	**-0.137*** **	0.042	0.088	0.0578
Age X	0.049	0.085	**0.151** **	0.079	-0.170	0.107	0.020	0.068	0.742	63.520
Age Y	0.007	0.081	0.124	0.077	-0.134	0.096	-0.057	0.058	0.715	63.520
Gender	-0.078	0.077	----	---	**-0.193** *	0.103	0.065	0.079	0.057	0.072
Household size	-0.017	0.012	**-0.018** **	0.009	0.004	0.014	**0.028*** **	0.008	0.004	0.007
Income	**-0.085** *	0.051	**0.129** **	0.063	0.066	0.070	-0.042	0.049	0.001	0.034
Area BZ	-0.038	0.066	1.087	156.4	**-0.250*** **	0.078	**0.210*** **	0.065	---	---
Area Z	-0.102	0.092	0.955	156.4	-0.150	0.110	**0.166** **	0.082	0.077	0.051
Area TT	-0.019	0.071	0.973	156.4	-0.146	0.097	**0.137** *	0.082	**0.115** **	**0.051**
Effect	-0.001	0.057	**0.073** *	0.041	-0.088	0.072	-0.036	0.046	0.049	0.041
Access to credit	**0.128** **	0.052	0.014	0.043	-0.100	0.070	-0.056	0.047	0.057	0.039
Farm size	0.003	0.004	-0.007	0.007	**0.022*** **	0.006	**-0.036*** **	0.009	-0.006	0.005
No. observation	195		195		195		195		195	

Source: Author's compilation from household survey, 2008. Note: *, ** and *** represent significance at 10%, 5% and 1% respectively.

Household heads belonging to farmer-based organizations (FBOs) are more likely to plant trees or cover crops to adapt to drought. Likewise, families with large size are more likely to use trees and cover crops planting as a coping measure to drought. This adaptation measure is labor intensive, requiring lots of man-hours to be an effective coping mechanism. Also large household size decrease the likelihood of adopting drought resistant or early yielding crops as a coping option to drought, as the results show a negative significant relationship between household size and planting drought resistant crops. Increasing the number of household by one decreases the probability of adopting drought resistant crops by 0.018 but increases the probability of adopting tree or cover crops planting by 0.028 to adapt to drought.

It is interesting to note that seed source has a significant effect on adoption decisions. Early planting and planting of trees or cover crops respectively, are positively and negatively influenced by the source of seeds for planting. If the farmer depended largely on his own seed for planting, the likelihood of adopting early planting increased by 0.166 and the likelihood of selecting tree or cover crops planting strategy reduced by 0.137. High income households are less likely to adopt early planting strategy, but more likely to adapt to drought events by planting drought resistant or early yielding crops. The latter is relatively a more effective measure and this could explain the reason why high income households opt for that option to cope with drought.

Access to credit is strongly associated with the use of early planting measures to cope with drought. Having access to credit increased the probability of selecting early planting strategy by 0.128. Surprisingly, the coefficient of farm size is significant and positive for no adaptation but negative for tree or cover crops planting. This implies that households with large farm size will more likely do nothing to adapt to drought, but smaller sized households have higher probability to plant trees or cover crops as an adaptive measure to drought. The probability of selecting tree or cover crops planting strategy declined by 0.036 whiles the probability of selecting no adaptation rose by 0.022 with a one acre addition of farmland.

Area council TT (Tanga-Timonde and Tilli-Wadnaba) is the only variable that significantly influenced the adoption of irrigation practices. The probability of adopting irrigation practices increased by 0.115 for farmers living in area TT (Tanga-Timonde and Tilli-Wadnaba) than for farmers living in area BZ (Binaba-Kusanaba and Zebilla area council). Likewise, there is a positive correlation between the area of residences and the choice of tree or cover crops planting as an adaptation measure to drought. The likelihood of households severely impacted by drought to adopt the planting of drought resistant or early yielding crops strategy to cope with drought increased by 0.074. The results show a positive significant relationship between adoption of drought-resistant crops and the impact of drought on households.

RESULTS: COPING STRATEGY FOR BUSHFIRES

The results from the study revealed three main effects of bushfire on sampled households are presented in Table 11. Twenty eight survey respondents were affected by bushfires. According to the survey, most farmers (71.4%) affected by bushfire responded that they lost their farm produce as a result of the bushfires that occurred in the 2007/2008 growing season. For others (10.7%) there was no field for their livestock to graze on since a large portion of

their grassland were destroyed by the bushfires. Livestock farming in the district and most part of Ghana is primarily 'free range' and availability of grassland areas is a significant factor to livestock productivity. Any decline thereof in grazing fields affects farm income and rural livelihood. The other effect of bushfire includes the burning of part or all the buildings of respondents.

Table 11. Effect of Bushfire on Households

	Percent
Farm produce burned	71.4
No field for livestock grazing	10.7
Part or all house burned	17.9

Source: Author's compilation from household survey, 2008.
Note: N = 28.

In general, most of the 28 sampled households (61%) reported the use of improved farm management practice as a coping measure to bushfires (table 2). Such improved management practices included creating fire belts more than two meters from other neighboring farms, regularly clearing weeds around house or farms especially during the dry season and keeping their surroundings clean. Fire prevention educations through anti-bushfire campaigns and household heads educating their wards on the effects and steps to preventing bushfires have been resulted to for adaptation to bushfires. Ten percent did nothing to cope.

Regression results bushfire-induced coping strategies are presented in Tables 12 and 13. The chi-squared values from the likelihood ratio statistics are highly significant, an indication of a strong explanatory power. Based on the survey, a limited number of factors were found to influence the adoption of strategies to cope or adapt to bushfire situations. Results show that, seed source, gender, income and effect of bushfires significantly influenced the adoption of improved farm management practices. Similarly, fire prevention education was significantly influenced by radio ownership, source of seeds, gender and income. Also, no adaptation is significantly affected by FBO membership and farm size.

According to the regression results, radio ownership is positively and significantly related to the adoption of fire prevention education as an adaptive measure to bushfires. Households with access to radio are privilege to lots of information on bushfire control and prevention. This suggests that, anti-bushfire campaigns on radio and other media channels is an effective way of reducing occurrence of bushfires.

Ownership of a radio increased the probability of using fire prevention education to cope with bush fires by 0.124. Source of seeds appeared to be negatively associated with improve farm management practices and no adaptation. The negative sign on seed source suggests a smaller likelihood for farmers that depend on their own stored seeds as the main source of seed for planting to cope with bushfires by improving doing nothing or embark on fire prevention education respectively. However, the probability of adopting improved farm management practices is 0.299 greater for farmers who use their own seeds for planting than those who depends on government for their seed provision.

Table 12. Parameter Estimates of the Logit Model of Coping Strategies for Bushfires

Variables	Improve Farm Mgt Practices		Fire Prevention Education		Did Nothing	
	Coeff.	*Std. Err.*	*Coeff.*	*Std. Err.*	*Coeff.*	*Std. Err.*
Literacy	0.558	0.456	-0.396	0.494	-0.488	0.754
Radio ownership	-0.321	0.382	**0.707***	0.406	-0.517	0.617
Mobile phone	-0.254	0.444	-0.334	0.480	0.970	0.724
Access to electricity	0.001	0.569	0.543	0.561	-1.496	1.275
FBO	-0.315	0.460	0.062	0.4778	-0.368	0.759
Seed source	**1.562*** **	0.373	**-1.160*** **	0.381	**-1.540*** **	**0.588**
Age X	-0.208	0.557	0.202	0.596	0.125	0.888
Age Y	-0.455	0.492	0.193	0.507	0.282	0.765
Gender	0.895	0.552	**-1.082** **	0.567	-0.073	0.852
Household size	-0.016	0.071	0.049	0.074	-0.123	0.120
Income	**-0.876** **	0.379	**0.777** **	0.403	0.527	0.564
Area Z	-0.566	0.573	0.890	0.599	-0.548	0.944
Area BZ	0.582	0.433	-0.141	0.458	-0.950	0.733
Area TT	-0.510	0.491	0.506	0.518	-0.349	0.730
Effect	**0.949***	0.573	-0.789	0.624	-0.047	0.861
Access to credit	0.470	0.370	-0.239	0.384	-0.568	0.628
Farm size	-0.009	0.026	-0.032	0.030	**0.063***	**0.034**
Constant	1.882	1.224	-2.350	1.299	-2.242	1.903
No. observation	195		195		195	
Log likelihood	-110.339		-102.470		-50.912	
LR chi square	40.09		27.06		18.24	
Pseudo R2	0.154		0.116		0.152	
Prob>chi2	0.001		0.057		0.374	

Source: Author's compilation from survey, 2008.

Note: *, ** and *** represent significance at 10%, 5% and 1% respectively.

Low-income households tend to improve their farm management practices while high income households resort to fire prevention education to cope with bushfires. Also, male household heads have a higher tendency to adopt improved farm management practices and fire prevention education as strategies to adapt to bushfires. There exist positive significant correlations between gender and improve farm management techniques and fire prevention education. Again males are well educated, and have relatively easy access to information and resources, explaining this outcome.

The prior expectation was for the effect of bushfires on households to significantly affect adaptation. However, only improve farm management practices appeared to be significantly influenced by effect of bushfires on households. This finding suggests that households that have experienced a negative effect from bushfires are likely to adapt by improving their farm management practices (creating fire belts around farm or house and regularly weeding around farm or house). This likelihood is 0.182 higher for households that have suffered from bush fires than those otherwise.

Table 13. Marginal Effects of Logit Model of Coping Strategies for Bushfires

Variables	Improve Farm Mgt Practices		Fire Prevention Education		Did Nothing	
	dy/dx	Std. Error	dy/dx	Std. Error	dy/dx	Std. Error
Literacy	0.107	0.086	-0.069	0.086	-0.036	0.056
Radio ownership	-0.062	0.073	**0.123***	0.069	-0.038	0.046
Mobile phone	-0.048	0.085	-0.058	0.086	0.071	0.054
Access to electricity	0.0003	0.109	0.095	0.097	-0.110	0.095
FBO	-0.060	0.088	0.010	0.084	-0.027	0.056
Seed source	**0.299*****	0.059	**-0.202*****	0.061	**-0.113*****	0.044
Age X	-0.039	0.107	0.035	0.104	0.009	0.066
Age Y	-0.087	0.094	0.033	0.089	0.020	0.057
Gender	**0.171***	0.104	**-0.189****	0.096	-0.005	0.063
Household size	-0.003	0.014	0.008	0.013	-0.009	0.009
Income	**-0.168****	0.069	**0.135****	0.068	0.039	0.042
Area Z	-0.108	0.109	0.155	0.103	-0.040	0.070
Area BZ	0.111	0.082	-0.024	0.080	-0.070	0.055
Area TT	-0.09	0.093	0.088	0.090	-0.025	0.054
Effect	**0.182***	0.107	-0.138	0.108	-0.003	0.064
Access to credit	0.090	0.070	-0.041	0.067	-0.042	0.046
Farm size	-0.001	0.005	-0.005	0.005	**0.004***	0.003
No. observation	195		195	195		

Source: Author's compilation from household survey, 2008.

Note: *, ** and *** represent significance at 10%, 5% and 1% respectively.

CONCLUSION AND POLICY RECOMMENDATIONS

Climate is changing faster in Northern Ghana relative to other parts of the country. Prolonged high temperatures and fires that burn crops, coupled with erratic rainfalls have characterized the climatic pattern of the region over the period 1983 to 2011. As the poorest and most agricultural dependent region of Ghana, the impact of such climatic conditions is devastating. A clear example is the 2007/2008 prolonged drought season which was followed immediately by a devastating flood in the entire Northern Ghana. Several food crops and livestock were destroyed (some washed away by the flood) causing severe food shortage; farm income declined; buildings, roads and other infrastructure collapsed; yield from crops declined and countless people were rendered homeless.

This study examined the effect of extreme climatic conditions (drought, flood, and bushfires) on the livelihood of households in the Bawku West district of Ghana, identified the mechanisms with which these households cope in such situations, and analyzed factors influencing the adoption of coping strategies for flood, coping strategies for drought and coping strategies for bushfire respectively. Data for the study were collected in selected villages across the district in the aftermath of the 2007/2008 extreme events. A binary logit regression model was used to estimate factors that influence the adoption of given coping

mechanisms. In all 13 coping mechanisms were identified to be used by households in the event of flood, drought or bushfires.

Evidence from the study showed the destruction of crops as the major effect of flood on households. Other effects included food shortage and the destruction of livestock and household buildings. Expectations would have been for households to develop effective strategies to cope, but surprisingly an overwhelming proportion of households reported no adaptation (or did nothing) as a coping measure to flood. NGO or government supports, modern building techniques, early planting, improve drainage system and farming in lowland areas were identified as the other main coping strategies to flood. Several factors significantly influenced the adoption of these flood-induced coping measures. Among them are the size of household, farm size, access to credit, household income, access to electricity, membership with an FBO, source of seed for planting, farm size, location of household and the impact of drought on households.

On the other hand, the impacts of drought on affected households were poor yield or harvest, destruction of crops and livestock and water shortage. The main coping mechanisms households resorted to in the event of drought comprised irrigation or dry season farming, food storage, trees or cover crop planting, planting drought tolerant or early yielding crops and early planting. From the results of the BLR for coping strategies for drought, it was concluded that the literacy level of household head, size of household, farm size, access to credit, household income, source of seed for planting, membership with an FBO, gender, location of households, household head aged between 40-39 years and the impact of drought on households affected the probability of households adapting to drought conditions.

According to the study results, a limited number of factors significantly influenced the adoption of coping strategies for bushfire. They included radio ownership, gender, source of seed for planting, farm size, household income and the impact of bushfires on households. Surveyed respondents reported fire prevention education and improve farm management practices as the main tools used for adapting to bushfires.

Though the focus of this paper is on climate change, it is worth noting that the incidence of flood in most developing regions cannot be attributed entirely on changes in the ecosystem. Another contributory factor as shown implicitly from the result of the study is a matter of proper land, housing and infrastructure management (such as rivers overflowing their banks, choked gutters etc.).The quest for an improved drainage system as indicated by 14 percent of sampled households could explain this phenomenon. Management of the ecosystems to achieve reasonable outcome requires a concurrent management of local infrastructures.

Drawing on the results of the study, the need for appropriate government policies in mitigating the harsh effects of extreme climatic events on the well-being of households in the Bawku West district is quite apparent. Policies should be directed towards creating an enabling environment for households in the district to cope with climate extremes and this could be achieved through three comprehensive and interconnected policy instruments: improvement of human capital capabilities and access to information, investing in new and improving effectiveness of existing FBOs, and strengthening income-generating avenues available to farming households in the district.

Human capital development rest on educating households on the use of modern techniques on safety and mitigating against the impact of extreme climatic events. The current adult education program instituted by government needs to be strengthened to encourage and increase literacy level among older individuals most especially, women. In many African

countries women are responsible for food security and providing other basic needs of the family, but these women tend to have limited access to information which impairs their decision to adopt certain coping measures. Government policies should not only educate but also provide necessary information on anticipated weather and climate conditions. Such policy intervention could simplify and expedite information dissemination (on anticipated change in climate and necessary coping measures) through radio and other public media to enhance households' adaptive capacity.

The study results indicate that FBOs are effective in helping small holder farmers adapt to climate change. The investments in FBOs by donor agencies and non-governmental organizations since 2000 shows signs of a worth-while venture that needs not only to be continued but expanded and improved. FBOs facilitate easy access to extension, farm credit and educate farmers on the use of proper farm management techniques as it increases the likelihood of adaptation. Educating low-income household heads on proper farm management practices has the likelihood to deepen their adaptive skills.

Households better adapt to climate change if they utilized their own seeds for planting. Therefore, policies directed towards readily accessible and affordable improved seeds to households could be beneficial to adaptation. The recent breadbasket initiative in selected villages in Ghana by the Alliance for Green Revolution is typical of an income-generating source for farming households. Under this initiative, farmers gain access to extension service, and access to credit to purchase farm inputs like fertilizer and quality seeds. Such initiatives in the district would encourage income generation, minimize severe food shortage and increase the adaptive capacity of small holder farmers.

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ON THE CAUSAL LINKS BETWEEN EXPORTS AND ECONOMIC GROWTH IN COSTA RICA

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ABSTRACT

A large body of literature has investigated the export-led growth (ELG) hypothesis, which states that export growth is a major determinant of output growth. Because of its economic and political realities, Costa Rica represents an interesting case study of the ELG hypothesis, which is tested using time series (1960 - 2011) and applying a modified version of the Granger-causality test. *The path analysis technique is also used to account for direct and indirect effects of exports on GDP. The results show* causal relationships between exports and Costa Rica's GDP, between imports and output, import and exports, and between imports and capital formation.

Keywords: Export-led growth hypothesis, Costa Rica, modified Wald test, path analysis

JEL codes: F10, O49, O54

1. INTRODUCTION

The linkages between trade expansion and economic growth have received considerable attention from development economists over the last three decades. A large body of literature has investigated the so-called export-led growth (ELG) hypothesis, which states that export growth is a major determinant of output growth. Nevertheless, evidence from these studies

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has been mixed and often conflicting, thus the ELG hypothesis remains a debated topic and further research is warranted so that new findings may help governments implement more effective growth and development policies.

During the 1980s, many Latin American countries were affected by a severe economic crisis commonly known as the "debt crisis." This economic downturn exposed the shortcomings of the import substitution industrialization (ISI) development strategies adopted hitherto by many countries in the region. Furthermore, many Latin American countries responded to this crisis with the adoption of the Washington Consensus. Some of the economic measures prescribed by the Washington Consensus included deregulation, fiscal discipline, privatization and trade liberalization. In this context, and starting in the mid-1980s, Costa Rica gradually replaced an ISI model with an export-oriented development model. These new policies were behind the emergence of a dynamic export sector and an overall good economic performance. Because of its economic and political realities, Costa Rica represents an interesting case study of the ELG hypothesis that merits rigorous empirical analysis. This country has been regarded as politically stable, with a well-established democratic tradition, and a relatively well educated population. In only a few decades, Costa Rica transformed its economy from being relatively closed and highly dependent on few agricultural exports, to become the largest exporter of software per capita in Latin America. Additionally, and during the past twenty years, the volume of Costa Rican exports has grown significantly, and the export of goods and services as a share of Costa Rica's Gross Domestic Product (GDP) has gone from 21 percent in 1960 to almost 49 percent in 2006, and 39 percent in 2011 (World Bank 2012). This exports oriented agenda was based on the premise that export growth is conducive to economic growth. However, and as shown in table 1, Costa Rica has failed to attain the same high rates of economic growth experienced during the ISI period. Moreover, Costa Rica's recent exports surge has been heavily dependent on foreign companies that have invested there and used free trade zones as platforms to export their output to other markets. Interestingly, and according to the U.S. Department of Commerce (2011), just over half of foreign direct investment (FDI) in Costa Rica has come from the United States. The most notable examples of these investments are Del Monte, Dole, and Chiquita in the banana and pineapple industries, Motorola in the 1970s, DSC Communications Corporation in 1995, Intel's $ 300 million investment in 1997, and Procter and Gamble, Hewlett-Packard, Boston scientific, and Abbot's investments in the 1990s (Cordero and Paus 2008). These new nontraditional exports include electronic products, computer parts and medical devices, which became the nation's top exports.

Table 1. Average Rate of Economic Growth and Volatility of the Economic Growth Rate in Costa Rica

Average			Volatility (standard deviations)		
1965-1979	1980-1983	1984-2011	1965-1979	1980-1983	1984-2011
6.15	-1.48	4.76	2.55	4.40	2.65

Source: Author's own calculations based on data from the World Bank Development Indicators data.

While a number of studies have examined the economic impact of Costa Rica's export-oriented strategy, their mixed results raise questions about the real benefits of the recent surge

in non-traditional and high added-valued exports on the overall economy (Ferreira and Harrison 2012). The present study examines the causal relationship between exports and Costa Rica's output using recent advancements in time series techniques, and it contributes to the existing literature on the export-output nexus in multiple ways. Firstly, the ELG hypothesis is tested using longer data series (from 1960 to 2011) in conjunction with time series modeling techniques such as, a unit root test that accounts for structural breaks, and a modified version of the Granger-causality test (MWALD hereafter) developed by Toda and Yamamoto (1995) and Dolado and *Lütkepohl (1996). Then, path analysis technique is applied to account for direct and indirect effects of exports on GDP, and its results are compared to the results from the MWALD. Secondly, this study expands* the classical bivariate framework by including real imports as an endogenous variable in one model, and then capital and labor variables in another model. Furthermore, this study includes U.S. real GDP and a temporal dummy variable as exogenous variables in the estimation of the models. This step is warranted because Costa Rica's economy went through important structural reforms during the 1980s, and has been historically dependent on the United States. The inclusion of U.S. GDP in the model is particularly important given that the United States has been Costa Rica's main foreign investor and main trading partner, accounting for about 40 percent of Costa Rica's total imports (U.S. Department of Commerce 2011). The final contribution of this paper is the distinction made between GDP and non-export GDP, because exports themselves are a component of GDP. In order to avoid specification and simultaneity biases that would arise from this accounting problem, all models are estimated using Costa Rica's real GDP adjusted for exports.

The remainder of this paper is organized as follows. Section 2 includes a review of empirical literature on the ELG hypothesis and an overview of Costa Rica's export-based growth model. Section 3 discusses the proposed theoretical framework. Section 4 presents a historical overview of important events and policies that have affected Costa Rica's trade and economic performance in the last four decades. The econometric methodology and the data used are described in section 5. Finally, conclusions and policy implications are offered in section 6.

2. EMPIRICAL LITERATURE REVIEW

2.1. Linkages between Economic Growth and Exports

A large portion of the empirical research studying the effects of trade liberalization and export promotion policies has focused on the ELG hypothesis, which supports the argument that the growth of exports stimulates the overall economic performance. Economic theory provides a series of arguments that buttress this hypothesis. Firstly, export growth can lead to productivity gains because of greater economies of scale achieved with the enlargement of the market size. This is particularly important for small countries like Costa Rica with small domestic markets. Exports also provide additional foreign exchange that allows for increasing levels of imports of capital and intermediate goods. These imports are essential for industrialization and capital formation, which in turn stimulate output growth (Balassa 1978; Buffie 1992; Esfahani 1991; McKinnon 1964). Other potential benefits from export-led

growth are learning-by-exporting externalities. More specifically, a diffusion of technical knowledge may occur in the form of improved management practices and more efficient production techniques, and eventually these externalities are likely to be transmitted to the non-export sector (Grossman and Helpman 1991). Higher exposure to other markets provides an incentive for domestic firms to increase investment, become more efficient, and improve their production technology. All this will lead to a productivity differential in favor of the export sector, and when this sector expands at the expense of other sectors, a positive impact on aggregate output is expected. Finally, export growth can lead to production specialization based on comparative advantages in international markets, which results in a more efficient allocation of a nation's resources.

The study of the role of exports on economic growth is a recurrent issue in the international trade and economic development literature, and there are an ample number of empirical studies that tested the ELG hypothesis[1]. Early studies began analyzing the linkages between export and economic growth using a simple bivariate correlation modeling framework (Emery 1967; Kravis 1970). More econometrically involved models were later developed to test the ELG hypothesis, and these studies can be categorized in two main groups. Due to lack of long time-series data, the first group consisted of cross-countries studies that examined the export-growth nexus using cross-sectional or panel data. Pioneering work in this group includes the studies of Balassa (1978a), Feder (1983), Heller and Porter (1978), Kavoussi (1984), Michalopoulos and Jay (1973), Michaely (1977), Tyler (1981), and Voivodas (1973). Overall, these cross-sectional studies found a significant and positive relationship between export growth and output growth. However, these findings have been criticized because they implicitly assumed that countries share common characteristics and have similar production technologies, when in reality they may have different economic, political and institutional structures[2].

With the development of time series methodologies and longer data sets, a large number of new studies have tested the ELG hypothesis for individual countries, often using Granger-causality tests. While results from cross-countries studies generally support the economic role of exports, time series studies have been less conclusive and failed to provide strong support for the ELG hypothesis (Ahmad and Kwan 1991; Chow 1987; Hsiao 1987; Jung and Marshall 1985). More recent empirical research has employed cointegration and error-correction modeling, and found evidence of a bi-directional causality between exports and growth (Ahmad and Harnhirun 1995; Kugler and Dridi 1993).

2.2. Overview of Costa Rica's Export-Based Growth Model

Evidence of the ELG hypothesis in Costa Rica has been mixed and inconclusive, and further research is warranted. While a number of time series studies found some evidence in favor of the ELG hypothesis for this country, others failed to do so. Using Ordinary Least Square (OLS), Bivariate Granger, and Vector Autoregressive models (VAR), Dodaro (1993) examined the ELG hypothesis for 87 countries for the period of 1967 to1986 and confirmed that exports Granger-caused economic growth in Costa Rica. In another study, Van den Berg

[1] Giles and Williams (2000a) and Bahmani-Oskooee and Economidou (2009) provide comprehensive surveys of the empirical research on the ELG hypothesis by reviewing papers published between 1963 and 1999.

[2] For a critical review of cross-country studies see Giles and Williams (2000).

and Schmidt (1994) studied seven Latin American countries using annual data from 1960 to 1987, and found a significant relationship between output and exports in Costa Rica. Sharma and Dhakal (1994) tested causality between exports and growth in 30 developing countries over the period of 1960 to 1988 using two different models. The first model reflected a neoclassical production function with domestic output, exports, labor and capital as endogenous variables, while the second estimated model tested for causality between exports, domestic output, exchange rate, and foreign output. The results for Costa Rica also showed causality running from exports to output. The ELG hypothesis was also tested within a production function framework by Amirkhalkhali and Dar (1995), who examined the role of export expansion in the economies of 23 developing countries between 1961 and 1990. A positive and significant impact of exports on economic growth was found in nine out of 11 Latin American countries, including Costa Rica. In another study, Riezman et al. (1996) investigated the ELG hypothesis for 126 countries using annual data for the period of 1950 to 1990. This study lends support to the ELG hypothesis for only four countries within the Latin American region, including Costa Rica. Medina-Smith (2001) specifically tested the ELG hypothesis for Costa Rica employing cointegration procedures and using annual data for the period of 1950 to1997. Once again, a long-term relationship was found between GDP and exports.

Despite evidence found supporting the ELG hypothesis for Costa Rica, a series of other studies have questioned the existence of an export-growth nexus in Costa Rica. Amade and Vasavada (1995) examined the relationship between real agricultural output and real agricultural exports for 17 Latin American countries and 17 Asian and Pacific Rim countries for the period of 1961 to 1987. The ELG hypothesis was not confirmed within the Costa Rican agricultural sector. Pomponio (1996) examine both the bivariate causal relationships between manufactured export growth and manufactured output growth, and the trivariate causal relationships between manufactured exports, investment and manufactured output. For the bivariate case, no causality was found between exports and output in Costa Rica, and only when the investment variable was included, output and investment were found to cause exports. More recently de Piñeres and Cantavella-Jordá (2007) tested Granger causality running from exports to GDP growth for several Latin American countries using different methodologies and data sources. Once again mixed results were found for the case of Costa Rica. Finally, Ferreira and Harrison (2012) used the autoregressive distributed lags (ARDL) and dynamic OLS (DOLS) models and found no long-run relationship between export diversification and growth.

3. THEORETICAL FRAMEWORK

Based on methodology and evidence from previous research, this study proposes three different theoretical frameworks to test the ELG hypothesis for Costa Rica:

$$Y = f\,[(X);\ USY,\ T] \tag{1}$$

$$Y = f\,[(X,\ M);\ USY,\ T] \tag{2}$$

$$Y = f\,[(K,\ L,\ X);\ USY,\ T] \tag{3}$$

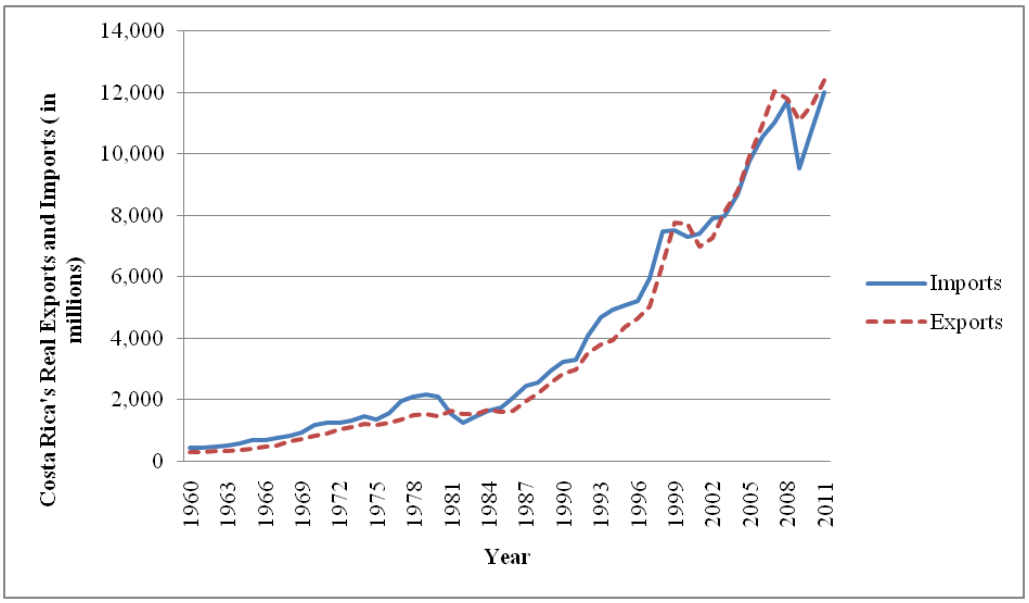
where Y represents Costa Rica export-adjusted real GDP, and X, M, K, L, USY, and T represent real exports, real imports, gross fixed capital formation (as a proxy to capital), labor force, the United States real GDP as a proxy to the foreign economic shocks, and a step time dummy variable that accounts for the economic crisis and the subsequent structural economic reforms, respectively. Each of these three models represents an attempt to overcome some of the problems commonly found in previous studies that questioned the validity of their results. Y, M, X, K, and L will be estimated as endogenous variables, while the last two variables (USY and T) are included in all three models as exogenous variables[3]. The first issue being addressed is one raised by Greenaway and Sapsford (1994), who cautioned about the need for distinguishing between GDP and non-exports GDP. This is important because exports themselves are a component of GDP, and the results from past studies that failed to handle this accounting problem inevitably suffered from specification biases and simultaneity. To avoid this problem all models are estimated using Costa Rica adjusted of exports real GDP[4].

Model 1 represents a classic bivariate framework that was commonly used in early studies to test for Granger-causality between real GDP and real exports. However, it has been widely accepted that causality tests are sensitive to model selection and functional forms, and that bivariate tests fail to consider other relevant determinants of economic growth (Xu 1996). Another problem identified by scholars has to do with testing the ELG hypothesis using Granger-causality without including imports as an explanatory variable. This can potentially generate misleading results because imported capital goods are inputs for both export and domestic production. As figure 1 shows, the level of Costa Rica's exports and imports follow very similar patterns and have greatly increased following the liberalization of the economy in the mid-1980s. Growing exports will earn additional foreign exchange that may relieve constraints to the import of capital goods, which in turn could result in economic growth. Riezman et al. (1996) tested the ELG hypothesis in 126 different countries, and when a bivariate framework was used they confirmed it in only 16 countries. However, when imports were included in the estimations, the number of cases increased to 30. The inclusion of real imports in model 2 will mitigate this potential variable omission bias.

An augmented Cobb-Douglas production function is presented in model 3, in where real exports are included as an additional input. This approach aims to handle variable omission bias by including capital and labor in the estimation of a VAR model, and in subsequent Granger-causality test. Finally, the inclusion in all models of the U.S. real GDP and a step dummy time variable as exogenous variables seeks to correct for misspecification bias that would cast doubts in the final results of this study. The rational for the inclusion of these exogenous variables is to account for external economic shocks or internal economic reforms that are likely to have important repercussions in a small open economy like the case of Costa Rica.

[3] These variables are assumed to affect the variables system but are not influenced by the endogenous variables. For a small open economy like Costa Rica that is highly dependent on the economy of the U.S., USY will account for output shocks in that country. On the other hand, the step time dummy variables attempts to account for the crisis and structural reforms that affected the proposed endogenous variables.

[4] To compute the real GDP adjusted of exports, real exports were subtracted to total real GDP. Both variables are in 2000 US $.



Source: World Development Indicators, World Bank (2008).

Figure 1. Costa Rica Real Exports and Imports at 2000 US$ Constant Prices (1960-2011).

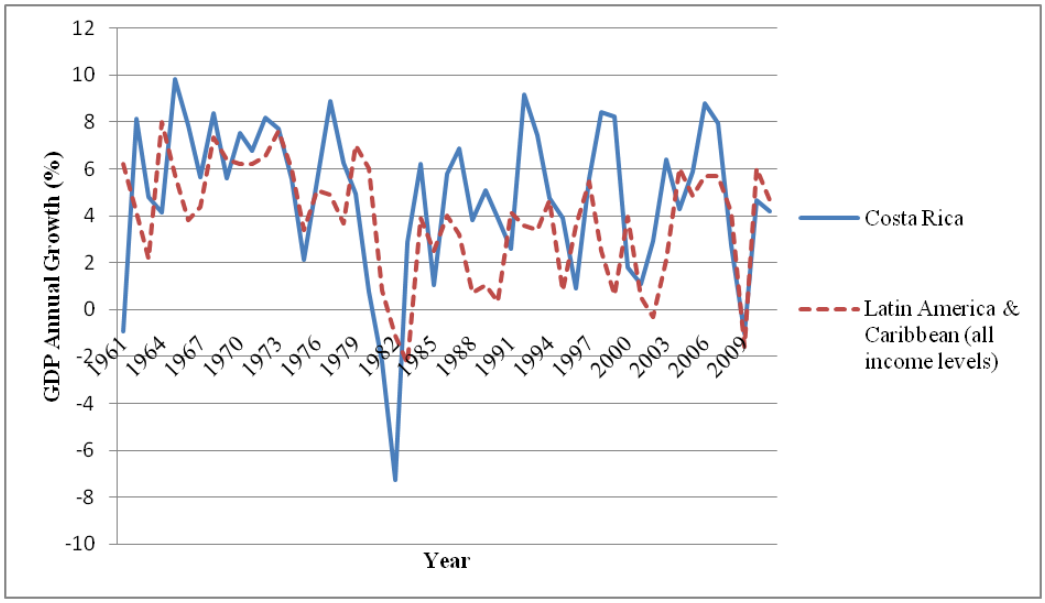
4. EXPORTS AND ECONOMIC GROWTH IN COSTA RICA

Costa Rica is a small open economy[5] often lauded for relative economic stability and a long democratic tradition. Its population of little over four million people has an income per capita that is above the Latin American average. Following the disbandment of the national army in 1948, which freed up millions of dollars, the Costa Rican government began to play a very active role in the economy and made large public investments in education and health sectors during the 1950s, 60s, and 70s (Villasuso, 1999). Consequently, Costa Rica became a forerunner in Latin America in the provision of universal education and healthcare to its population. In terms of economic performance, as figure 2 reveals, Costa Rica has consistently outperformed Latin America from 1961 to 2011. Overall, Costa Rica's economy has expanded at an average annual rate of almost five percent, while Latin America grew at an average rate of less than four percent. Nevertheless, during the debt crisis that affected the region in the early 1980s, the economy of Costa Rica suffered a more severe contraction than the average of Latin America.

In addition to its relatively successful economic record, Costa Rica's exports experienced impressive growth and important changes in its structure. This nation went from being highly reliant on the exports of a few primary goods to having flourishing high-tech and medical equipment manufacturing export sector, and well diversified agricultural and service sectors. In order to better identify the linkages between economic growth and exports in Costa Rica it is imperative to have a good understanding of the economic history of this country in the past decades and review some of the policies implemented to support the export sector. The

[5] The CACM is an economic trade organization established on December 13 of 1960 and it included Guatemala, El Salvador, Honduras, Nicaragua and later Costa Rica.

remainder of this section examines the historical changes of Costa Rica's export sector and divides it into three important periods of time.



Source: Word Development Indicators, World Bank (2008).

Figure 2. GDP annual growth (%) of Costa Rica and Latin America (1961-2011).

4.1. Period of Import Substitution Industrialization (1960 to 1979)

After World War II, Costa Rica was considered an agro-exporting economy due to its high dependence on the exports of a few agricultural products. More specifically, coffee and bananas alone accounted for almost 90 percent of the value of Costa Rica's total exports, and drove economic growth through the 1960s (Mesa-Lago et al. 2000). Because of the vulnerability of this economic model to external shocks and commodity prices oscillations, Costa Rican authorities adopted a new development model that would transform the country's economy during the 1960s and 1970s. This new strategy was based on industrialization through import substitution, in particular of consumer goods, and its beginning was marked by the enactment of the Industrial Protection and Development Law in 1959. Furthermore, this strategy included high tariff rates for consumer goods, low import taxes for intermediates and capital goods, and the application of export taxes to goods in which Costa Rica had a strong comparative advantage (Cattaneo et al. 1999). This new economic environment stimulated investments in domestic industry, which resulted in years of high average annual growth rates in the industrial sector - above nine percent between 1965 and 1973 (Villasuso 1999). Nevertheless, this economic protectionism alone would not address the fact that Costa Rica's small domestic market lacked the capability of sustaining GDP growth on the demand size. This policy would also reduce the chances of producing certain goods that are subject to economies of scale, and it would represent an important obstacle to Costa Rica's infant industrial sector. One initial response to this problem was the entry of Costa Rica to the

Central American Common Market (CACM) in 1963. The CACM allowed for free trade among the five signatory countries and implemented a common external tariff. For Costa Rica's export sector it meant an expansion of its market from nearly two million to approximately 15 million potential consumers (Zimbalist 1988), and the CACM became the main destination market for its manufactured consumer goods.

The adoption of an ISI model and the incorporation of Costa Rica into the CACM resulted in the creation of new industries and in the increase of the share of manufactured goods to the country's exports. Textiles and shoes produced by the *maquiladoras* were amongst Costa Rica's first nontraditional manufacturing exports (Barhman et al. 1992). Later , and during the administrations of Presidents Figueres (1970-1974) and the Oduber (1974-1978), Costa Rica authorities began to gradually move away from the ISI model and supported a new set of policies that encouraged the creation of new industries. These new industries would be sufficiently competitive to export to world markets and would use domestic inputs more intensely. As part of these efforts, a new economic and social development plan was designed for the 1972-1978 period and it would include further reduction of the nation's dependence on primary commodities, and the expansion of manufactured exports to other countries outside the CACM. In 1972, the Export Promotion Act was enacted to promote nontraditional exports via fiscal incentives, and Costa Rica's central bank financed the creation of a new public agency - the Costa Rican Development Corporation (CODESA). CODESA operated as a government holding company and would enter into joint ventures as a majority shareholder with private firms in order to develop important sectors of the economy (Mitchell and Pentzer 2008). CODESA was also in charge of supporting new productive activities and the promotion of Costa Rican exports. In addition, Costa Rica built a relatively good transportation infrastructure (airports, roads and ports) that facilitated trade and the integration of its economy in world markets (Villasuso 1999).

Overall, Costa Rica experienced high rates of economic growth during this period, with real benefits for its population in terms of education, health and economic prosperity. New industries were created such as fertilizers, pharmaceutical goods, clothing products, fungicides and insecticides, plastic goods, galvanized metal sheets, tires, leader products and synthetic fabrics (Colburn and *Patiño* 1988; ECLAC 1977b). Nevertheless, it was not until the mid-1980s, as a reaction to the economic crisis affecting the country, that the most important export-promotion policies were successfully implemented.

4.2. Period of the Debt Crisis and the Structural Reforms (1980-1983)

After years of uninterrupted economic prosperity, Costa Rica experienced one of its worst economic crises in the early 1980s. This crisis was the result of unsustainable foreign borrowing, rising oil prices and real interest rates, and unfavorable international prices (Buttari 1992; Gutiérrez de Piñeres and Ferrantino 2000; Weeks 1985). National production was greatly reduced in the agricultural, industrial and construction sectors, and between 1980 and 1982, the nation's GDP contracted by almost ten percent. As figure 2 shows, the contraction of Costa Rica's economy was more severe than of Latin America in general. The unemployment rate reached almost ten percent, while the inflation rate reached ninety percent by 1982 (Mitchell and Pentzer 2008). This crisis also exposed some of the intrinsic

weaknesses of the ISI model, namely the dependence of the domestic industrial sector on imported inputs, the relatively small size of the domestic and Central American markets, and the unsustainable levels of public debt. Consequently, in the early 1980s, a number of international financial organizations (the World Bank, the International Monetary Fund (IMF), and the *United States Agency for International Development (USAID*) assisted Costa Rican authorities in the implementation of a series of structural adjustment programs. The new policies pushed for a gradual opening of the economy, further promotion and diversification of production and exports, and the reduction of government expenditures (Cattaneo et al. 1999). It is worth noting that during this period, Costa Rica was regarded by the USAID as a testing ground for its export promotion programs that were to be later implemented in other developing economies (Clark 1995). In the domestic arena, a national political consensus was reached over a sustained economic recovery via export promotion and an increase of inflows of foreign capital - in particular in nontraditional export sectors. Subsequently, in 1982 the newly elected administration began the implementation of an economic stabilization package. The years of 1984 and 1985 can arguably be considered the starting point of the new and ongoing development model because of the numerous economic measures implemented. More specifically, in 1984, a cabinet-level Ministry of Exports (MINEX) was created to: (1) promote Costa Rican exports to new markets; (2) simplify trade procedures; (3) coordinate policies from other export promotion agencies; (4) reduce or eliminate export taxes; (5) fees and streamline procedures for exporting. Also in 1984, the Caribbean Basin Initiative (CBI) came into effect and was designed to spur economic revitalization in the region by giving all Central American and Caribbean countries (with the exception of Nicaragua) duty-free access to the U.S. market for most of their products. The CBI provided comparative advantages to Costa Rica's agribusinesses, assembly and light manufacturing, thus stimulating exports in those sectors. One year later, Costa Rica's government began a gradual implementation of a comprehensive structural adjustment program that included measures to improve the financial environment, the launch of a trade reform program, and the creation of several new governmental agencies. At the same time, the USAID financed the creation of CINDE (Coalición Costarricense de Iniciativas de Dessarollo) - Costa Rican Investment Promotion Agency. A central goal of this non-governmental agency was the attraction of foreign firms from the electronic, medical equipment, and service sectors. Additional, this institution pushed legislation that created a series of new export incentives and provided technical assistance to producers of nontraditional agricultural exports. In 1985, another public agency, the National Investment Council, was created to assist Costa Rican firms that wanted to export their products. As the structural reforms gained momentum, president Arias Sánchez was elected in 1986 and declared that the main objective of his administration would be the consolidation of the economic recovery through an increase and diversification of the nation's exports (Villasuso 1999).

4.3. Period of Foreign Direct Investment and Export Diversification (1984-2007)

This period was characterized by a very rapid expansion of real exports as it is shown in figure 1. It is important to note that the small reduction in exports registered around the year

2000 was caused by the economic recession affecting the United States and other countries around the World. Also during this period, exporters continued to benefit from a strong domestic political backing, and government support that included exchange-rate reforms, export tax reduction, and subsidies. Furthermore, three regulatory frameworks were designed to help nontraditional exporters namely export contracts, the temporal admission regime (TAR), and the free trade zones (FTZ) regime[6]. Consequently, Costa Rica export supply went through important changes during this period.

From 1983 to the early-1990s, the expansion of nontraditional exports continued with economic assistance from the United States, and the early leading products included textile products, fresh and frozen fish and shrimp, flowers, ornamental plants and foliage, and fresh pineapple (Clark 1995; Clark 2001). Support to the export sector continued throughout the second half of this period with the implementation of further measures and the creation of new institutions.

In 1996, the Promotora del Comercio Exterior de Costa Rica (PROCOMER) was created to assist local firms that wanted to export their products. More specifically, PROCOMER has been providing several services that include the participation in international fairs, the organization of business and trade missions, the maintenance of the "Market Place Costa Rica" website, etc. (Martínez, Padilla, and Schatan 2008). Also in 1996, the export contracts and the TAR were replaced by two new regimes: the Régimen Devolutivo de Derechos and the Régimen de Perfeccionamiento Activo. These two new regimes grant firms tax exemptions without the issuing of redemption certificates (ECLAC 2000). Since 1997, the Ministry of Foreign Trade (COMEX) has been working closely with CINDE for FDI attraction and with PROCOMER for export promotion.

It is important to understand that despite the visible increase in volume of Costa Rica's exports, in particular of industrial goods, a great share of these exports has been produced by foreign firms operating from the FTZs. According to Arce et al. (2008), in 2007 exports from FTZs accounted for almost 55 percent of Costa Rica's total exports and included mainly industrial products produced by multinational corporations (i.e. computer parts, electronics, medical equipment, textiles, and processed food products).

5. DATA AND ECONOMETRIC METHODOLOGY

5.1. Data

The data set used in this paper consist of annual observations obtained from the 2012 *World Development Indicators* on Costa Rica real GDP, real exports, real imports, gross fixed formation capital (as a proxy to capital), labor force, and the United States real GDP (as a proxy to the foreign economic shocks).

All variables are expressed in 2000 constant U.S. dollars, with the exemption of labor force and time dummy variable which are measured in their respective units, and were transformed into the logarithm form. Given data availability, for all models, the sample period

[6] Because all variables exhibit linear upward trends, the unit root tests were computed with an intercept together with a trend. However, the same tests were also computed without a trend and no major qualitative differences were found between the two versions.

goes from 1960 to 2011 (Complete variable definitions and data sources are provided in Appendix 2).

5.2. Modified Version of the Granger Causality Test

The cointegration technique proposed by Johansen (1988) and Johansen and Juselius (1990) has been often used to examine the relationship between exports and economic growth. Both procedures are based on the error-correction representation of the VAR(*k*) model with Gaussian error, but when there are more than two cointegration vectors this may be problematic. Furthermore, the power of cointegration likelihood ratio (LR) tests of Johansen and Juselius (1990) is high only when the correlation between the shocks that generate the stationary and non-stationary components is high, and their power tends to rapidly deteriorate when there is over-specification of the lag length (Bewley and Yank 1996; Toda 1994).

One additional problem is the reliance of this method on conventional unit root and cointegration tests, which in turn were found to suffer from size distortions, and to have relatively low power (Giles and Mirza 1998). In other words, there are potential distortions associated with tests for unit roots and cointegration, and the stability. Consequently, the stability and rank conditions are not fulfilled when there is more than one cointegrating vector in a multivariate model. Finally, it has been argued by Toda and Phillips (1993) and Zapata and Rambaldi (1997) that when variables are integrated or cointegrated, the standard Granger-causality tests no longer have asymptotic properties, and the F-test based on VAR or error correction model (ECM) estimations are no longer valid.

This study applies the modified version of the Granger causality test (MWALD) proposed by Toda and Yamamoto (1995) and Dolado and *Lütkepohl (1996)* to test restrictions on the parameters of the VAR(*k*) model. The MWALD procedure has a number of advantages over the commonly used multivariate ECM, whose results are well known to be sensitive to the number of variables, lag length selection and the choice of the normalizing cointegration. More specifically, the MWALD is a more flexible tool that does not require prior knowledge of cointegration properties of the system, and can be carried out even when there is no cointegration and/or the rank conditions are not satisfied (Zapata and Rambaldi 1997). In other words, results from the MWALD procedure *are valid* independently of the *integration and cointegration features of the series, which mitigates potential pretest biases* (Caporale and Pittis 1999).The MWALD also reduces the impact of pre-testing on the conclusions regarding causality, although knowledge of the maximum order of integration and lag structure is still required.

The implementation of this method requires two steps. The first step includes determination of lag length (k) and the maximum order of integration ($d_{\max}$) of the variables in the system. Unit root tests are conducted to determine the maximum order of integration d of all variables in the system, and the appropriate lag structure of the VAR is selected by minimizing the values of the Akaike's information criterion (AIC), the Schwarz's Bayesian criterion (SBIC), and the Hannan and Quinn information criterion (HQIC). Then, the selected lag length (k) of the VAR is artificially augmented by the maximum order of integration in the system ($d_{\max}$). Finally, the VAR(p) represented in equation 4 is estimated with all variables with a total of $p = [k + d(\max)]$ lags

$$Z_t = Z_0 + Z_1 y_{t-1} + \ldots + Z_p y_{t-p} + \varepsilon_t \; t = 1, \ldots, T \quad (4)$$

where Z_t is a vector of different endogenous variables, and ε_t is a zero-mean, serially uncorrelated random term. For the three different proposed models, the vector Z_t includes the following variables:

$$\text{Model 1: } Z_{1t} = (Y, X) \quad (5)$$

$$\text{Model 2: } Z_{2t} = (Y, X, M) \quad (6)$$

$$\text{Moldel 3: } Z_{3t} = (Y, K, L, X) \quad (7)$$

The second step includes conducting inference on Granger causality by carrying out the standard Wald tests to the first *k* VAR coefficient matrix, which are included in equations 8 through 16 (see Appendix1). The MWALD has an asymptotic chi-squared distribution with *k* degrees of freedom in the limit when the VAR [$k + d(\max)$] is estimated, and the order of integration of the process cannot be greater than the true lag length of the model, that is $d(\max) \leq k$. Since all the variables are in levels, the results provide information about the long-run causal relationships among the variables in the VAR system.

5.3. Path Analysis

Path analysis is used to describe the direct dependencies among a set of hypothesized explanatory variables, and it involves staging or building the model through several regression stages. This method involves simultaneous analysis of multiple causal relationships among variables, which in turn allows the discovery of the direct and indirect effects among the model's variables. More specifically, while direct effects represent a directional relation between two variables, indirect effects are the effect of an independent variable on a dependent variable through one or more intervening or mediating variables. This methodology will be used in order to have a better understanding of how the hypothesized relationships might occur and through which paths. Its results will be compared with the findings from the MWALD, and they will shed light on the relationships between exports, imports, capital and economic growth in Costa Rica.

6. EMPIRICAL RESULTS

6.1. Unit Root Tests

Prior to testing for causality, it is necessary to establish the order of integration of each variable. A visual inspection of the plots of each variable, and of the autocorrelation functions (ACF) and partial autocorrelation functions (PCF) suggest that all variables are linearly trended. Even though this implies that the series are potentially non-stationary, formal unit root tests are still needed for more concrete conclusions. Initially the stationarity of the series

is investigated via the following unit root tests: the augmented Dickey-Fuller (ADF), the Phillips-Perron (1988) test (PP), the Kwiatkowski et al. (1992) test (KPSS), and a modified Dickey-Fuller test (DFGLS) proposed by Elliot et al. (1996). These tests are applied to the variables in log levels and in first differences of the logs, and the results are shown in table 2 [7]. With the exception of the KPSS test, when the Z(t) value from the test is greater than the critical value, then the null hypothesis of a unit root will be rejected and the series is said to be stationary. Overall, the tests strongly suggest that, at the 5 percent level of significance, none of the variables in log levels represent a stationary process. However, and after applying first differences, the same tests show that all variables are integrated of order one, *I*(1). However, it is important to note that when testing for stationary of a series exhibiting a structural break, these conventional unit root tests tend to identify a structural break in the series as evidence of non-stationarity, and thereby fail to reject the null hypothesis of non-stationarity (Lumsdaine and Papell 1997). An analysis of the plots of series reveals that most of the variables exhibit a change in their mean in the early 1980s. This time period coincides with the severe economic crisis that affected the country, and with the important structural economic reforms that were implemented in the early 1980s. To formally evaluate the time series properties in the presence of a structural break at an unknown point in time, the Zivot and Andrews (1992) (ZA) unit root test is undertaken. This test has a null hypothesis of a unit root process, and after utilizing the full sample it will use a different dummy variable for each possible break date. The break date is then selected where the t-statistic from the ADF test of unit root is at a minimum (most negative). Hence, a break date will be chosen where the evidence is least favorable for the unit root null hypothesis. Table 2 presents results that confirm that all variables are *I*(1) even with the presence of structural breaks. Finally, most of the break dates fall between 1979 and 1985, which coincides with period of economic downturn and resulting reforms. Overall, the results from the stationarity tests used appear to be consistent for most variables, which in turns allows for a more accurate estimation of MWALD procedure.

6.2. Granger Causality Tests

Different diagnostic tests that are commonly present in time series econometrics analysis were used to confirm the validity of the results after the estimation of each VAR model and prior to the employment of the MWALD procedure. Previous time-series studies using VAR models have assumed that the errors associated with a given time period do not carry over into future time periods. Although the presence of serial correlation does not affect the unbiasedness or consistency of OLS estimators, it does however affect their efficiency. Ultimately, this will lead to a R^2 that is too large and an error variance that is smaller than the true variance. This study applies the Breusch-Godfrey test and no high order serial correlation in the disturbance was found. Furthermore, the Jarque-Bera statistic, a kurtosis statistic, and a skewness statistic were also computed to test the null hypothesis that the disturbances in the VAR systems are normally distributed.

[7] Because all variables exhibit linear upward trends, the unit root tests were computed with an intercept together with a trend. However, the same tests were also computed without a trend and no major qualitative differences were found between the two versions.

Table 2. Unit Root Tests for All Variables (1960-2011)

Variable	Unit Root Tests										
	ADF		PP		KPSS*		DFGLS		ZANDREWS		
Levels	Z(t)	5%	Z(t)	5%	Z(t)	5%	Z(t)	5%	Z(t)	5%	Year
LAGDP	-1.894	-3.499	-1.994	-3.499	0.189	0.146	-1.528	-2.931	-5.030	-5.080	1981
LX	-1.677	-3.499	-1.981	-3.499	0.075	0.146	-3.307	-2.802	-3.006	-5.080	1979
LM	-2.061	-3.499	-2.390	-3.499	0.068	0.146	-2.661	-2.931	-4.312	-5.080	1981
LL	0.393	-3.499	0.256	-3.499	0.229	0.146	-0.321	-3.166	-1.096	-5.080	1979
LK	-2.716	-3.499	-2.907	-3.499	0.065	0.146	-2.747	-3.166	-4.956	-5.080	1980
LUSGDP	-1.41	-3.499	-1.583	-3.499	0.151	0.146	-1.977	-3.166	-4.487	-5.080	2003
First Differences											
ΔLAGDP	-4.968	-3.500	-4.954	-3.500	0.096	0.146	-2.081	-2.991	-5.84	-5.08	1980
ΔLX	-5.951	-3.500	-5.941	-3.500	0.068	0.146	-3.872	-3.171	-7.098	-5.08	1987
ΔLM	-5.441	-3.500	-5.381	-3.500	0.061	0.146	-4.009	-3.097	-6.504	-5.08	1983
ΔLL	-4.751	-3.500	-4.853	-3.500	0.076	0.146	-2.612	-3.171	-6.098	-5.08	2003
ΔLK	-7.201	-3.500	-7.202	-3.500	0.046	0.146	-4.920	-3.171	-7.798	-5.08	1985
ΔLUSGDP	-5.629	-3.500	-5.553	-3.500	0.068	0.146	-4.996	-3.171	-6.379	-5.08	1983

*The Kwiatkowski, Phillips, Schmidt, Shin (KPSS, 1992) test difers from the other conventional unit root tests by having a null hypothesis of stationarity and is often used in conjunction with those tests to investigate the possibility that a series is fractionally integrated (that is, neither I(1) nor I(0)).

Table 3. Results of Granger Causality Tests between Economic Growth and Macroeconomic Variables for Costa Rica - Without the Inclusion of US GDP and Time Dummy as Exogenous Variables (1960-2011)

Direction of granger causality	Chi-square	p-value from causality test
Model 1		
Exports → AGDP	10.199	0.017**
AGDP → Exports	1.299	0.729
Model 2		
Exports → AGDP	19.149	0.000***
AGDP → Exports	2.955	0.399
Imports → AGDP	10.840	0.013**
AGDP → Imports	0.334	0.953
Imports → Exports	17.522	0.001***
Exports → Imports	4.613	0.202
Model 3		
Exports → AGDP	10.290	0.006***
AGDP → Exports		
Imports → AGDP	4.798	0.083*
AGDP → Imports	0.885	0.643
Imports → Exports	16.046	0.000***
Exports → Imports	0.874	0.646
Imports → Capital	5.203	0.074*

*, **and *** denote 10, 5 and 1 per cent level of significance respectively.

The results here are consistent and show that the residuals are normally distributed. Finally, the eigenvalue stability condition was confirmed for all estimated models after the estimation of the parameters of a vector autoregression.

For the purpose of comparison, the MWALD test was carried out for the three models with and without the inclusion of the two proposed exogenous variables (U.S. real GDP and a temporal dummy variable). Table 3 shows the results from the MWALD test without the exogenous variables, while table 4 corresponds to the causality test results including the exogenous variables. The first column states the direction of the granger causality tested, the second column shows the overall significance of the models, and the third column indicates whether or not Granger causality is significant or not.

In the bivariate model, a positive causality between exports and output is found only when the exogenous variables are not included (table 3). Interestingly, in the models where imports are included, causality between exports and output is both positive and statistically significant at one percent. Positive and significant causalities were also found between imports and output and between imports and exports in both tables 3 and 4. Finally, in the augmented production function model, the positive causality between exports and output remains statistically significant.

Table 4. Results of Granger Causality Tests between Economic Growth and Macroeconomic Variables for Costa Rica - With the Inclusion of US GDP and Time Dummy as Exogenous Variables (1960-2011)

Direction of granger causality	Chi-square	p-value from causality test
Model 1		
Exports → AGDP	2.790	0.425
AGDP → Exports	1.242	0.743
Model 2		
Exports → AGDP	9.642	0.022**
AGDP → Exports	3.660	0.160
Imports → AGDP	10.462	0.015**
AGDP → Imports	0.577	0.902
Imports → Exports	16.964	0.001***
Exports → Imports	2.319	0.509
Model 3		
Exports → AGDP	4.951	0.804*
AGDP → Exports	6.118	0.047**
Imports → AGDP	3.820	0.148
AGDP → Imports	0.904	0.636
Imports → Exports	6.728	0.035**
Exports → Imports	0.522	0.770
Imports → Capital	5.286	0.071*

*, **and *** denote 10, 5 and 1 per cent level of significance respectively.

The causality between imports and output is now only significant at the ten percent level when the exogenous variables are not included, but imports continue to Granger cause exports in both tables. These results suggest that the long-run causal relationship between exports and GDP growth may be affected indirectly by real imports. In other words, the significant causality from imports to exports may be an indication of the dependence of Costa Rica's export sector on the imports of specific inputs. To further investigate this possible relationship the Granger causality between imports and capital formation in Costa Rica was analyzed. Regardless of the inclusion or not of the exogenous variables, a positive and statistically significant at the 10 percent level causality was found between imports and gross capital formation. Arguably, these results reflect the importance of efficiency-seeking FDI in Costa Rica, which in turn has led to increased dependence on imports of capital goods and manufacturing inputs to support the growth of manufactures exports - whose share to total exports has increased from 28 percent in 1980 to almost 65 percent in 2007. As described earlier on this paper, Costa Rica's export sector and its dependence on foreign firms is the result of an industrialization strategy emphasizing the attraction of high-tech FDI. This has been done under the premise that capital investments from these industries has a greater potential for spillover effects in comparison to other not so technologically intensive sectors. Another expected externality has been the formation of backward linkages between foreign

investors and domestic firms. Nevertheless, some scholars have questioned the actual benefits of this model to the overall economy. Ciarli and Giuliani (2005) reported that on average. between 2001 and 2003 merely five percent of the inputs processed in Costa Rica by high-tech firms were provided by local suppliers. In a case that has remarkable similarities to Costa Rica, Lall (1995) argued that Malaysia excessive reliance on foreign-dominated electronics created a shallow industrial sector with very limited linkages with the rest of the economy and a weak national technological base.

6.3. Path Analysis

Path analysis is now applied to confirm the robustness of the findings from the MWALD regressions and to identify direct and indirect effects of exports on GDP. Based on the results from the MWALD, the following direct and indirect relationships between variables are hypothesized in figure 3. While the solid arrows indicate direct effects of the suggested variables on economic growth, the dashed lines *represent* indirect effects of an independent variable on growth through one or more intervening or mediating variables. Three regressions were estimated simultaneously to account for multiple causal relationships among variables, and all variables were transformed to first differences. More specifically, one regression included all variables in the augmented production function, a second one regressed exports on imports, and a third one regressed capital on imports. The path analysis was conducted without and with the inclusion of the two exogenous variables, and the results are shown in tables 5 and 6, respectively. In both cases exports have a positive and highly significant direct effect on economic growth, which confirms the estimated causality relation found by the MWALD. Also in the main regression, a positive and significant direct effect of imports on output was identified. The results from the two other regressions were also in accordance with the estimated Granger causalities. Path analysis shows that imports have a positive and highly significant direct effect on exports, which in turn is also interpreted as its indirect effect on through exports output. On the other hand, imports have a positive and significant direct effect on capital formation, which confirms the Granger causality between these same two variables. Once again, they were no significant differences between the results from the estimated models that included or omitted the U.S. GDP and the time dummy variables.

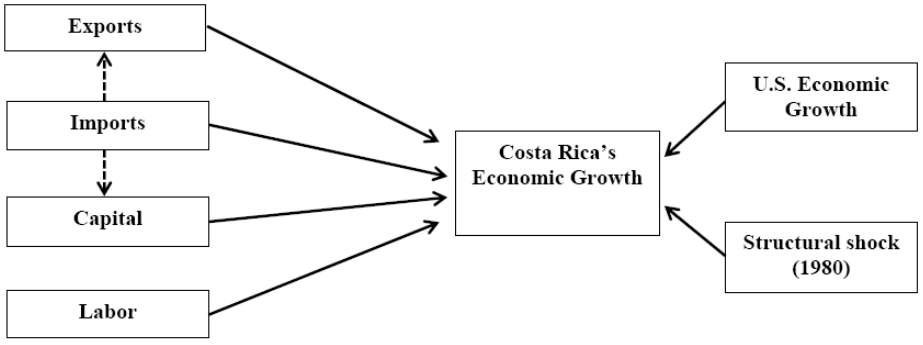


Figure 3. Framework Explaining the Sequential Linkages between Imports, Capital, Exports and Economic Growth.

Table 5. Results of Path Analysis: Causal Linkage between Exports, Imports and Economic Growth in Costa Rica - Without the Inclusion of US GDP and Time Dummy Variable (1960-2011)

Proposed relationship	β
**Direct linkages between economic growth, exports and imports*	
ΔLAGDP = constant + 0.352(ΔLX)*** + 0.427(ΔLM)*** + 0.159(ΔLL) + 0.281(ΔLK)*	
Constant	
Exports on economic growth	0.352(2.81)***
Imports on economic growth	0.427(2.71)***
Labor on economic growth	0.159(1.37)
Capital on economic growth	0.281(1.88)*
n = 51	
Model R^2 = 0.389	
**Direct linkages between capital and imports*	
ΔLK = constant + 0.638(ΔLM)***	
Imports on capital	0.638(5.79)***
n = 51	
Model R^2 = 0.406	
**Direct linkages between exports and imports*	
ΔLX = constant +0.381(ΔLM)***	
Imports on exports	0.381(2.89)***
n = 51	
Model R^2 = 0.145	

Note: Asterisks indicate significance at the 10 percent (*), 5 percent (**), and 1 percent (***) level respectively.
Note: The values in paranthesis represent the estimated t-values.

Table 6. Results of Path Analysis: Causal Linkage between Exports, Imports and Economic Growth in Costa Rica - With the Inclusion of US GDP and Time Dummy Variable (1960-2011)

Proposed relationship	β
**Direct linkages between economic growth, exports and imports*	
ΔLAGDP = constant + 0.402(ΔLX)*** + 0.389(ΔLM)** + 0.230(ΔLL) + 0.033(ΔLK) + 0.103(ΔLUSGDP) - 0.315(DU80)**	
Constant	
Exports on economic growth	0.402(3.21)***
Imports on economic growth	0.389(2.55)**
Labor on economic growth	0.033(0.29)
Capital on economic growth	0.230(1.63)
U.S. GDP on economic growth	0.103(0.76)
DU80 on economic growth	-0.315(-2.66)**
n = 51	
Model R^2 = 0.	
**Direct linkages between capital and imports*	
ΔLK = constant + 0.638(ΔLM)***	
Imports on capital	0.638(5.79)***
n = 51	
Model R^2 = 0.406	
**Direct linkages between exports and imports*	
ΔLX = constant + 0.381(ΔLM)***	
Imports on exports	0.381(2.89)***
n = 51	
Model R^2 = 0.145	

Note: Asterisks indicate significance at the 10 percent (*), 5 percent (**), and 1 percent (***) level respectively.
Note: The values in paranthesis represent the estimated t-values.

These findings are in line with arguments presented by previous studies that a large number of multinational corporations operating from Costa Rica's FTZ has undoubtedly contributed to an increase in exports and direct employment, but failed to generate substantial linkages with the rest of the economy and intra-industry trade (Giuliani 2008; Sanchez-Ancochea 2006). Additionally, these firms tend to import a large share of their inputs from their own subsidiaries or from companies operating in other countries. The establishment of a microprocessor plant in 1997 by Intel is the most notable example, and it merits a more detailed discussion. The initial investment in Costa Rica totaled $300 million, and at a macroeconomic level, Intel has led to higher rates of economic growth. Furthermore, it helped to reverse the drop in the country's terms of trade due to low world prices of its most traditional exports, and was responsible for surplus in Costa Rica's trade balance - the first surpluses in fifty years (World Bank 2006). Because of its sheer production capacity, Intel has impacted the volume and composition of Costa Rican exports, and in the year 2000 computer parts alone accounted for almost 40 percent of total exports. Furthermore, this investment has had a subsequent "signaling" effect on other potential foreign investors, and Costa Rican authorities have used it as a "stamp of approval" to attract other foreign electronic manufacturers (Rodríguez-Clare 2001). Intel also contributed to the diversification of Costa Rica's trade patterns by expanding the array of nations with which it trades as well as the number of goods being traded. Finally, Intel has had some positive impact in education through improvements in local human capital and training programs (Larrain et al. 2000). Despite the aforementioned positive impacts of Intel on Costa Rica's economy, this firm has been operating more as an enclave economy. More specifically, Intel has been importing most of its components for its assembly operation and has failed to generate number of domestic suppliers (World Bank 2006). This situation is comparable to numerous export -based industries located in developing countries but dominated by international firms. These exploitative relations could be found across Latin America and other developing economies and are well described in a seminal article by Dos Santos (1970). In summary, the results show a clear and positive impact of exports on economic growth in Costa Rica. Nevertheless, these results also suggest that these same exports are dependent on imports, and in particular of capital goods.

CONCLUSION AND POLICY IMPLICATIONS

The present study has employed the Granger-causality procedure developed by Toda and Yamamoto (1995) and the path analysis to examine the export-led growth hypothesis for Costa Rica. Despite the differences between these two methodologies, the results were consistent and robust across all models. Using annual data from 1960 to 2011, the analysis began with a simple bivariate framework. The empirical results indicate that changes in real exports precede changes in real GDP only without the inclusion of the U.S. real GDP and a time dummy as exogenous variables. However, because bivariate systems have been criticized as incomplete for omitting potentially important variables, the MWALD test was carried out again with the inclusion of real imports. In this case, the results suggest that there are significant causal relationships from exports and imports to GDP, and from imports to exports. In addition, the causal links held even when exogenous variables were included in the VAR estimation. A third model was also estimated in the form of an augmented

production function including capital, labor and exports as inputs. In this case, the MWALD found again a causal relationship between exports and Costa Rica's GDP along with causality relationships between imports and output, import and exports, and between imports and capital formation. These results were confirmed by the path analysis methodology and they highlight a dependence of Costa Rica's export sector on imports – most likely in the form of inputs and capital goods. According to the endogenous growth model, imports may become indirect channels for long-run economic growth when they provide domestic firms needed intermediate technology and foreign-technology. In the case of Costa Rica, when multinational firms import technologically advanced inputs to produce and export high value-added goods, this seems to have a positive impact on exports, which in turn becomes conducive to higher economic growth.

The findings from this study have important policy implications for Costa Rica and all Central America and the Caribbean region. In the case of Costa Rica, the results of this study suggest that there is a dependency between imports and exports, and between imports and capital creation. Although the export promotion policies implemented by Costa Rican authorities have resulted in economic growth, this study raises questions on the sustainability of this development model. That is, the future of Costa Rica's export sector may be directly linked to FDI inflows rather than to the development of domestic export industries. Thus, an alternative development strategy should seek to increase the share of export products produced by domestic firms and create a stronger national export sector capable of generating significant spillovers to the rest of the economy. Nevertheless, Costa Rica's governments may not discontinue their policies that have successfully attracted numerous foreign investors in high-tech sectors with the hope that this would lead to technology transfer and to the generation of technological spillovers in Costa Rica economy. Instead, new policies should promote and facilitate the creation of stronger linkages between foreign export firms operating at the FTZs and domestic firms. The ultimate objective would be that domestic firms become competitive input suppliers of the multinational firms. This may represent the path through which the export sector can transform Costa Rica' economy and further contribute to its future development. Finally, future research should explore and disentangle the unequivocal economic impact of the tourism sector in Costa Rica. This sector, and in particular the so-called eco-tourism, has been supported by the government since the mid-1980s, and the entrance of foreign currency due to tourism has grown in importance when compared to other sources of foreign exchange. As an illustration, in 2010 there were 21 million arrivals of international tourist in Costa Rica, and international tourism receipts accounted for almost 17 percent of total exports (World Bank 2011).

APPENDIX 1: STANDARD WALD TESTS

Model 1

$$Y_t = \alpha_0 + \sum_{i=1}^{k+d\max} \beta_{11i} Y_{t-i} + \sum_{i=1}^{k+d\max} \lambda_{11i} X_{t-i} + e_{1t} \quad (8)$$

$$X_t = \tau_0 + \sum_{i=1}^{k+d\max} \beta_{21i} Y_{t-i} + \sum_{i=1}^{k+d\max} \lambda_{21i} X_{t-i} + e_{2t} \quad (9)$$

Model 2

$$Y_t = \zeta_0 + \sum_{i=1}^{k+d\max} \beta_{31i} Y_{t-i} + \sum_{i=1}^{k+d\max} \lambda_{31i} X_{t-i} + \sum_{i=1}^{k+d\max} \phi_{11i} M_{t-i} + e_{3t} \quad (10)$$

$$X_t = \omega_0 + \sum_{i=1}^{k+d\max} \beta_{41i} Y_{t-i} + \sum_{i=1}^{k+d\max} \lambda_{41i} X_{t-i} + \sum_{i=1}^{k+d\max} \phi_{21i} M_{t-i} + e_{4t} \quad (11)$$

$$M_t = \sigma_0 + \sum_{i=1}^{k+d\max} \beta_{51i} Y_{t-i} + \sum_{i=1}^{k+d\max} \lambda_{51i} X_{t-i} + \sum_{i=1}^{k+d\max} \phi_{31i} M_{t-i} + e_{5t} \quad (12)$$

Model 3

$$Y_t = \xi_0 + \sum_{i=1}^{k+d\max} \beta_{61i} Y_{t-i} + \sum_{i=1}^{k+d\max} \lambda_{61i} X_{t-i} + \sum_{i=1}^{k+d\max} \psi_{11i} K_{t-i} + \sum_{i=1}^{k+d\max} \pi_{11i} L_{t-i} + e_{6t} \quad (13)$$

$$X_t = \chi_0 + \sum_{i=1}^{k+d\max} \beta_{71i} Y_{t-i} + \sum_{i=1}^{k+d\max} \lambda_{71i} X_{t-i} + \sum_{i=1}^{k+d\max} \psi_{21i} K_{t-i} + \sum_{i=1}^{k+d\max} \pi_{21i} L_{t-i} + e_{7t} \quad (14)$$

$$K_t = \delta_0 + \sum_{i=1}^{k+d\max} \beta_{81i} Y_{t-i} + \sum_{i=1}^{k+d\max} \lambda_{81i} X_{t-i} + \sum_{i=1}^{k+d\max} \psi_{31i} K_{t-i} + \sum_{i=1}^{k+d\max} \pi_{31i} L_{t-i} + e_{8t} \quad (15)$$

$$L_t = \gamma_0 + \sum_{i=1}^{k+d\max} \beta_{91i} Y_{t-i} + \sum_{i=1}^{k+d\max} \lambda_{91i} X_{t-i} + \sum_{i=1}^{k+d\max} \psi_{41i} K_{t-i} + \sum_{i=1}^{k+d\max} \pi_{41i} L_{t-i} + e_{9t} \quad (16)$$

APPENDIX 2: VARIABLE DEFINITIONS AND DATA SOURCES[1]

GDP AT CONSTANT PRICES (US$ 2000) (Y)

GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2000 U.S. dollars.

[1] **Source:** World Development Indicators online version, World Bank 2008.

Dollar figures for GDP are converted from domestic currencies using 2000 official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used.

Adjusted of exports real GDP (US$ 2000) (AGDP)

The adjusted of exports real GDP is computed by subtracting real exports to total real GDP. Both variables are in 2000 US $.

Export of goods and services (US$ 2000) (X)

Export of goods and services represent the value of all goods and other market services provided to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude labor and property income (formerly called factor services) as well as transfer payments. Data are in constant 2000 U.S. dollars.

Import of goods and services (US$ 2000) (M)

Imports of goods and services represent the value of all goods and other market services received from the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude labor and property income (formerly called factor services) as well as transfer payments. Data are in constant 2000 U.S. dollars.

Gross fixed capital formation (US$ 2000) (K)

Gross fixed capital formation is measured by the total value of a producer’s acquisitions, less disposals, of fixed assets during the accounting period plus certain additions to the value of non- produced assets (such as subsoil assets or major improvements in the quantity, quality or productivity of land) realized by the productive activity of institutional units.

Labor force, total (L)

Total labor force comprises people who meet the International Labor Organization definition of the economically active population: all people who supply labor for the production of goods and services during a specified period. It includes both the employed and the unemployed. While national practices vary in the treatment of such groups as the armed forces and seasonal or part-time workers, in general the labor force includes the armed forces,

the unemployed and first-time job-seekers, but excludes homemakers and other unpaid caregivers and workers in the informal sector.

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TRADE LIBERALIZATION, FREE TRADE AGREEMENTS, AND ECONOMIC GROWTH: THE CASE OF SRI LANKA

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ABSTRACT

This study examines the relationship between trade liberalization and economic growth based on Sri Lanka's national data for the period of 1960 to 2010. The study found that trade openness, investment, and interest rates are significant factors positively related to Sri Lanka's economic growth. Moreover, findings of the study confirmed that trade liberalization has a significant positive relationship with economic growth. Furthermore, results implied that the regional and free trade agreements are also significant and positively related to the economic growth of Sri Lanka.

JEL Classification: Q17 Q18

Keywords: Trade Liberalization, Economic Growth, Trade Openness, Free Trade Agreements, Sri Lanka

INTRODUCTION

The process of trade liberalization and market- oriented policy reforms started in many developing countries in the early 1980s and intensified in the 1990s. Trade liberalization of economies and the complete elimination of trade barriers has become the most popular economic policy of developed and developing nations today. Import and export tariffs, quotas, export subsidies, and technical barriers had become the popular trade barriers during the last decades (Herath 2008). The major objective of free trade is to achieve the macroeconomic welfare by accelerating economic growth. During recent decades, developing nations, like Sri Lanka, have been implementing trade liberalization policies. A positive link

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between economic growth and trade openness likely implies that trade liberalization increasingly evolves as most economies develop. Further, most countries' experience on trade liberalization policies seems to indicate that trade policy reforms achieve larger welfare gains in those countries.

Traditional trade theory emphasizes that free trade based on allocative efficiency, increases social welfare assuming perfect competition. The theory further implies that free trade policies improve welfare of any economy by reducing dead weight loss associated with the characteristics of monopoly or oligopoly. Even though trade theory states that free trade increases welfare, the welfare effects of free trade have been debated. Some studies show that there is little or no evidence to suggest that trade liberalization involves accelerating economic growth or per capita income. However, there is a substantial levels of empirical evidence confirms that there is a link between trade openness and growth which results from trade liberalization (Andersen and Babula 2008). These authors further suggest that well-defined property rights, better educational facilities, stable political environments, well-developed infrastructures, and competitive business environments are also matters that interactively determine the degree of potential benefits from trade liberalization. A substantial level of analysis points out that Sri Lanka has mostly benefitted from trade policy reforms in moving away from protectionism.

The Sri Lankan economy responded positively to economic liberalization and macroeconomic policy adjustments that introduced in1977. The trade liberalization increased the availability of goods and services to consumers and expanded the opportunities to employment seekers. Enhanced market competition and increased investments raised the potential for economic growth rate. Overall, trade liberalization seems to have increased total welfare.

However, the overall welfare effect is influenced by the nature of initial policy distortions. Despite the structural adjustments and policy reforms after 1977, some important distortions remained in Sri Lanka. Therefore, Sri Lanka's Gross Domestic Product (GDP) was growing at an average rate within the approximate 5-5.5% average range and it was lower than expected. The economic policies reduced the unemployment to a large extent. The strong market competition and the expanded investments with modern technologies improved the quality of the products and raised factor productivity. The diversification of exports by reducing the primary agricultural exports increased the resilience of the economy to fluctuations in international terms of trade.

PROBLEM STATEMENT

Since implementing the market oriented economic policies in 1977, Sri Lanka's Gross Domestic Product (GDP) has grown at an approximate annual average 5-5.5 percent. Even though Sri Lanka introduced market, trade, and tariff liberalizations, the economic growth rate was not as high as expected until 2010. Further, investments and savings grew at a lower rate than expected. This may be due to lack of policies that support economic growth. Research in this field has produced conflicting results that do not yield a definitive answer to this complex issue. Therefore, it is an important and justifiable task to assess the impacts of trade liberalization on Sri Lanka's economic growth.

This study investigates the relationship between the trade liberalization and the economic growth of Sri Lanka. Therefore, this study examines more specifically the contribution of international trade on economic growth, investment level, trade openness, and Sri Lanka's interest rate. Further, this research examines whether the regional Free Trade Agreements (FTA) like SAFTA (South Asian Free Trade Agreement) or ILFTA(India Sri Lanka Free Trade Agreement) do in fact economic benefits to the country.

TRADE LIBERALIZATION, TRADE OPENNESS, AND ECONOMIC GROWTH

According to standard international trade theory, trade liberalization leads to an accelerated economic growth. Because international trade can act as an engine of growth, trade reforms facilitate international trade to be more accessible and simple. Trade policy reforms further encourage and motivate trade liberalization which tends to ultimately increase welfare derived from an efficient allocation of domestic resources. Efficient allocation of domestic resources reduces the production of import substitutes and increase production of exportable products. Simultaneously, trade liberalization helps to increase consumer welfare by lowering the price of import goods and import substitutes. On the other hand, increasing of exports and adjusting of efficient resource allocation generate comparative advantages which eventually can result into higher producer surplus. Thus, international trade with more liberalized policies certainly improves international openness to the rest of the world by mobilizing capital, labor, goods, and services across borders. Furthermore, the increasing of foreign trade can have a significant impact on wages, employment and investment which finally does result on a higher aggregate output and a broader country development.

TRADE LIBERALIZATION EPISODES IN SRI LANKA

Until 1977, Sri Lanka was a relatively closed economy. Trade goals were protected by quantitative restrictions on imports and foreign investment was subjected to direct barriers. In 1977, the United National Party government of Sri Lanka introduced a series of trade policy reforms. Thus, market liberalization policies were introduced, and Sri Lanka was actually the first country to implement free trade among the South Asian countries. This trade liberalization attempt focused on cutting tariffs and non-tariff barriers, introducing a six band tariff structure, limiting quantitative restrictions, and avoiding the entry barriers to foreign investment. The six-band tariff structure that was introduced by the budget of 1977 was as follows: i) zero percent on the price of essentials;(ii) 5 percent on most raw materials; (iii) 12.5 to 25 percent on most intermediate goods; (iv) a rate of 50 percent on goods that are neither " essential" nor "luxury" (v) a protective rate of 100 percent on goods being produced domestically and ; (vi) a prohibitive rate of 500 per cent on goods considered to be "luxury" consumer items (White and Weerakoon 1995). These tariff reforms were followed by setting up a presidential tariff review commission and the tariff liberalization recorded a sharp increase of imports by US$ 382.3 million in the 1978 compared to 1976.

While keeping a six-band tariff structure, substantial tariff reforms were implemented and those included a further reduction of tariff rates on certain items from the very high levels of

500, 300, 150 and 100 percent to 60 percent; a removal of the 5 percent tariff on chemicals and pharmaceuticals, a reduction in the tariff from 7.5 percent to 5 percent on machinery. Fertilizers were allowed duty free. License control on textiles was replaced by the imposition of a 100 percent duty. Further, there were several substantial changes followed by the tariff commission for tariff rates over the years and in 1995, a three band tariff structure was introduced with tariff cuts. This tariff structure consisted of 10, 20 and 35 percent. Major changes were the reduction of import duties on textiles and fabrics and apparel from 50 to percent (White and Weerakoon 1995).

These trade policy reforms were wide ranging, and in addition to the open market policies, included removal of administrative controls over domestic prices and reductions in food subsidies. Further, the trade policy reforms that encouraged foreign direct investment that have been highly regulated by the previous governments, promoted in term privatization of state-owned firms by the end of 1990s.

The trade policies carried out a sharp devaluation of the exchange rate at the initial stage of market liberalization policies. Undoubtedly, this devaluation process promoted the export sector and these kind of trade incentives increased the supply of Sri Lankan exports to the world market. The removal of export taxes and controls on commodity exports and the establishments of export processing zones were the main policy packages for the export sector. The exports increased by US$286.3 million in 1978 immediately after the trade liberalization. Overall, these reforms dramatically increased the export and import expansions compared to previous years. Overall, the trade policies resulted into fare economic growth to the country.

According to the World Bank, Sri Lanka's real GDP grew at an annual average rate of 4.9 percent between 1977 and 2007, managed to achieve 6 percent in 2008. Even though the country faced an economically costly thirty-year war, a comparatively higher growth rate was maintained, the main driving force behind it was the implemented trade liberalization policies since 1977. As a result, the country grew at an average of 8.2 percent in 2010 (Central Bank of Sri Lanka 2011).

A study done by Gunawardena (2012) shows that agricultural productivity has improved during past years in Sri Lanka and all the provinces have positive regional GDP growth as agricultural productivity increased. The author further states that this productivity improvement has mostly benefited rural agricultural provinces. These findings suggests that Sri Lanka's GDP has considerably grown with trade policy reforms adapted in 1977. Rising of agricultural productivity in the long run can increase returns to production factors, and this increase of real income ultimately will generate positive economic benefits. It is obvious that these positive benefits would improve overall welfare that would make both consumers and producers better off across the economy.

World Situation of Trade Liberalization

Trade liberalization has been the main policy instrument with which to carry out structural adjustments in many developing economies. Considerable evidence shows that more outward-oriented countries are growing faster than ones that are inward-looking. According to the IMF, the countries that have opened their economies in recent years, including India, Vietnam, and Uganda, have achieved faster rates of growth and more rapid

poverty reduction. On average, those developing countries that lowered tariffs sharply in the 1980s grew more quickly in the 1990s than those did not that (IMF, 2012).Thus, trade liberalization may have been a major determinant of countries' economic growth today. Trade liberalization further raised relative returns to the abundant factors by growing international trade with implementing free trade agreements.

Sri Lankan Situation

Achieving higher economic growth in Sri Lanka has been the main priority for the government in the past few decades. Although realized growth rates were not as high as expected under the noted trade liberalization policies, the country ultimately achieved strong economic growth after 1977. Based on these liberalization policies, Sri Lanka's current strategy for the future is to achieve growth rates of above 8 per cent per annum in order to double the current per capita income and reach the approximate level of US $ 4000 by 2016. Also, Sri Lanka will aim at achieving US $ 18 bn exports by 2016.

Economic Growth

Even though Sri Lanka introduced open market policies ahead of other Asian developing nations e.g. India, China, Vietnam etc., the achieved economic growth rate did not reach expectations. A number of factors were responsible for this lower- than- expected economic growth, including ethnic conflicts, political distortions, policy failures, poor infrastructure. Such factors resulted in irregular economic growth rates. Sri Lanka experienced lower economic growth from 1960 to 1976, an era when Sri Lanka had a closed economy with mostly trade- restricted policies and civil unrest. Sri Lanka's GDP grew at a 0.2 percent during 1971. This was Sri Lanka's lowest economic growth rate. However, a higher growth rate was recorded immediately after the liberalization policies were introduced in 1977. As a result, the growth rate increased up to 5.2 annual percent. The growth rate had decreased to an average of 2.1 percent from 1987 to 1989 due to heavy civil unrest. Also, a negative economic growth of -1.5 percent was realized in 2001 due to terrorist attacks in the capital city of Colombo (Central Bank of Sri Lanka, Annual Report). However, there is enough evidence to suggest that the country has generally benefited from the 1977 trade liberalization policies.

Table 1 presents Sri Lanka's average growth rates by sub periods. The table suggests that Sri Lanka's lowest economic growth occurred during the 1971 to 1976 period, when the economy grew 2.68 percent per year. The second lowest economic growth rate occurred during 1986 -1990. As a whole, the country has grown annually at a rate of 5 percent after implementing the liberalization policies.

Trade Openness

Our study used a trade openness measurement as one of the major explanatory variables for economic growth. Trade openness is defined by the World Bank as the ratio of total exports and total imports to total Gross Domestic Products(X+M/GDP). The statistics from

1977 show that trade openness has increased due to eliminating trade barriers. Furthermore, the trade openness measurement shows a decreasing trend during the closed economy era, whereas a gradual increase of exports and imports to GDP occurred with trade and tariff liberalization. Notwithstanding, the trade openness measurement exhibited a rapid upward shift immediately after trade liberalization.

Table 1. Average Growth Rates for Sub Periods in Sri Lanka

Period	Average growth Rate
1960 - 1965	4.15
1966 - 1970	5.24
1970 - 1976	2.68
1977 - 1985	5.61
1986 - 1990	3.40
1991 - 2000	5.20
2001 - 2005	5.06
2005 - 2010	5.51

Source: Annual Reports of Central Bank of Sri Lanka Herath, H. 2008 (http://www.kln.ac.lk/uokr/ICBI2010/6.pdf)

A Brief Overview of Economic Integration in South Asia and South Asian Free Trade Agreement (SAFTA)

An important element of Sri Lanka's trade policy reforms was a promotion of trade and regional economic cooperation. The South Asian Preferential Free Trade Agreement was signed in April 1994, and implemented in December 1995 for the member countries of India, Sri Lanka, Pakistan, Nepal, Bangladesh, Bhutan, and Maldives (South Asian Association for Regional Cooperation (SAARC)). The objective of the agreement was to establish an effective competitive framework in the free trade area and to achieve equitable benefits to the country members.

SAFTA was the free trade agreement with the seven members of South Asia. The agreement was signed in January, 2004 and it entered into force in January 2006. Some studies show that the SAFTA generates significant gains for Sri Lanka largely due to the preferential access to the regional market with more than 20 percent of world population. The main provision of the SAFTA was the gradual reduction of tariffs, customs, and other trade barriers.

The SAFTA regional trade was estimated at 5.5 percent of 2011 world trade. Also, Sri Lanka maintains strong and healthy trade relations with India under the India-Sri Lanka Free Trade Agreement (ILFTA).

Evidences suggested that trade between the two nations rose by 128 percent and reached US $ 2.6 billion by 2006 compared to previous years. Based on the 1996-2008 data from the IMF Statistical trends, Sri Lanka's total projected exports to the SAARC region will rise and reach US $ 1005.95 million by 2015. By 2015, total Intra-SAARC exports are expected to cross US $ 17500 million mark. According to Asian Development Bank statistics, further

liberalization under the SAFTA will help regional consumers greatly, in the form of low-cost products and services.

REVIEW OF THE EMPIRICAL LITERATURE

This section describes previous studies that have investigated the relationship between trade liberalization and economic growth. Also, some research has showed the relationship between trade openness and economic growth. However, these studies illustrate conflicting results. Some analysts found that trade liberalization has increased the performance of exports and can eventually increase the national welfare of a country, whereas other researchers emphasized that there is not enough evidence to suggest a strong relationship between trade liberalization and economic growth (Herath 2008).

Relationship between trade openness and growth is a highly debated topic in the literature. The most serious problem faced by researchers is the lack of a clearly established definition for trade liberalization and trade openness (Yanikkaya 2002). Therefore, researchers have used different criteria or indices to assess a country's openness on economic growth. Most previous studies measuring the relationship between trade liberalization and economic growth were based on the comparison of Gross Domestic Product (GDP) growth between closed and opened economies or before and after trade liberalization on the same economy. However, until recently, most studies on the relationship between trade liberalization and economic growth focused on comparing Gross Domestic Product growth before and after liberalization. Under this criterion, two studies found that trade liberalization induced economic growth in an economy. In 1987, the World Bank identified a group of 41 countries and classified them into four categories (i) strongly outward orientation, (ii) moderate outward orientation, (iii) moderate inward orientation, and (iv) strongly inward orientation. The study identified a year of liberalization to determine the impacts of trade liberalization. The World Bank concluded that economic performance of the outward oriented economies has been much superior to inward–oriented economies. Nash and Thomas (1991) observed a higher GDP growth rate after the reforms and concluded that trade liberalization leads to higher economic growth in developing countries. This analysis also showed that supply responses were stronger as institutions and infrastructure supported the reforms and resource allocations. A major limitation of their study is that it does not control for other factors of economic growth after trade liberalization.

Edwards (1993) reviewed country-specific analysis of the relationship between trade orientation and levels of economic performance based on multi-country studies of country-specific examples of protectionist practices and free trade policies. He suggested that technical progress is a dominant factor of promoting and enhancing trade policy reforms and liberalization policies in a country. In a separate study, Edwards analyzed total factor productivity growth separately on nine indicators of openness for 93 developed and developing countries for the period of 1960-90. He further concluded that there was a significant positive relationship between trade openness and productivity growth.

Ballasa (1995) constructed an index of trade policy to measure the relationship between trade orientation and economic growth for 43 countries over the 1973 -1979 period. He observed that the level of country's exports is highly correlated with its GDP growth.

However, he did not consider capital accumulation and labor force growth as explanatory variables which were a limitation of the analysis.

Incgo (1997) evaluated the effects of trade liberalization in least developed and net-food importing countries. Her analysis confirmed that welfare changes were affected significantly by an economy's structure of trade distortions.

Ahmed (2000) studied a long-run equilibrium relationship among quantities of exports, relative export price and export weighted real effective exchange rate in Bangladesh. He used a co-integration modeling approach to investigate the aggregate export supply function for Bangladesh. He concluded that trade liberalization can influence exports, relative export prices and exchange rates. He further suggested that trade liberalization policies needed to be associated with devaluations for rapid expansion of exports in that country.

Lin (2000) examined the relationship between trade and economic growth based on China's national data for the 1952-1997 period, and found that the growth rates of exports, imports, and trade volume were positively related to the growth rate of per capita GDP.

Aksoy and Salinas (2004), estimated the relationship between economic growth before and after trade liberalization of world economies. A sample of 39 developing countries with time series data from 1970 to 2004 was used and findings confirmed that small countries have benefited from trade reforms.

In a study of trade liberalization and economic growth, Parikh and Stirbu (2004) examined the relationship between liberalization, growth, and balance of payments. For this study, they used panel data of 42 countries from Asia, Africa, and Latin America, employed OLS regression to analyze impacts of trade liberalization on economic growth in each country. This study's findings implied that trade liberalization promoted growth. However, growth has negative effect on trade balance for most countries. Consequently, this study has produced conflicting results, since some of the sampled countries show a positive and significant effect in some countries whereas trade liberalization negatively affected the trade balance of the other countries. However, this study generated evidences that trade liberalization has a positive effect on economic growth in many economies.

In a major study of economic growth, and trade openness, Sarkar (2005) applied a co-integrated Auto Regressive Distributive Lag (ARDL) model to study the relationship between trade liberalization and trade openness in India and South Korea. However, he identified that there was not a positive relationship between trade openness and growth in India and South Korea.

Vamvoukas (2007) studied the relationship between trade liberalization and economic expansion in four European countries: Greece, Ireland, Portugal and Spain. This study applied sensitivity analysis with Granger multivariate tests based on error correction modeling. The study further suggested that more empirical evidence from developing and developed countries was needed in order to examine the qualitative and the quantitative factors that affect the causality between exports and economic growth.

Anderson and Babula (2008) carried out a study of trade openness and economic growth. They performed the empirical estimation between international trade and economic growth, as well as an empirical analysis of the relationship between trade and productivity growth. Although they found endogeniety and measurements errors, they showed that there was a positive relationship between international trade and economic growth.

Awokuse (2008) analyzed the relationship between the real GDP growth, real export, real imports, gross capital formation and the labor force levels. He found that the degree of trade openness increased with import-increased growth.

In a major study, Alessandrini, Fattouh, Ferrarini and Scarmozzino (2010) assessed the effects of trade policy reforms, especially, tariff liberalization, on India's trade structure. They used the Lafay Index and OLS to analyze India's patterns of trade specialization. The results implied that tariff reduction has elicited the largest improvements in trade specialization due to trade policy reforms carried out in 1991.

This section describes previous studies that have investigated the relationship between free trade agreements and economic growth. International trade theory suggests that eliminating tariff and non-tariff barriers provides a wide variety of economic impacts to the member countries and to the rest of the world. FTAs comprise on welfare, production, exports, and imports. Baldwin and Venables (1995) demonstrated that FTAs affect to welfare levels.

In addition, several researchers have concluded that the effects of trade liberalization may have positive impacts on economic growth under FTAs. They emphasized that eliminating tariff can provide an incentive to mobilize inputs and increase overall efficiency of management through the increased pressure of competition. Abe (2006) found that Japan was to expect much larger potential welfare gains from the bilateral FTAs with China, Korea, Australia, and New Zealand.

Bandara and Yu (2001) reviewed the desirability of forming Preferential Trade Agreements (PTA) in South Asia and they assessed the necessary conditions for SAFTA to be successful. However, this study indicated that south Asian countries gain much more benefits from the unilateral trade liberalization than from SAFTA.

Tennakoon (2000) found that the SAFTA generated significant economic benefits to Sri Lanka. His study assessed the welfare effects of the unilateral and regional trade liberalization on Sri Lankan economy by using GTAP (Global Trade Analysis Project) model. According to the study, the regional free trade agreements were more preferable than the unilateral trade liberalization.

METHODOLOGY

This study focuses on secondary data published in the Central Bank of Sri Lanka's annual reports. Therefore, the selected sample period is 1960-2010, a 51- year period. This study's time period was delineated into two sub periods before 1977 and after 1977, when trade liberalization was introduced. Price effects of variables were removed using the GDP deflator of selected years to avoid the inflationary effects.

Analytical Methods

Application of the economic growth theory requires a specific model. Econometric studies of economic growth include Single Equation Models (SEMs). Therefore, our study applied SEMs to examine the determinants of the economic growth function. SEM regression analysis was performed by incorporating four variables. The dependent variable was the

economic growth rate in the country. In this study, real Gross Domestic Product (GDP) was used as a proxy for economic growth. The explanatory variables were trade openness, total investment, and real interest rate. Two dummy variables (D_1&D_2) were added for trade liberalization and Free Trade Agreements (FTA). D_1 was assigned to trade liberalization or after 1977. D_2 was assigned to FTA, after 1995. In summary, regression analysis was performed for four models to analyze four alternative models are as follows.

Model 1

$$\text{Economic Growth} = \beta_0 + \beta_1 \text{ Trade Openness} + \beta_2 \text{ Investments} + \beta_3 \text{ Real Interest} + \\ + \beta_5 D_1 + u_i \quad (1)$$

This model used the data from 1960 to 2010 and the main objective was to observe the impacts of trade liberalization and trade openness on economic growth.

Model 2

$$\text{Economic Growth} = \beta_0 + \beta_1 \text{ Trade Openness} + \beta_2 \text{ Investments} + \beta_3 \text{ Real Interest} + u_i \quad (2)$$

The main purpose of this model was to show the impacts of trade openness on economic growth before trade liberalization, from 1960 to 1977.

Model 3

$$\text{Economic Growth} = \beta_0 + \beta_1 \text{ Trade Openness} + \beta_2 \text{ Investments} + \beta_3 \text{ Real Interest} + u_i \quad (3)$$

The data used from 1977 to 2010 and main purpose was to show the impacts of trade liberalization and trade openness on economic growth.

Model 4

$$\text{Economic Growth} = \beta_0 + \beta_1 \text{ Trade Openness} + \beta_2 \text{ Investments} + \beta_3 \text{ Real Interest} + \\ + \beta_4 D_2 + u_i \quad (4)$$

This model also used data from 1977 to 2010 and included the FTA dummy variable aiming to show the impacts of FTA on economic growth with liberalized trade policies.

Trade openness was defined as the ratio of the total export and imports to total GDP (X+M/GDP). For our study, total investments included both domestic and foreign investments. In Sri Lanka, interest rates decisions are taken by the Central Bank of Sri Lanka, and this interest rate was the lending interest rate adjusted for the inflationary effects. All the statistics of exports, imports, investments, and interest rates were from the annual reports of central bank of Sri Lanka.

Multiple Regression Model

The study used the Ordinary Least Square (OLS) method to estimate multiple regression models. To examine the effects of trade liberalization on economic growth, the following variables were used: Economic Growth, Trade Openness, Investment, Interest Rate, Trade Liberalization (dummy), and FTAs (dummy).

The general Regression Equation used as of form:

$$\text{Economic Growth} = \beta_0 + \beta_1 \text{ Trade Openness} + \beta_2 \text{ Investments} + \beta_3 \text{ Real Interest} + \\ + \beta_5 \text{ Dummy} + u_i \quad (5)$$

Trade openness is assumed to have a positive impact on economic growth because the ratio of total exports and imports as well as their combined total to GDP (X+M/GDP) are expected to increase with trade liberalization. Total investments are assumed to have a positive relationship with economic growth because the lifting of trade restrictions attracts foreign firms, and accordingly raises the demand and returns to factors. The interest rate is expected to have a negative impact on economic growth because high interest rates suppress investments. Such rates provide opportunities to convert money to time deposits, depressing investments by the private sector, and decreasing investment may lead to poor economic growth. The trade liberalization dummy variable was added to check whether there is a change in the economic growth after introducing the market economy in 1977. The Free Trade Agreement dummy variable was added to study the impacts of trade liberalization with FTAs on economic growth in Sri Lanka after 1995. The regression analysis was performed for five models using SAS as the analytical tool.

EMPIRICAL ANALYSIS AND RESULTS

Table 2 provides the descriptive statistics of the study for the period of 1960 to 2010.

Model 1 can be represented as Equation (1). The coefficient of the Determination, adjusted R-square for Model 1 for the period of 1960 to 2010 is 93 percent. Therefore, the R^2 statistics suggested that more than 92 percent of the total variation in real GDP is explained by the Single Equation regression model.

The Table 3 provides the parameter estimates of trade openness, investment, interest rate, and the trade liberalization dummy variable of the model 1 for the period of 1960 to 2010.

The variable trade openness shows a positive and significant relationship at the 95 percent level. The elasticity of means suggest that 1 percent increase of trade openness can increase 0.05 percent increase of GDP growth. The study period for the model was 1960 to 2010. Within this selected period, there were several changes in the economy in the country. The most prominent feature was that the government introduced the open market policies in 1977 and liberalized the trade and tariff policies. At the same time these new conditions encouraged local and foreign investors. This situation may have facilitated rapid expansion of the export and import sectors and may have changed production systems towards increase networking, assembly operations, and establishing of export processing zones in Sri Lanka. These factors increased trade openness and production and may have significantly increased Sri Lanka's real GDP.

The variable investment is positive and significant at the 90 percent level. This GDP increase may be due to increasing foreign direct investment and domestic investments. Increasing both investments elicits an independent influence on economic growth with the introduction of open market economy because both foreign direct investment and domestic investment increase as openness of the trade policy regimes.

Real interest rate and economic growth illustrate a negative relationship and it is significant at 5 percent. Increases in interest rates are also advocated as a means of curbing expenditure and investment. Interest rate is a double edge weapon as high interest rates could increase costs of production which increases prices.

The trade liberalization variable (D_1) and the economic growth variable indicate a positive relationship and it is clearly evident that trade liberalization has promoted economic growth in Sri Lanka. The model shows the liberalization variable is significant at 10 percent. Simultaneously, the results exhibit that there had been a structural change in the economy. On average the real GDP is higher in the post-1977 period. This indicates that the overall trade policy framework adopted after 1977 has accelerated the economic growth in Sri Lanka. In other words the open economic policy seemed to be successful in attracting investments and increasing trade openness. This environment has resulted into higher levels of international competitiveness by expanding and diversifying exports and facilitating import liberalization which ultimately increased the economic growth in the country.

To ensure the accuracy of the regression results, the multicollinearity was tested and results indicated that multicollinearity was not a problem. Autocorrelation was found and corrected using the Cochrane-Orcutt procedure.

Model 2 (the data from 1960 to 1977) is represented as Equation (2) and Model 3 (the data from 1977 to 2010) is represented as Equation (3). The table 4 and 5 state the parameter estimates of the Model 2 and the Model 3.

The adjusted R square for model 2 and for model 3 is 98 percent and 93 percent, respectively. It shows that more than 92 percent of the total variation in the real GDP is explained by the regression model.

Regression results of model 2 provide interesting results. Model 2 reports that trade openness is negatively related and a significant determinant at the 5 percent significance level. This is obviously evidence that the closed economic policies have not supported international competiveness through increased imports and exports in this era. As mentioned earlier, for model 2, the Study period was 1960 to 1977 and the government had the authority in making decisions and policy implementation. This might be the reason for negative relationship between trade openness and economic growth. The government policy may have increased only imports but not exports. Either there was not a significant private sector contribution or no export and import expansion during this most restricted era. This situation may have led to slower economic growth. However, model 3 illustrates that trade openness is a highly significant determinant on the economic growth of Sri Lanka. The elasticity of means illustrate that 1 percent increase of trade openness increases 0.43 percent of real GDP. This was the period of implementing trade liberalizing policies and this new policies encouraged the international competitiveness.

Both models show that the investments are positively related to the economic growth and significant. Before the open market establishment, the average inflation rate in Sri Lanka was lower than 6 percent. Due to having low inflation rate investors can make more investments. After 1977, market liberalization policies have increased the allocation of investment to

productive activities especially for the manufacturing and industrial sectors. Therefore, changes of trade policies have attracted the foreign and domestic investments and this increased investment have accelerated the economic growth of Sri Lanka.

The interest rate is negatively related to the economic growth after 1977 and it is statistically in significant. As indicated before, interest rate is a double edge weapon as high rate of interest rate could increase costs on production and it could increase prices. These high interest rates encourage people to save rather than invest.

Each model was tested for the multicollinearity and results indicated that it was not a problem. Autocorrelation was found and corrected using the Cochrane-Orcutt procedure.

The model 4 can be represented as Equation (4). The table 6 explains the regression results of model 4 for the period of 1977 to 2010. The results report the relationship between the economic growth and other variables including FTA dummy variable.

The model summary provides that the adjusted R-Square is 95 percent and this shows 95 percent of the total variation in the real GDP is explained by the regression model.

Table 2. Descriptive Statistics of the Study for the Period 1960 to 2010

Variable	Mean	Std. Deviation	Minimum	Maximum
Real GDP	9830.7394	6514.72405	2631.76	26454.32
Tradeopeness	0.0363	0.03347	0.0035628	0.1189838
Investments	136064.5882	184027.78491	978.0000	752200.00
Interestrate	11.5980	5.15560	4.0000	25.0000
D1	0.6667	0.47610	0	1.0000

Table 3. Parameter Estimates of the Model 1

Model 1		Parameter Estimate	Std. Error	t
	(Constant)	3032.37	938.5484	-1.866*
	Investments	0.0254	0.001	1.928**
	Tradeopeness	12869	6387.7	2.014**
	Interestrate	-186.34	83.808	-2.220**
	D1	1572.66	927.06	1.701*

Note: Adjusted R-Square: 93%, D-W Statistics is 1.55.

**,* denote significance at the 5% and 10% level, respectively.

Table 4. Parameter Estimates of the Model 2

Model 2		Parameter Estimates	Std. Error	t
	(Constant)	51.65	153.77	0.34*
	Tradeopeness	-4218.75	1449.70	-2.91**
	Investments	0.34	0.058	5.95**
	Interestrate	487.34	41.08	11.86**

Note: Adjusted R-Square: 98% , D-W Statistics is 2.011.

**,* denote significance at the 5% and 10% level, respectively.

Table 5. Parameter Estimates of the Model 3

Model 3		Parameter Estimates	Std. Error	t
	(Constant)	10581	1740.503	6.08**
	Tradeopeness	118424	30245	3.92**
	Investments	0.022	0.001	12.48**
	Interestrate	-32.559	90.459	-0.36

Note: Adjusted R-Square: 93%, D-W Statistics is 1.794.
**,* denote significance at the 5% and 10% level, respectively.

Table 6. Parameter Estimates of the Model 4

Model 4		Parameter Estimates	Std. Error	t
	(Constant)	10682	1603.5	6.6**
	Tradeopeness	120473	26201	4.61**
	Investments	0.01898	0.00250	7.59**
	Interestrate	-285.740	80.7500	-0.32**
	D2	1681.462	887.0312	1.9*

Note: Adjusted R-Square: 95%, D-W Statistics is 1.4.
**,* denote significance at the 5% and 10% level, respectively.

The results illustrate that the trade openness is positively related to economic growth and is significant on economic growth after 1977 with trade liberalization. Elasticity of means suggest that 1 percent increase of trade openness will increase 0.5 percent increase of real GDP. This further suggests that trade openness has increased economic growth by eliminating major trade barriers that were exhibited in the economy.

The investment is also positively related to the economic growth and is a significant variable and further explains that domestic and foreign investment accelerated economic growth.

As the theoretical relationship, the interest rate is negatively related to the economic growth and it is a significant variable on the economic growth after 1977. The higher interest rates reduce investment and lead to slower the economic growth. After introduced the open market economy, the inflation rate was increased significantly. The average inflation rate was 13 percent in the period of 1977 to 1993 in Sri Lanka. Several reasons were responsible for this high inflation rate including changes in the food subsidy and devaluation of the rupee. In order to counteract this movement, monetary policy was adjusted and nominal interest rate was raised.

The real interest rate always leads to moves oppositely to the nominal interest rate and to the inflation rate in macro-economic sense. This changing real interest rate will suppress economic growth of a country in the long run.

The dummy variable of the model 4 is Free Trade Agreements (FTA) and the variable is positively related to the economic growth. Moreover, the FTA variable is a significant determinant of economic growth at 1 percent significance. Sri Lanka signed the India-Sri Lanka Free Trade Agreement in 1998 and fully implemented in 2000. In 2004, Sri Lanka signed the South Asia Free Trade Agreement (SAFTA) and it implemented in 2006. Both agreements have generated facilitating environment for trade liberalization and eventually

increased export surplus resulted into higher economic growth to the country. This further highlight the overall trade policy framework adopted after 1977 has promoted the economic growth in Sri Lanka.

The model was tested for the multicollinearity and results suggested that multicollinearity was not an issue. Autocorrelation was found and corrected using the Cochrane-Orcutt procedure.

SUMMARY AND CONCLUDING REMARKS

Economic literature tends to emphasize that trade liberalization leads to improve social welfare by allocating domestic resources efficiently, and consequently, free trade can have considerable beneficial effects on economic growth. With this concept, this research article contributes to the literature by assessing the impacts of trade liberalization on economic growth of Sri Lanka by using OLS regression models. Moreover, the study examined those impacts in conjunction with other factors such as trade openness, investment, interest rate, and policy reforms.

The analysis encompassed five decades with three trade regimes, post and pre liberalization period and post regional trade agreement period. After 1977, the Sri Lankan government's main emphasis was given to attract investments and to expand exports and imports in order to gain higher economic growth. On top of that, the political instability after 1983 and the subsequent ethnic war were major factors that Sri Lanka was deprived investments. If a suitable political stability was maintained, the country would have attracted more investments and would have had accelerated development. Despite all these, market liberalization may have proved to attract foreign investments.

In summary, this study's results confirm that trade liberalization may have a positive influence on trade openness and resulted in accelerated economic growth of Sri Lanka. These new trade policies would have been responsible for more efficient use of the country resources in terms of increased welfare. After 1977, the government started the Free Trade Zones and telecommunications infrastructure to create a facilitating environment to encourage private sector contributions to deal with export and import sector. As a result, the country's total GDP significantly increased during the post-liberalization period.

Moreover, the results report that the trade agreements such as the India-Sri Lanka Free Trade Agreement and the South Asia Free Trade Agreement (SAFTA) have had considerable influence in increased economic growth by introducing liberalization programs like tariff reduction, Safeguard Measures, and new institutional arrangements.

CONCLUSION

Opening up of developing countries' economies to the global economy has been reported as an instrument enabling these countries to develop competitive advantages. The empirical results of this study confirmed that the trade liberalization policies adapted in 1977 has significantly increased real GDP by stimulating trade openness in Sri Lanka. Similarly, as a significant factor, investment also has promoted economic growth in Sri Lanka all along with these open market policies.

These findings also imply that the interest rate has had no impact on growth rate and therefore, raises the question of effectiveness of monitory policy in managing the economy. The study also indicated that the average growth rate was much higher in post liberalization period. Thus, it is reasonable to confirm the well-established positive impact of market liberalization on economic growth during the post liberalization period in Sri Lanka. The dummy variable for trade agreements may prove that there was a higher growth rate after implementing the regional trade agreements. Overall, liberalization seems to have significantly contributed to the acceleration of economic growth and investment level over the period of 1977-2010. If political stability would have been maintained, the impact of trade policies on economic growth may have been more profound. Previous studies which focused on trade openness and growth in Sri Lanka produced conflicting results. This analysis provides obvious conclusions that the trade liberalization policies have been instrumental in enhancing international competitiveness and trade openness. This research further shows that the trade liberalization policies may result in high economic growth and the findings of this study may be helpful for the policy reforms in other nations in South Asia.

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