THREE ESSAYS ON TRADE AND ECONOMIC GROWTH

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ABSTRACT

A central proposition of international trade theory is that trade allows a country to achieve a higher level of income than would otherwise be possible. Initial studies have shown evidence in support of a positive relationship between the volume of trade and the level of national income. However, numerous problems have prevented the estimation of a consistent relationship between trade and income. These problems include endogeneity, cointegration between trade and income, and the lack of an accurate measure of trade openness.

This study investigates the relationship between trade and income in three distinct ways. First, the endogenous nature of trade in a simple growth equation is controlled for by constructing a predicted level of trade from a gravity model. The results show that greater trade does exert a positive influence on economic growth; however, once the effects of geography are controlled for in the growth equation the effect of trade becomes insignificant. Second, trade is included in a neoclassical production function to assess the dynamic and causal relationships that exist among exports, imports, and national income. The variables are first tested for the presence of unit roots and the possibility of cointegration. Subsequently, appropriate Granger causality tests are used to determine the causal patterns among the variables of the model. The results of the Granger causality tests indicate that both exports and imports are important determinants of national income for several of the countries examined in the study.

Finally, the actual trade shares and the predicted trade shares from a large sample of countries are used to construct a new trade restrictiveness statistic. A higher value of the statistic indicates that a country has adopted more restrictive trade policies. The trade restrictiveness measure is included in a growth equation to assess the effects that trade policy has on the average annual growth rate of per capita income. The results of the estimation indicate that countries that began the sample period with more restrictive trade policies tended to grow at a faster rate than countries with less restrictive trade policies; however, the relationship is statistically insignificant.

DEDICATION

This dissertation is dedicated to my grandfather, James Mullinax, who helped to instill a life-long love of learning in me at a young age and who always thought that I would be a professor someday.

LIST OF ABBREVIATIONS AND SYMBOLS

A_i	Land area of country in square kilometers
ADF	Augmented Dickey-Fuller Test
AIC	Akaike Information Criteria
ASEAN	Association of Southeast Asian Nations
B_{ij}	Common Border dummy variable
CEPII	Centre d'Etudes Prospectives et d'Informations Internationales
$ComCol_{ij}$	Common Colonizer for countries i and j
$CulSim_{ij}$	Cultural Similarity between countries i and j
D_{ij}	Distance between two countries
ECM	Error-correction model
ECT	Error-correction term
ERS	Economic Research Service
FE	Fixed Effects
FPE	Final Prediction Error
GDP	Gross Domestic Product
GNP	Gross National Product
GR	Growth rate or per capita income
Hstock	Human capital stock
I_i	Island dummy variable
I(1)	Integrated of order one

I(2)	Integrated of order two
IFS	International Financial Statistics
IMF	International Monetary Fund
INV	Investment-to-GDP ratio
IV	Instrument Variable
K	Real capital stock
K per worker	Physical capital stock per worker
KPSS	Kwiatkowski, Phillips, Schmidt, and Shin test
Kstock	Physical capital stock
L	Labor force
L_i	Landlocked dummy variable
$Lang_{ij}$	Common Language dummy variable
LAT_i	Average Latitude of a country
LDC	Less Developed Countries
Ln	Natural Logarithm
M	Real Imports
N_i	Population of country
NBER	National Bureau of Economic Research
NIC	Newly Industrialized Countries
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares Regression
OPEN	Measure of trade openness
POP_i	Population
r	Cointegrating rank

S_i	Size of country
SIC	Schwartz Information Criteria
SITC	Standard International Trade Classification
T_i	Actual Trade Share
$\hat{T}_i$	Predicted Trade Share
T*	Predicted Trade Share
TFP	Total factor productivity
$Trop_i$	Tropical exposure
VAR	Vector Autoregressive Model
VECM	Vector Error-Correction Model
X	Real Exports
Y_i	GDP per capita
Δx_t	Growth rate of exports
Δy_t	Growth rate of Real GDP
Θ	Sensitivity of trade flows to bilateral distance
θ_{t-1}	One period lagged error-correction term
τ_{ij}	Volume of bilateral trade between two countries i and j

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

Overview of the Work

A central proposition of international trade theory is that trade allows a country to achieve a higher level of income than would otherwise be possible. Initial studies have shown that there is evidence of a positive relationship between the amount that a country trades and their level of national income. Early studies like Michaely (1977), Balassa (1978), and Feder (1983) employed cross-country regressions of per capita income on trade ratios and other explanatory factors to assess the impact that trade has on income. However, as the economics of trade has evolved, the early findings of a positive effect of trade on income have come into question. Several studies have observed that the estimated relationship between trade and income may not capture the true effects of trade.

This dissertation consists of three essays which examine the effects of a country's level of trade on national income. The first essay addresses the problems that arise because of the endogenous nature of trade in growth equations. Several studies have attempted to solve the endogeneity problem by using a country's geographic attributes in a gravity model to construct an instrument variable for the level of trade.[1] These studies often show that the OLS estimation is downwardly biased and that geography is a good proxy for trade based on the high correlation between the actual level of trade a country participates in and the level of trade predicted by the gravity

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[1] Frankel and Romer (1999), Irwin and Trevio (2002), Noguer and Siscart (2005)

model. However, the results obtained in these studies are imprecisely estimated indicating that the models need some additional specifications. This paper develops a new empirical gravity model by including additional variables to capture the effects that cultural similarity and other historical connections have on the volume of trade between nations and also re-examines the results of previous studies of trade's effects on the level of income in an economy, most notably the study by Frankel and Romer (1999).

The estimation of the model is a two-step process. First, an expanded gravity equation is estimated to obtain the level of trade for each country predicted by their geographical features as well as their cultural similarity and historical connections with their trading partners. Second, the predicted levels of trade from the constructed gravity model are utilized in place of the actual trade shares in a simple growth equation to assess the effect that trade has on per capita national income. The goal of this study is to determine whether or not the coefficient on trade in the growth equation is more precisely estimated when the expanded gravity model is employed compared to the estimates of previous studies. Furthermore, since no consensus has been reached on the appropriate measure of international distance, an additional aspect of this study is to see whether the choice of the distance variable has any discernable effect on the estimation of the gravity model. Overall, the IV estimates of the relationship between trade and income tend to outperform the results of OLS estimations. The trade shares predicted by the gravity model developed in this study indicate a strong, positive relationship exists between the level of trade and the level of per capita income. However, once geography is controlled for in the income equation, as suggested by Rodriguez and Rodrik (2001), the positive effect of trade on income becomes statistically insignificant. Moreover, when any of four measures of distance are included in the gravity model, there are no statistical differences in the estimation.

In the second essay the goal is to determine if any causal relationships exist between trade and GDP. In order to assess the true impact that trade has on income and economic growth it becomes necessary to first determine the direction of the relationship between trade and income. Numerous studies beginning with Jung and Marshall (1985) have attempted to find evidence of a causal relationship between trade and income that corresponds to the accepted trade theory. A majority of the studies conducted employed simple, bivariate Granger causality tests to determine the direction and magnitude of the causal relationship. However, most of the research has centered on the effect that export expansion has on economic growth. Few papers examine the role that imports or total trade play in the direction of the causal relationship.

The purpose of the second essay is to determine the role that total trade plays for economic growth in a general production function framework. This paper first examines the early studies of export-led growth as well as more recent extensions of the literature which include the addition of imports in the production function and testing for cointegration among the variables to determine if any long-run relationships exist. Next, the model employed in this paper is developed following the methodology of Awokuse (2008). This study differs from previous studies of export-led growth in the use of both an economy's level of exports and imports in a neoclassical production function. The production function is used so that other variables affecting growth are controlled for including measures of both physical and human capital and the size of the labor force for a set of 21 OECD economies from 1970 - 2006. Consequently, a multivariate VAR model is estimated. First, the model is tested for the presence of unit roots in the time-series data and for a cointegrating relationship among the variables. Whenever a cointegrating relationship is found, an error-correction (ECM) model is employed. Finally, Granger causality tests are performed to determine the direction of the causal relationship between trade and income. When two lags are included in the VAR model, the Export-led Growth hypothesis (exports Granger-cause GDP) is supported for seven of the twenty-one countries. Moreover, five countries show support of Granger causality from imports to GDP. When one lag is included in the model, the Export-led growth hypothesis is supported for five countries and the Import-led growth hypothesis is supported for four countries. Overall, the estimations signify that imports are an important variable in the causal pairings and must be controlled for to more accurately estimate the effects of trade on economic growth.

The third essay examines the role that trade openness plays in promoting economic growth. Are countries that are more open to trade richer than more closed countries? Do open economies grow faster than closed economies? These questions are still debated with no clear answers provided by empirical investigations. The general argument is that more open economies will grow faster than closed economies; however the empirical literature has often failed to support this argument. One reason is that there are problems with creating a measure of a country's trade policies and the overall degree of openness. Many openness indexes have been developed in the literature and applied to this problem but the results have been mixed and often conflicting.

In this paper a trade openness index based on Leamer (1988) is constructed. For this study, the degree of openness is measured by the deviation between the actual trade level and a predicted level of trade derived from the gravity model of bilateral trade. This method removes the level of natural trade from actual trade and leaves the level of trade determined by trade policy. This trade measure, then, is a measure of the restrictiveness of a country's trade policy. A higher value for the trade measure will indicate more restrictive trade policy. The trade restrictiveness measure should be highly correlated with trade policies since the gravity equation controls for many non-policy determinants of trade. The restrictiveness measure is then used to test the degree to which an initial level of openness can predict future growth in per capita income for a set of 112 countries from 1970 - 2006. Following Barro (1991) the average annual growth rate of real GDP per capita is regressed on the initial level of real GDP (1970), initial human and physical capital, labor, and the trade restrictiveness measure. A negative and significant relationship between the restrictiveness measure and the per capita growth rate would further justify the argument that having fewer trade restrictions is beneficial for growth. The results of the estimation, though, show that the trade restrictiveness measure and per capita economic growth do not have a statistically significant relationship. However, a country's "natural" level of openness as predicted by the gravity model of trade is found to be positively correlated with economic growth. This result confirms the findings of Frankel and Romer (1999).

Chapter 2

Endogenous Trade, the Gravity Equation, and Distance

Introduction

Since the arrival of Adam Smith and his ideas in the late 18th century economists have been interested in the different factors that determine the standard of living of countries around the world. This investigation of living standards cannot be completed without attention being paid to the amount that each economy trades with one another. A central proposition in international trade theory is that trade allows an economy to reach a higher level of income than would be possible in the absence of trade. Whether through specialization according to comparative advantage, access to larger markets, or the rapid spread of new ideas and technology, trade can play an important role in shaping a country's standard of living. However, despite the effort that has been devoted to identifying the effect trade has on a country's income, economists have so far found little persuasive evidence of a positive relationship with many papers yielding confounding and sometimes contradictory results.

Previous studies of the relationship between trade and income have considered cross-country regressions of income per capita on the ratio of exports to GDP and other explanatory variables in order to ascertain the impact trade has on income.[2] These studies employed an ordinary least squares (OLS) regression framework and typically found a moderate, positive relationship between the amount a country trades and their

[2] Michaely (1977), Feder (1983) and others

level of per capita income. However, this seeming relationship may not reflect a true effect of trade on income because, as Helpman (1988) and Bradford and Chakwin (1993) observe, an economy's trade share may be endogenous. That is, a country may decide to trade more with the rest of the world simply because the country's income is high for reasons other than trade. Thus, the OLS estimates of the impact of trade on income will be biased due to this endogeneity issue.

One possible solution for this endogeneity issue could be to use some measure of a country's trade policies in place of the actual trade share in the income equation.[3] However, this approach fails to correct the issue given that a country's choice of trade policy may also be endogenous to their level of income. Countries that trend toward adopting freer trade polices also tend to adopt more free-market domestic policies in addition to adopting stable monetary and fiscal policies. The freer and more stable domestic policies are highly likely to positively affect the income level of the economy by facilitating trade among the country's citizens. Consequently, the newly adopted trade policies are likely to be correlated with variables omitted from a simple OLS estimation. Because of this, trade polices cannot be used as an instrument to assess the impact trade has on income.

Frankel and Romer (1999) propose an alternative instrument for a country's trade share. The authors employ a variation on the gravity model to construct an instrument for the trade variable in the income growth equation. The literature on the gravity model has consistently demonstrated that geography is a powerful determinant of bilateral trade.[4] This relationship is also true of the country's total trade. Considerable information about the volume of trade can be determined by knowing how far away one

[3] Fischer (1991, 1993), Easterly (1993), Jeffrey Sachs and Andrew Warner (1995), and others.
[4] For example, see Linneman (1966), Frankel et al. (1995).

country is from another or all others. The literature has shown that distance has a significant negative impact on the amount that two countries trade and may act as a proxy for the higher transportation costs of shipping goods over long distances.

Another important facet of the gravity model is that most geographic variables are unlikely to be correlated with a country's level of income or with government policies. Moreover, it can sometimes be a difficult task to find reasons for why geography would affect income except through its impact on trade. Thus, using geography to instrument for a country's trade share may serve to correct the major problems of endogeneity.

In a cross-section of countries for 1985, Frankel and Romer find that the effect of trade on income is significantly higher when an instrument variable (IV) method is used as opposed to the standard OLS method, which the authors show to be downwardly biased. This suggests that the positive association of trade and income is not completely due to the fact that high income countries are trading more extensively than other countries. Frankel and Romer also note that while the estimates generated when the IV estimation was employed were larger than the OLS estimates, they were less precisely estimated. The point estimates were only marginally able to reject the null hypothesis that country size and trade have no effects on income at conventional significance levels.

The first paper to evaluate the findings of Frankel and Romer was by Irwin and Trevio (2002) who applied the gravity equation estimation of trade to different time periods in the 20^{th} century. Their purpose is to determine if there are any systematic differences between the OLS and IV estimations of the trade effect on income. The findings of Irwin and Trevio are consistent with the findings of Frankel and Romer; in most of their test periods, instrumenting for trade with a set of geographic variables substantially increases the estimated positive effect of trade on income. Irwin and Trevio were also able to slightly improve the precision of their estimates, rejecting the null hypothesis that the IV and OLS estimations are equal for three of the eleven time periods they evaluated.

Recently the findings of Frankel and Romer and Irwin and Trevio have been called into question for several reasons. First, the effect of trade on income is continually estimated with low precision and the coefficient is only marginally significant. Second, Rodriguez and Rodrik (2001) argue that the existing correlation between trade and income is spurious. This is because the geography-based instrument used in the studies is likely correlated with other geographic variables that affect income through non-trade channels. Thus, Rodriguez and Rodrik argue, the trade estimate is simply capturing some of the non-trade effects. The authors then demonstrate that when any of three summary indicators of geography are used as additional controls[5], the estimate of trade's positive impact on income disappears; the coefficient on the trade share becomes highly statistically insignificant.

Even if geography affects income through non-trade channels, the geography-based instrument can still be valid if it is not correlated with these other factors. The literature suggests three main channels through which geography affects income:

1. *Disease Environment and Morbidity*: Countries with large portions of their population in tropical climates have been burdened with infectious diseases that have hindered economic development.[6]

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[5] Rodriguez and Rodrik use distance to the equator, the percentage of a country's land area in the tropics, and a set of regional dummies as additional geographic controls.

[6] Gallup et al. (1998); McArthur and Sachs (2001)

2. *Resource Endowments and Agricultural Productivity*: Land endowments in the tropical climates of the Americas and Africa led to plantation-style agriculture based on slavery which caused market-oriented economic growth and development to be suppressed.[7]

3. *Institutions*: Higher latitude countries populated by Europeans and their descendants are endowed with more developed economic, social, and cultural institutions that many tropical countries still lack years after the European nations gave up their colonies.[8]

Noguer and Siscart (2005) consider three possible geographic controls to include in the gravity equation estimated by Frankel and Romer: 1) the percent of a country's population in tropical regions, 2) the percent of a country's land area that lies in tropical areas, and 3) a measure of a country's latitude. The trade instrument constructed by Noguer and Siscart is highly correlated with latitude and the percent of the population in the tropics. This is not surprising since the trade instrument, in essence, measures proximity to the largest markets (largest concentrations of population). Moreover, two-thirds of the world's population is concentrated between 20°N and 50°N latitude. This suggests that the income equation is incorrectly specified and should be modified to control for the effects that latitude and tropical exposure have on economic growth. After considering a number of additional geographic controls, Noguer and Siscart observe that the coefficient on trade remains around 1 (ranging from 0.84 to 1.22)

[7] Engerman and Sokoloff (1997)

[8] Hall and Jones (1999) use a country's absolute latitude to instrument for institutional quality. Acemoglu et al. (2001) show that the effect of latitude on income works via institutions and that once institutions are taken into account, latitude does not have an independent effect on economic performance.

implying a near one-to-one relationship between increases in the trade share and increases in income per capita. Additionally, the coefficients are more precisely estimated than those estimated by Frankel and Romer.

The purpose of this paper is to reexamine the findings of Frankel and Romer and determine whether their estimates are robust to the inclusion of additional geographic variables. Moreover, this paper aims to improve the precision of the point estimates of trade's effect on income by employing an expanded gravity model. Section II will provide more detail and explanation of the original estimation by Frankel and Romer. Section III will introduce a new, expanded gravity equation and the motivations behind the choice of variables. The data and results will be presented in Section IV and Section V will conclude.

Does Trade Cause Growth? Frankel and Romer (1999)

As the literature on the gravity model has consistently shown, trade between two countries is negatively related to the distance between them and positively related to their overall sizes. Therefore, larger countries that are closer to one another should trade together more than with smaller, more distant countries. Frankel and Romer note that while international trade can influence a country's income, national income can also be influenced by the amount that the country's residents trade with each other. Thus, geography can also be a determinant of within-country trade; residents of larger countries trade more with their fellow citizens simply because there are more people to trade with and specialization of the labor force is more likely to occur. Thus, the authors suggest a second geography-based test of the impact of trade on income; they test if within-country trade raises income by establishing whether larger countries are more likely to have higher levels of income. The reason for this complication in the estimation is that country size and the proximity to other countries are negatively related. Because France is larger than Switzerland, the average citizen in France is farther away from other countries than the average Swiss citizen. Therefore, it will be necessary to control for country size in the income equation.

Frankel and Romer estimate a variation of the gravity model which includes only geographic characteristics in an attempt to thoroughly distinguish geography's contribution to overall trade.[9] The minimal specification of the gravity equation is written in log-linear form and relates bilateral trade between a pair of countries to the distance between the countries and their sizes. The basic gravity equation takes the following form:

$$\textbf{(1)} \qquad \ln(\tau_{ij}/GDP_i) = a_0 + a_1 D_{ij} + a_2 S_i + a_3 S_j + e_{ij}$$

where τ_{ij} is the volume of bilateral trade between countries i and j measured as the exports from i to j plus the exports from j to i. D_{ij} measures the distance between each country. S_i and S_j are the variables capturing the size effect of each country in the pair.

The minimal specification of the gravity equation does omit a considerable amount of relevant geographic data about trade. Estimates of trade in equation (1) could be highly biased due to a missing variables problem. In the gravity model they estimate, Frankel and Romer include two variables to control for size: population and

[9] This is in contrast to conventional gravity models of trade which tend to include policy variables and price indices or other variables that may be correlated with the level of income.

area.[10] Additionally, whether countries are landlocked or share a common border will have important effects on trade. Access to ports eases trade by facilitating transportation; a dummy variable is included to capture this effect. Furthermore, a large part of a country's trade is with their immediate neighbors, so another dummy variable is included to capture the effect of sharing a common border.

Frankel and Romer estimate the following log-linear gravity equation:

$$\textbf{(2)} \quad \ln(\tau_{ij}/GDP_i) = a_0 + a_1 \ln D_{ij} + a_2 \ln N_i + a_3 \ln A_i + a_4 \ln N_j + a_5 \ln A_j + a_6(L_i + L_j) + a_7 B_{ij} + a_8 B_{ij} \ln D_{ij} + a_9 B_{ij} \ln N_i + a_{10} B_{ij} \ln A_i + a_{11} B_{ij} \ln N_j + a_{12} B_{ij} \ln A_j + a_{13} B_{ij}(L_i + L_j) + e_{ij}$$

where N is population, A is area, L is a dummy for landlocked countries (1=landlocked), and B is the common border dummy variable (1=common border). The remaining variables in the model are interaction terms between each of the independent variables and the common-border dummy variable and are included to capture all the geographic influences on overall trade.

Frankel and Romer estimate the gravity equation using bilateral trade data from the IFS Direction of Trade statistics for 1985. The estimation covers trade for a set of 63 countries due to data availability issues. Distance is measured as the great-circle distance between two countries' principal cities.[11] Information on area, common borders, and the landlocked countries can be taken from any atlas or geography textbook. Data on population are from the Penn World Table (Mark 5.6).

[10] The labor force is used as the measure of population. Using total population makes little difference to the results. Area is measured in square miles.

[11] The capital city is used as the principal city, except for a small number of cases where the capital is far from the center of the country (in terms of population). In these cases, a more centrally located large city is chosen. For the United States, for example, Chicago rather than Washington D.C. is used as the principal city.

The results derived from estimating the gravity model in equation (2) are presented in Table 1. Frankel and Romer find that distance has a large, significantly negative impact on bilateral trade. The estimated elasticity of trade with respect to distance is slightly less than -1. They also note that trade between any two countries i and j is strongly increasing in country j's size[12] and is decreasing in country i's size. Furthermore, the bilateral trade shares decline when at least one country in the pair is landlocked. Overall, the regression confirms that geographic variables are a strong indicator of bilateral trade. Aggregating the results across countries will demonstrate that geographic variables are also important determinants of a country's overall level of trade.

Table 1 – Frankel and Romer (1999) Bilateral Trade Equation

	Variable	Interaction
Constant	-6.38**	5.10**
	(0.42)	(1.78)
Log of Distance	-0.85**	0.15
	(0.04)	(0.30)
Log of population i	-0.24**	-0.29
	(0.03)	(0.18)
Log of area i	-0.12**	-0.06
	(0.02)	(0.15)
Log of population j	0.61**	-0.14
	(0.03)	(0.18)
Log of area j	-0.19**	-0.07
	(0.02)	(0.15)
Landlocked	-0.36**	0.33
	(0.08)	(0.33)
Observations	3220	
R-squared	0.36	
MSE	1.64	

Standard Errors are in parentheses
** significant at 5% level * significant at 10% level

[12] The elasticity with respect to j's population is about 0.6

In order to find the implications for the geographic component of a country's overall trade, Frankel and Romer aggregate the fitted values across country pairs from the bilateral trade gravity equation. Equation (2) can be rewritten as

(3) $\ln(\tau_{ij}/GDP_i) = \mathbf{a}'\mathbf{X}_{ij} + e_{ij}$

where **a** is the vector of coefficients and $\mathbf{X}_{ij}$ is the vector of all the right-hand-side variables in the gravity equation. The estimate of the geographic component of country i's overall trade share is

(4) $\hat{T}_i = \sum_{j \neq i} e^{\hat{a}' X_{ij}}$

The estimate of the geographic component of country i's trade, $\hat{T}_i$, is the sum of the estimated geographic components of its bilateral trade with every other country in the world. The calculation in equation (4) only requires data on each country's population and geographic characteristics. Therefore, the sum in equation (4) can be taken over all countries in the world and not just the 63 countries in the gravity equation data set. The overall trade share can also be constructed for every country in the world even when bilateral trade data is missing. This allows for a wider range of countries to be included in the growth equation estimation. Frankel and Romer construct a predicted trade share for a set of 150 countries and a set of 98 countries[13] to employ in the second stage of the estimation.

The constructed trade instrument is next used to assess the relationship between trade and income per capita in the following equation:

[13] The set of countries considered by N. Gregory Mankiw et al. (1992).

(5) $\ln Y_i = \alpha + \beta T_i + \gamma_1 \ln N_i + \gamma_2 \ln A_i + \varepsilon_i$

where Y_i is per capita income and T_i is the actual trade share. Population (N_i) and area (A_i) are included in the income regression to control for a country's size, and thus control for the country's level of within-country trade since there is as yet no definitive measure of within-country trade. Following the argument that geographic variables are the only relevant components to the constructed trade share implies that there is no reason to believe additional determinants of income will be correlated with the trade instrument. The additional independent determinants of income are relegated to the error term in the income equation.

With the basic income equation, the authors estimate a statistically significant relationship between the share of trade in GDP and income. The results of the income equation are reported in Table 2. The t-statistic on the trade share is 3.5 and the point estimates imply that a one percentage point increase in a country's trade share is associated with a 0.85% increase in per capita income. The OLS regression also implies that after controlling for international trade there is a positive relationship between country size and income; this supports the authors' view that within-country trade is a favorable contributor to increasing income per capita.

The constructed trade share from equation (4) is used to instrument for the actual trade share. The coefficient on the trade share shows a marked increase when the IV method is employed, lending support to the hypothesis that estimating the model using OLS understates the effect trade has on per capita income. The point estimate of the coefficient on the constructed trade share implies that a one-percentage point increase in a country's trade share increases per capita income 1.97 percent. However, the null hypothesis that the coefficient on the instrumental variable is zero is only marginally rejected at conventional levels.[14] Frankel and Romer further perform a Hausman test (1978) on the hypothesis that actual trade is uncorrelated with the residual and that the OLS estimate is unbiased. They were unable to reject the hypothesis that the IV and OLS estimates are equal (t-stat = 1.2).

Table 2 – Frankel and Romer (1999) Income Equation

	I	*II*	*III*	*IV*
	OLS	**IV**	**OLS**	**IV**
Constant	7.40**	4.96**	6.95**	1.62
	(0.66)	(2.20)	(1.12)	(3.85)
Trade Share	0.85**	1.97**	0.82**	2.96**
	(0.25)	(0.99)	(0.32)	(1.49)
Log of population	0.12**	0.19**	0.21**	0.35**
	(0.06)	(0.09)	(0.10)	(0.15)
Log of area	-0.01	0.09	-0.05	0.20
	(0.06)	(0.10)	(0.08)	(0.19)
Observations	150	150	98	98
R-squared	0.09	0.09	0.11	0.09
MSE	1.00	1.06	1.04	1.27
F-test on excluded instrument		13.13		8.45

Standard Errors are in parentheses
** significant at 5% level * significant at 10% level

In both the 150-country and the 98-country samples the IV estimation yielded larger point estimates than the OLS estimation although the difference between the estimations was not statistically significant. This implies that income's partial association with the component of trade not correlated with the instrument is weaker than income's association with the component of trade that is correlated with the instrument variable. One explanation is that a possible measurement-error leads to the downward bias of the OLS estimates. This could occur because trade may be an

[14] t-stat = 2.0

imperfect measure of income-enhancing interactions between countries. Trade is perhaps a proxy for these interactions that include specialization and the spread of new ideas and products. However, Frankel and Romer conclude that a sampling error in the instrument accounts for the gap between the OLS and IV estimates.

Re-examining the Gravity Equation

Because of the ongoing debate and discussion of the actual effects of trade on a country's income and the movement that many countries have made toward freer trade, this issue is important and warrants further exploration. Initial results are promising and seem to coincide with the widely accepted intuition that participation in international trade does exert some positive impact on income. However, estimates have only weakly supported this claim. Because of this lack of consistency in the literature, the first thing to examine should be the specification of the gravity model in the previous studies.

Gravity equations have been widely used in the literature to infer the trade flow effects of various institutional arrangements such as customs unions, exchange-rate mechanisms, ethnic ties, and linguistic identity. Additionally, the theory of gravity equations as developed by Anderson (1979) informs us that trade between two regions is decreasing in their bilateral trade barrier relative to the average barrier of the two regions to trade with all other partners once size is controlled for. Simply, the more resistant a region is to trade with all other regions, whether through government policy or other institutional factors, the more it will be induced to trade with a given bilateral partner. Two countries trade more with each other if the barriers between them are reduced. Anderson and van Wincoop (2003) refer to the average trade barrier as “multilateral resistance”. However, these previous gravity model studies and others have focused solely on the equation’s ability to estimate levels of bilateral trade. Many of these models include variables that will be endogenous to GDP when used to instrument for trade in the income equation.[15]

Since this study follows the work of Frankel and Romer, only variables that might affect trade and are exogenous to income are included in the bilateral trade equation. The simple gravity equation is expanded to include additional control variables to capture any information that was omitted from the previous study. The results of the new gravity equation developed here will then be used to instrument for the trade share of GDP in the income equation used by the previous studies. Additional controls will hopefully lead to stronger, more consistent results about how the geographic portion of trade affects income.

The following log-linear gravity equation of bilateral trade is estimated:

$$\textbf{(6)}\quad \ln(\tau_{ij}/GDP_i) = \alpha_0 + \alpha_1 \ln D_{ij} + \alpha_2 \ln N_i + \alpha_3 \ln A_i + \alpha_4 \ln N_j + \alpha_5 \ln A_j + \alpha_6(L_i + L_j) + \alpha_7 B_{ij} + \alpha_8 Lat_i + \alpha_9 Lat_j + \alpha_{10} Trop_i + \alpha_{11} Trop_j + \alpha_{12}(I_i + I_j) + \alpha_{13} ComCol_{ij} + \alpha_{14} Colony_{ij} + \alpha_{15} CulSim_{ij} + \alpha_{16} Lang_{ij} + \varepsilon_{ij}$$ [16]

The first seven terms on the right hand side of the equation correspond to the variables chosen by Frankel and Romer to account for distance, country size, landlocked, and

[15] Typically these variables include GDP for each country in the pair, consumer price indices, and a variable to account for trade barriers either using policy decisions, information on tariffs, or a constructed statistic.
[16] A full description of all variables appears at the end of the paper.

common border effects.[17] The remaining variables are new to this specification of the gravity equation but have their foundations in the gravity model literature.

The first additions to the gravity equation are variables representing the latitudes of each country in the trading pair[18] and the percentage of each country's population living in tropical regions.[19] These variables were introduced to the gravity equation literature by Rodriguez and Rodrik (2001) and Noguer and Siscart (2005) as variables to control for the effect that geography may have on income. As mentioned previously, latitude affects income through its effect on institutions and is used to proxy for institutional quality since economies with "good institutions" typically have higher levels of income and reside in higher absolute latitudes. McArthur and Sachs (2001) suggest that the most appropriate measure of tropical exposure is the percentage of the population living in tropical zones since income may be greatly affected if the labor force is exposed to the many debilitating tropical diseases.

The remaining variables are (1,0) dummy variables capturing other geographic and historical connections trading partners may have and were employed in the works of Andrew Rose (2000, 2005) and Adam and Cobham (2007). The first dummy variable in the gravity equation is designed to capture any effects on trade from one or more of the countries being an island. Since most island nations tend to be small or remote they may engage in more trade relative to their size. The next two variables in the model capture the past colonial linkages between trading partners. Countries that are linked colonially have been trading for a long time and may have continued trading after the

[17] The interaction terms used by Frankel and Romer (1999) are dropped because they are all statistically insignificant and do not greatly improve the equation's fit.
[18] The latitude of each country is scaled between -1 and 1 with zero representing the equator. Using a country's average latitude only affects the scale of the coefficients.
[19] The area between the Tropic of Capricorn and the Tropic of Cancer.

end of the colonial period. Moreover, other colonized areas have most likely had previous interactions due to being under the same government umbrella (e.g. the countries of the British Empire). Given these historical connections, trade may have continued after each colony gained independence because the trading partners are familiar with one another. $ComCol_{ij}$ is a dummy variable that equals 1 if countries i and j were ever colonized by the same country (e.g. South Africa and Australia were both British colonies) and $Colony_{ij}$ equals 1 if country i ever colonized country j or vice versa (e.g. Portugal colonized Brazil).

The remaining two dummy variables capture the effect that the cultural similarities between two countries have on trade. The first variable, $CulSim_{ij}$, equals 1 if the two countries share a common dominant religion (Christianity, Islam, Buddhism, etc.), and the second variable, $Lang_{ij}$, equals 1 if the trading partners share a common official or unofficial language. Beckerman (1956) proposed that cultural similarity is an important determinant of trade between two nations. Srivastava and Green (1986) showed that there was a significant relation between cultural similarity and the intensity of total trade among nations. As noted by Yu and Zeitlow (1995), the similarity between two countries primary characteristics, such as dominant religion, common business language, and common form of government, indicates the cultural distance between the nations is small. Sharing a similar culture reflects the propensity for the people in the two nations to consume the same type of goods as well as indicating a lower cost of doing business for firms in each country.

The expanded gravity equation (6) is used to construct the predicted geographic trade shares in equation (4). The new trade shares instrument for the actual level of trade in the following expanded income equation:

$$\text{(7)} \quad \ln Y_i = \alpha + \beta T_i + \gamma_1 \ln N_i + \gamma_2 \ln A_i + \delta_1 Lat_i + \delta_2 Trop_i + \varepsilon_i$$

The difference from Frankel and Romer's income equation (5) is the inclusion of the variables for latitude and tropical exposure. These two geographic features may have an effect on income and thus should be controlled for in order to generate unbiased estimators.

Data and Methodology

a. A Simple Gravity Model

The data on bilateral (dyadic) trade is taken from the Correlates of War Project Trade data set, version 2.01 (Barbieri, et al., 2008) and cover trade flows for 141 countries in 1985.[20] Data on population and income are obtained from the Penn World Table (version 7.0). The distance between two countries is measured as the great circle distance between the two most populous cities in each country. Data on distance, common borders, language, area, and colonial connections were taken from databases available from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII).

The first step, before the gravity model is estimated, is to verify that trade is an endogenous variable in the income equation (7). If trade is found to be exogenous to income, then the OLS estimators will be unbiased and there would be no need to create an instrument for trade. A Hausman (1978) test is performed on the income equation to test for the possible, and expected, endogeneity of trade. The income equation is

[20] Nine countries were dropped from the set employed by Frankel and Romer (1999) due to lack of data availability.

regressed on our geographic variables and the actual share of trade in GDP. The residuals for the trade share are obtained and then used in the income equation to evaluate the null hypothesis of no endogeneity. The results of the F-test indicate that we can reject the null hypothesis at all significance levels, signifying the highly endogenous nature of trade toward growth in per capita income.[21] From the results of the Hausman test, it is concluded that trade is an endogenous variable in the income equation and that the construction of an instrument variable for trade is required to obtain unbiased estimates of the effect of trade on income.

In constructing the gravity equation, the procedure developed by Frankel and Romer (1999) for country pairs in 1985 is initially followed in order to evaluate the previous authors' results. A reduced form gravity equation is estimated for trade among the set of 63 countries employed by the previous estimation. The following equation is estimated:

$$\textbf{(8)} \quad \ln(\tau_{ij}/GDP_i) = \alpha_0 + \alpha_1 \ln D_{ij} + \alpha_2 \ln N_i + \alpha_3 \ln A_i + \alpha_4 \ln N_j + \alpha_5 \ln A_j + \alpha_6(L_i + L_j) + \alpha_7 B_{ij} + e_{ij}$$

The interaction terms present in the previous estimation are dropped because each term is statistically insignificant and their inclusion does not substantially improve the overall fit of the model. Observations where bilateral trade is missing or recorded as zero are also dropped from the estimation.

The results of the reduced form gravity model are presented in Column I of Table 3. The estimated coefficients are consistent with the results obtained by Frankel and

[21] F-stat = 1512.21; P-value = 0.0000

Romer and have the same sign. The gravity equation confirms that distance has a large and extraordinarily negative impact on bilateral trade. The estimated elasticity of trade with respect to distance is -0.89, just slightly less (in absolute value) than -1. Moreover, trade between country i and country j is robustly increasing in the size of country j with an elasticity of trade with respect to country j's population of about 0.7, just slightly higher than the elasticity estimated by Frankel and Romer (0.61).

The variables capturing the effects of sharing a common border and at least one of the countries in the pair being landlocked also have the correct sign. Sharing a common border has a significantly positive impact on bilateral trade; this lends further proof to the accepted intuition that countries that share a border will naturally have a high volume of trade. Having at least one country in the pair being landlocked does have a negative impact of bilateral trade, capturing some of the effects of increased transportation cost. However, the coefficient is estimated to be statistically insignificant implying that the landlocked dummy variable is serving as an imperfect proxy for transportation costs. Further, as the previous authors also note, bilateral trade as a share of country i's GDP is decreasing in the overall size[22] of country i along with the area of country j. This lends some support to the belief that the citizens of larger countries will be trading more amongst themselves compared to the rest of the world.

A divergence in the results obtained in this study and the results of the previous study is the estimation of a slightly positive effect of the population of country i on their bilateral trade share. The results show that a 1% increase in the population of country i

[22] The coefficients on population and area

Table 3 – Gravity Equation Estimations

Dependent variable = ln(τ_{ij}/GDP_i) [log of bilateral trade share]

	I	II	III
Constant	-2.11**	-5.76**	-3.25**
	(0.709)	(0.724)	(0.38)
Log of Population i	0.019	0.091**	-0.074**
	(0.033)	(0.031)	(0.018)
Log of Population j	0.703**	0.73**	0.77**
	(0.032)	(0.03)	(0.018)
Log of Area i	-0.12**	-0.203**	-0.10**
	(0.027)	(0.025)	(0.015)
Log of Area j	-0.29**	-0.202**	-0.14**
	(0.026)	(0.025)	(0.015)
Log of $Distance_{ij}$	-0.89**	-0.668**	-0.98**
	(0.048)	(0.054)	(0.03)
Common Border	0.711**	1.01**	0.60**
	(0.219)	(0.21)	(0.13)
Landlocked	-0.047	-0.012	-0.13**
	(0.117)	(0.11)	(0.05)
Island	---	0.50**	0.12**
		(0.068)	(0.041)
Colony	---	0.55**	1.44**
		(0.21)	(0.14)
Common Colonizer	---	0.301	0.21**
		(0.22)	(0.077)
Language	---	0.464**	0.42**
		(0.11)	(0.06)
Cultural Similarity	---	0.254**	0.27**
		(0.077)	(0.05)
Latitude i	---	-0.58**	-0.82**
		(0.13)	(0.093)
Latitude j	---	0.96**	0.80**
		(0.13)	(0.092)
Tropics i	---	-0.16*	0.20**
		(0.089)	(0.053)
Tropics j	---	-1.54**	-1.80**
		(0.088)	(0.053)
Observations	3294	3294	11346
Adjusted R-squared	0.25	0.38	0.48
Root MSE	2.08	1.89	2.15

Standard errors are in parenthesis.

** significant at 5% level   * significant at 10% level increases their bilateral trade share in GDP by about 0.02 percent; however the coefficient is statistically insignificant (t-stat = 0.59). Previous studies calculate a statistically negative relationship between the two variables showing that a 1% increase in country i's population reduces their bilateral trade share by 0.24 percent (t-stat ≈ 8). There are two possible explanations for this discrepancy. First, in this study population is measured as the total population of the country; in the previous study, the labor force of each country was used to measure population.[23] Second, the choice of countries chosen for the gravity equation coupled with some differences in the measurements of the variables may be causing the difference that is reported. The majority of countries included in the gravity equation are the richest economies in the world.[24] These richer economies with larger populations are spending a portion of money on imported goods causing the trade share of GDP to rise.

The most important result is that this estimation of the gravity model verifies the previous authors' assertion that the geographic variables used in the model are important determinants of the volume of bilateral trade. The adjusted R^2 of the estimation is 0.25. Given that the results of the previous study have been largely confirmed, the expanded gravity equation is tested to determine if the estimation of the model can be improved.

b. The Expanded Gravity Model

Next, the set of 63 countries chosen by Frankel and Romer is tested using the expanded gravity equation (6). This specification of the gravity model employs the additional variables described in Section III of this study (Cultural Similarity, Colonial

[23] However, Frankel and Romer note that this makes very little difference in the estimation.
[24] Mainly U.S and Europe

ties, etc.). The goal of using this specification of the model is to construct a more complete and robust instrument variable for trade to be employed in the estimation of the income equation (7). The results of the estimation are presented in column II of Table 3.

As shown in the estimation of the reduced-form gravity equation, the variables in the expanded equation have the anticipated sign. The distance between trading partners continues to exert a significantly negative impact on the volume of bilateral trade, although the strength of the relationship has been reduced from -0.89 to -0.67. Country i's bilateral trade share of GDP is strongly increasing in the overall size of country j; though trade is decreasing in the area of country j. Sharing a common border and having a landlocked country in the pair also maintain their signs; moreover, the strength of the relationship between bilateral trade and countries sharing a border increases when the expanded gravity equation is utilized. The coefficient on the population of country i persists in yielding a positive effect on trade showing that a 1% increase in a country's population increases their bilateral trade share by 0.09 percent. A difference when using the expanded gravity equation is that the relationship is now statistically positive (t-stat = 2.91).

The effects of the additional variables in the gravity equation must also be examined. The additional variables are mostly significant and their signs correspond to the direction of the effects estimated by other papers. When at least one of the countries in the pair is an island, the volume of bilateral trade is 50% higher on average than if both countries are continental. Due to their lack of natural resources and land area for farming and manufacturing, many island nations will necessarily have a higher share of trade in their level of GDP because they must import many of the goods the economy consumes. When one country in the pair colonized the other country at some time in the past, bilateral trade between the countries is 55% higher than the volume of trade between two countries that do not share any colonial ties. Moreover, two countries that were both colonized by the same mother country have about a 30% higher volume of trade between them compared to their trade with other countries in the world; however, this effect is only significant when evaluated at the 20% confidence level.[25] This low significance is most likely a result of the country sample selection which excludes many countries that were once colonies of the traditional European powers. Overall, past colonial ties have a positive impact on the trade between two countries.

Additionally, sharing a common language and a common dominant religion also exert strong, positive influences on the amount that two countries trade. Countries that share a common language have a volume of bilateral trade about 46% higher than their trade with other countries in the world; additionally, two countries that share a common dominant religion have a 25% greater volume of trade on average. This result is expected because, as discussed earlier, sharing a common language and religion implies a relatively small cultural distance between the countries. The relatively small cultural difference facilitates and eases trade between the two nations because it is cheaper for firms in each country to deal with each other and the citizens of each country will have a propensity to consume similar types of goods.

The last geographic variables included in this specification of the gravity model account for the latitude of each country and each country's tropical exposure.[26] As noted earlier, latitude serves as a proxy for institutions and is one of the potential

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[25] t-stat = 1.35
[26] McArthur and Sachs (2001)

avenues through which geography may impact income. This relationship seems almost self-evident when we consider that a majority of the richest countries in the world lie above 20°N latitude. In this study, a country's average latitude is scaled to lie between -1 and 1 (the equator = 0).[27] Trade between countries i and j is strongly increasing in the latitude of country j with an estimated elasticity of trade to the latitude of country j of 0.96. However, bilateral trade volumes between two countries are decreasing in the latitude of country i; this is not unexpected since many of the countries in the higher latitudes tend to have a lower trade-to-GDP ratios than countries in lower latitudes.

In addition, a second geographic variable is included in the gravity equation to capture a country's exposure to tropical climates. This variable may also impact a country's GDP because countries in the tropical zones have been subject to many fatal and debilitating diseases which can affect the health of the labor force and inhibit a high rate of economic growth. Following McArthur and Sachs (2001) and Noguer and Siscart (2005), tropical exposure is measured as the percentage of a country's population that reside in the tropical zone.[28] This can be an important determinant of trade since upwards of 40% of the world's population lives in the tropical zone. Overall, exposure to tropical climates has a negative impact on the volume of bilateral trade. A one percentage point increase in the population of country j living in the tropic zone reduces bilateral trade by 1.54 percent, on average. Furthermore, an increase in the percentage of country i's population in the tropics also reduces trade, although the effect is only significant when measured at the 10% confidence level.

On the whole, the expanded gravity equation coincides with many of the results of previous gravity model studies. In addition, this specification of the gravity equation

[27] Following the procedure of Noguer and Siscart (2005).
[28] Between 23.4378°N (Tropic of Cancer) and 23.4378°S (Tropic of Capricorn)

improves the fit of the model. The adjusted R^2 of the model increased from 0.25 in the reduced model to 0.38 when additional geographic and historical controls are included.

As an extension of the scope of the gravity model, the number of countries used in the model is expanded. Instead of limiting the sample to trade among a set of 63 countries, every country pair that has some positive level of recorded trade is included. This increases the sample size of the model from 3,294 observations to 11,346 observations. By including the additional observations, the hope is to generate a truer, more robust estimate of the effects of geography on the volume of bilateral trade. The results of this estimation are presented in column III of Table 3. The results of using the extra observations, which were ignored by previous authors, strengthens the relationships between the variables and bilateral trade (all coefficients are highly significant) and also improves the fit of the equation ($R^2 = 0.48$). Moreover, the variables also appear to have the correct sign.

The distance between each country in the country pair is highly significant with a coefficient of -0.98. Country i's trade share of GDP is strongly increasing in the size of country j; each specification of the gravity model yields this result that a country trades more with its largest trading partners in terms of country size. Trade between the two countries is also clearly decreasing in the size of country i. In this specification of the model an increase in the population of country i has a significantly negative effect on bilateral trade; the results show that a one percent increase in the size of country i is responsible for a 0.17 percent reduction in the volume of bilateral trade.

Past colonial ties are also a strong predictor of trade between nations; if one country colonized the other country in the pair, trade is an astounding 144% higher than the country's trade with nations they did not colonize. An increase in the latitude of country j generates a higher volume of bilateral trade (an increase of 0.8% for every one percentage point increase in average latitude) and an increase in the latitude of country i in the pair serves to reduce the volume of bilateral trade (a reduction of 0.82% for every one percentage point increase in the average latitude of country i). Additionally, an increase in the percentage of country j's population residing in the tropics reduces bilateral trade by 1.80 percent. Interestingly, in this version of the model, an increase in the percentage of the population of country i living in the tropics will cause an increase in the volume of bilateral trade by roughly 0.2 percent. The previous model yielded a marginally significant, negative relationship between bilateral trade and the tropical exposure of country i. This result indicates that countries outside of the tropical zone tend to trade less with countries inside this zone while tropical countries seek to trade more on average.

The next stage of this study is to construct an instrument variable for trade based on the results of the gravity equations. An instrument will be created from each version of the gravity model and used to test the relationship between trade and per capita income in the income equation (7). Furthermore, the results of the income equation will be compared to previous results in an effort to determine which instrument best captures the relationship between trade and income.

c. The Quality of Constructed Trade

To construct the instrument variable for a country's trade share, the fitted values from the three gravity equation models are aggregated across each country pair. The procedure for aggregating the fitted values was outlined in Section II of this study.[29] The

[29] Equations (3) and (4).

geographic component of country i's trade is constructed as the sum of the estimated geographic components of country i's bilateral trade with each other country in the world. An important feature of the constructed trade share is that only information on a country's population, geographic components, and colonial ties are needed to perform the calculation in equation (4). The gravity model of bilateral trade was estimated using only 63 countries in the sample; however, the summation in equation (4) is taken over a set of 141 countries. This feature of the estimation allows predicted trade shares to be constructed even for the countries that are missing bilateral trade data or where trade volumes were recorded as zero.

Figures 1 – 3 show the actual trade share plotted against three constructed trade shares from the gravity estimations. The figures demonstrate that geographic variables do account for a major portion of the variation in overall trade. Columns I-III of Table 4 show the results of regressing the actual trade share on a constant and each of the three constructed trade shares. As the results show, the constructed trade shares have large, positive relationships with the actual trade share.

The constructed trade shares are also highly correlated with country size. This makes intuitive sense when we consider that the five countries with the smallest constructed trade shares are also the largest countries in the data set.[30] Similarly, the five countries with the largest constructed trade shares are some of the smallest countries in the data set. A regression of each of the constructed trade shares on a constant, log population, and log area yields a negative and significant effect of country size on trade. The adjusted R^2 for each estimation ranges from 0.27 for the trade share from the simple gravity model to 0.54 for the expanded gravity model.

[30] United States, Canada, China, Soviet Union, Brazil

Figure 1: Actual Trade Shares vs. Constructed Trade Shares 1

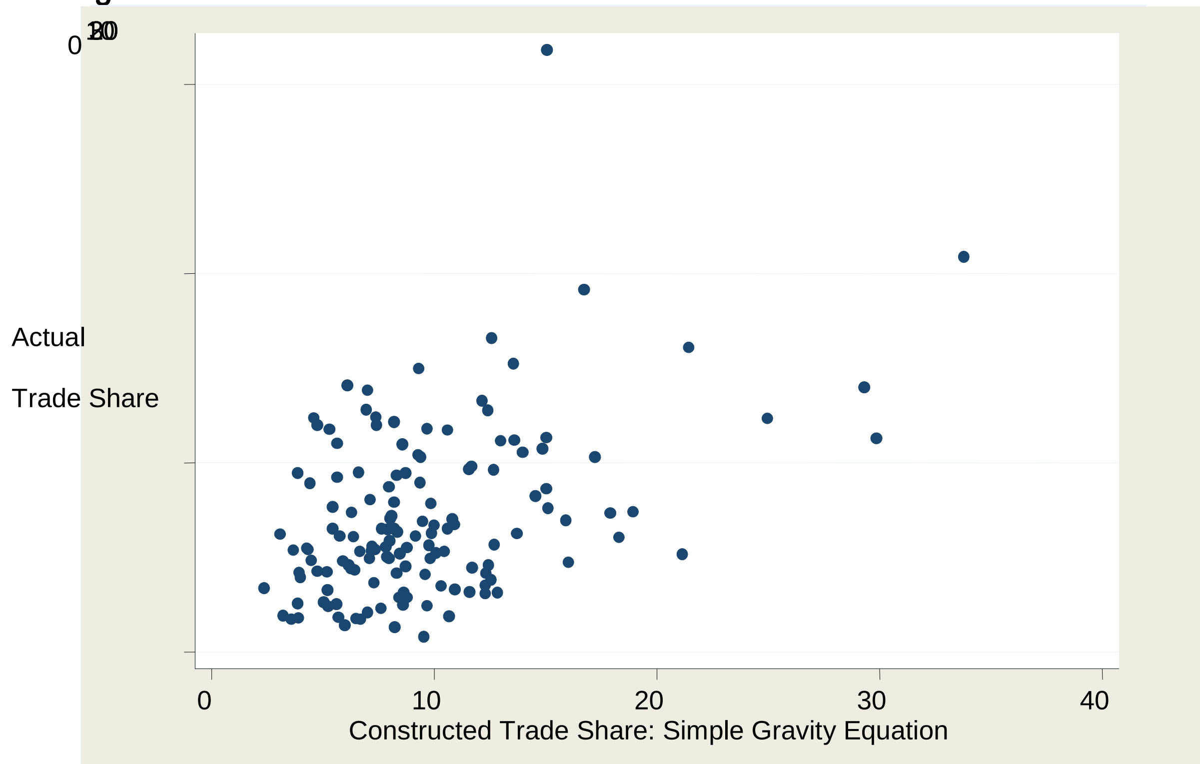

Figure 2: Actual Trade Shares vs. Constructed Trade Shares 2

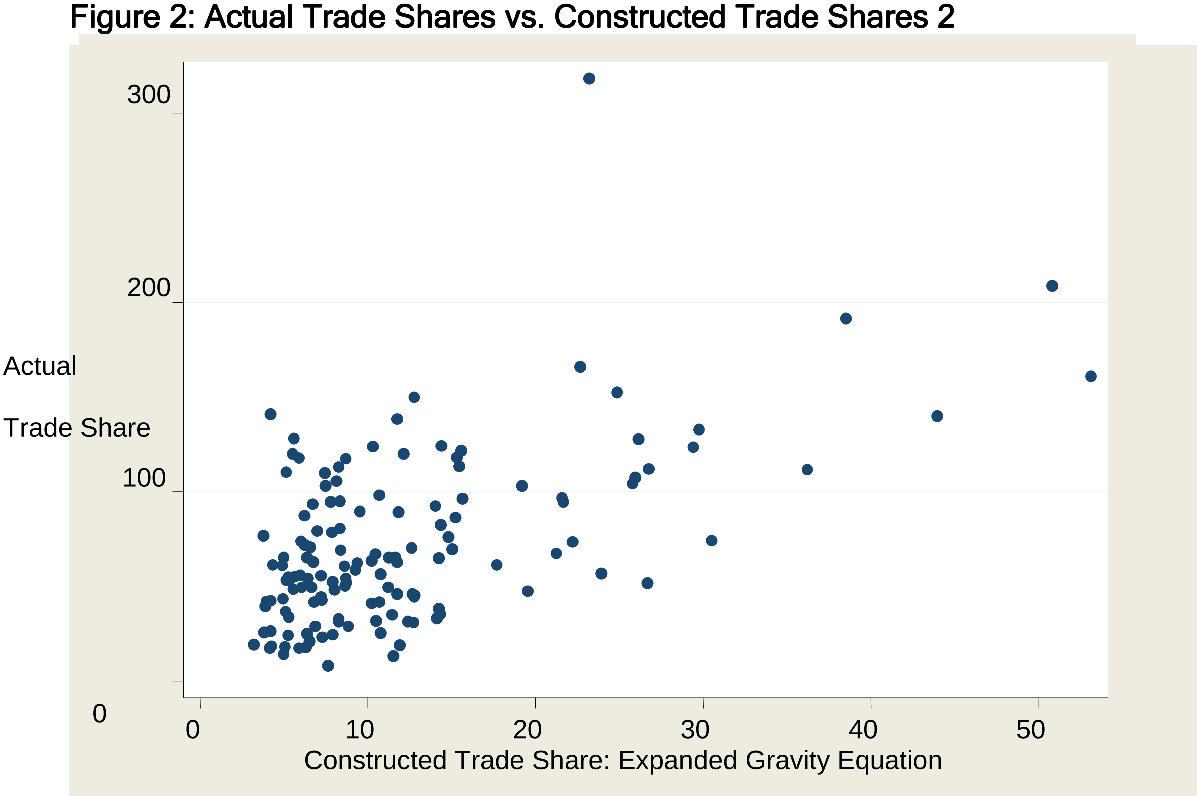

Figure 3: Actual Trade Shares vs. Constructed Trade Shares 3

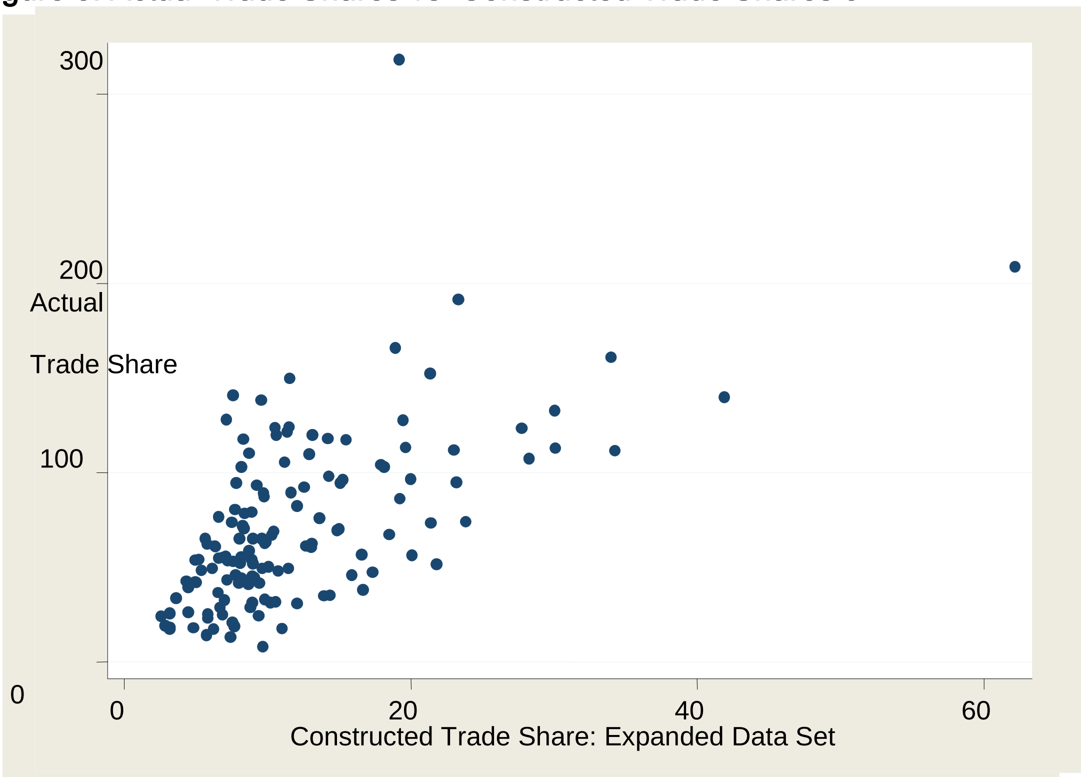

Table 4 – The relation between actual and constructed trade

	I	II	III	IV	V	VI
Constant	35.40**	37.78**	32.18**	258.62**	238.61**	227.39**
	(7.27)	(5.20)	(5.43)	(22.5)	(23.38)	(24.27)
Trade share 1	3.74**	---	---	2.07**	---	---
	(0.66)			(0.59)		
Trade Share 2	---	2.82**	---	---	1.80**	---
		(0.35)			(0.42)	
Trade Share 3	---	---	3.29**	---	---	1.74**
			(0.38)			(0.38)
Ln Population	---	---	---	-9.68**	-11.21**	-7.99**
				(2.15)	(2.19)	(2.00)
Ln Area	---	---	---	-4.77**	-1.20	-4.41**
				(1.97)	(2.33)	(1.86)
Sample Size	141	141	141	141	141	141
R-squared	0.18	0.32	0.35	0.54	0.56	0.56
Root MSE	40.37	36.85	35.94	30.27	29.65	29.48

The dependent variable is the actual trade share. Standard errors are in parentheses.

** significant at 5% level * significant at 10% level

Since country size is highly, negatively correlated with the constructed trade shares, it is necessary to ask whether the geographic variables provide additional information beyond that captured by the country size variables. Columns IV-VI of Table 4 present the results from the regressions of the actual trade share on a constant, each of the constructed trade shares, and the two size variables. As expected, the results indicate that country size has a negative effect on the volume of trade. Population is highly significant in each of the three estimations while area is only significant in two of the three estimations.

The results also show that the coefficient on each of the constructed trade share falls when country size is controlled for in all three estimations. However, the coefficients on the constructed trade shares remain highly significant. This suggests that there is still a considerable amount of information about actual trade contained in the constructed trade shares even after the country size variables are included. The results of an F-test on each of the three estimations shows that the constructed trade shares contain enough information about actual trade for the IV estimation to produce only moderate standard errors for the estimated impact of trade. Further, as demonstrated by Nelson and Startz (1990), Hall et al. (1996), and Staiger and Stock (1997), the F-statistics are large enough that the finite-sample bias of instrument variables estimations is not likely to be a serious concern for the IV estimations conducted in this study. Thus, the IV estimation of the income equation should not suffer from the same bias that arises in the OLS estimation.

d. The Income Equation

The geographic components of trade are now used in an income equation to assess the impact of trade on per capita GDP. Two income equations are considered in this study using each of the three instrument variables outlined previously. The first income equation is the specification originally employed by Frankel and Romer (1999). The model is given by equation (5). Per capita GDP is regressed on the trade share along with the two variables capturing the effects of country size. The second estimation of the income equation is given by equation (7). In this variation, a country's latitude and exposure to tropical climates are included to control for the avenues through which geography may affect income. Each of the two specifications of the income equation will be evaluated with the three instrument variables constructed by this study; moreover, as an additional test, the constructed trade shares calculated by Frankel and Romer (1999) will be utilized in each of the variations of the income equation.

The basic results of the estimation are presented in Table 5. Columns I and II display the results of the standard OLS estimations of the income equations. In each of the two estimations, the log of per capita income is regressed on a constant, the actual trade share in GDP, the two size variables, and, in the case of Column II, the two geographic variables that affect income. Column I reports the results from the estimation of the simple income equation. The findings show a statistically and economically significant relationship between the actual trade share and per capita income. The t-statistic on the trade share is 3.52.[31] Further, the point estimates imply that an increase of one percentage point in the trade share is associated with a 1.5

[31] Almost the same as that estimated by Frankel and Romer (3.5).

percent increase in income per person.[32] The results also demonstrate that, once international trade is controlled for, there is a positive, although only marginally significant, relationship between country size and income per capita. This lends support to the idea that within-country trade is beneficial to growth in per capita income. The point estimates suggest that increasing both population and area by one percent increases per capita income by about 0.18 percent. Overall, these results are consistent with the OLS results of previous estimations.

Column II of Table 5 reports the OLS estimation of the expanded income equation that includes the two geographic control variables. Even after controlling for geography in the income equation, the coefficient on the actual trade share remains positive and statistically significant; although both the coefficient on the trade share and the statistical significance of the variable are reduced after the inclusion of the geographic controls. The point estimates now imply that a one percentage point increase in the trade share increases per capita income by 0.87 percent. Furthermore, the effect of country size on income per capita is flipped once the two geographic variables are included. In this estimation, country size has a negative, yet statistically insignificant, impact on income per capita with a point estimate of the relationship of about -0.05 percent. The geographic variables each have the appropriate sign and imply that a one percent increase in a country's average latitude raises per capita income by about 1.6 percent while a one percentage point increase in the percent of a country's population in the tropical zone reduces income per capita by 1.56 percent.

[32] The percentage trade share was used in the estimation rather than the decimal form since this only represents a difference in the scale of the coefficients on trade.

Table 5 – Growth Equation Estimations

Dependent Variable: Log of per capita GDP

	OLS		**IV**							
	I	*II*	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*
Constant	3.51**	8.28**	5.60**	10.94**	6.64**	11.59**	4.79**	9.96**	6.63**	9.66**
	(1.59)	(1.38)	(1.44)	(1.28)	(1.16)	(1.07)	(1.14)	(1.21)	(1.14)	(1.24)
Log of Population i	0.26**	-0.013	0.20*	-0.09	0.067	-0.073	-0.08	-0.13	-0.14	-0.09
	(0.11)	(0.09)	(0.11)	(0.09)	(0.11)	(0.089)	(0.11)	(0.092)	(0.10)	(0.093)
Log of Area i	-0.08	-0.033	-0.12	-0.10	-	-0.15*	0.23**	-0.003	0.17	-0.001
	(0.09)	(0.074)	(0.10)	(0.08)	0.066	(0.081)	(0.11)	(0.10)	(0.11)	(0.11)
					(0.10)					
Trade Share	0.015**	0.009**	0.014**	0.0001	0.08**	-0.035	0.11**	0.027	0.072**	0.038*
	(0.004)	(0.003)	(0.006)	(0.005)	(0.03)	(0.028)	(0.02)	(0.021)	(0.021)	(0.021)
Latitude	---	0.016**	---	0.016**	---	0.019**	---	0.015**	0.025**	---
		(0.005)		(0.005)		(0.006)		(0.005)	(0.005)	
Tropics	---	-1.56**	---	-1.67**	---	-1.72**	---	-1.52**	---	-1.81**
		(0.26)		(0.26)		(0.26)		(0.29)		(0.27)
Observations	141	141	141	141	141	141	141	141	141	141
Adjusted R-squared	0.097	0.43	0.05	0.40	0.06	0.41	0.19	0.41	0.30	0.38
Root MSE	1.53	1.21	1.57	1.24	1.56	1.23	1.45	1.23	1.35	1.26

Standard errors are in parentheses. The trade share is measured in levels. **5% *10%

OLS: Actual trade share

Instrument variables: I, II – Trade shares from Frankel and Romer (1999)
III, IV – Trade shares constructed following the procedure in Frankel and Romer
V – VIII – Trade shares constructed by the author

The remaining columns of Table 5 report the results of the IV estimates of the income equations. In these estimations trade is treated as endogenous and the various constructed trade shares are used as instruments in the income equations. Columns I and II of the IV estimations employ the trade shares directly constructed by Frankel and Romer (1999). The results of the simple income equation imply that a one percentage point increase in the constructed trade share leads to a 1.36 percent increase in income per person. When the constructed trade share is used, the coefficient on trade falls compared to the OLS estimation. This is opposed to the previous study that noted a sharp increase in the coefficient for the trade share. However, the hypothesis that the coefficient in the IV estimation is zero is rejected at accepted confidence levels. Additionally, a country's size has a positive effect on income per person; yet, the size of the relationship is reduced to 0.8 percent and the effect is statistically significant only at the 10% level.

Column II of the IV estimations in Table 5 reports the results of the expanded income regression, which includes the geographic control variables, when Frankel and Romer's constructed trade share is employed. The highly significant nature of each of the geographic variables indicates that each control belongs in the income equation. As noted by Rodriguez and Rodrik (2001), when the geographic controls are included in the income equation the strong positive relationship between trade and income disappears. The effect of trade on income per capita falls to 0.01 percent and is highly insignificant (t-stat = 0.02). This finding is consistent with the hypothesis that the non-trade effects of geography are the main driving force behind the findings of Frankel and Romer. Moreover, the results yield a negative yet insignificant relationship between country size and income per capita. This is a common result in all of the estimations that include the geographic controls indicating that country size has no effect on income per capita. Additionally, the geographic controls have the correct sign and display similar effects in both the IV estimation and the OLS estimation.

The trade shares constructed specifically for this study are utilized in the remaining columns of Table 5 (Columns III-VIII). Columns III and IV report the results when using the trade instrument constructed from the simple version of the gravity model (equation (8)). The results of the estimations are somewhat surprising. When the constructed trade share is utilized in the reduced-form income equation, the estimate of trade's impact on income grows from 1.5% in the OLS estimation to 7.9 percent in the IV estimation. The estimated effect of trade is also highly statistically significant. This finding is in line with Frankel and Romer's results where they show that their IV estimation yields a higher coefficient on the trade share than with OLS; the difference is that the estimation in this study shows an even larger increase in the coefficient once the predicted trade shares are included in the growth equation. An interesting result in Column III is that the overall effect of country size on income falls to virtually zero and the effect is statistically insignificant implying that within-country trade does not play a significant role in the growth of per capita income; this is opposed to the previous study that found some moderate support for the benefits of within-country trade.

The results change considerably when the trade share instrument constructed from the simple gravity model is included in the income equation with geographic controls. The most interesting result is that this estimation yields a negative impact of trade on income per capita. The point estimates show that a one percentage point increase in the trade share will reduce income per capita by 3.5 percent; although the measured effect is insignificant once geography is controlled for in the income equation. Moreover, the results again show that country size has a negative, yet insignificant, effect on income per capita once the geographic controls are included.[33] Again, the geographic controls have the anticipated sign and are highly significant.

Columns V-VIII of Table 5 report the results of the estimations of the income equations when the trade share instrument constructed from the expanded gravity equation (6) is used. The trade instrument from the expanded gravity model outperforms the trade shares from the OLS estimations and the IV estimations utilizing both the Frankel and Romer trade shares and the simple gravity model trade shares. The point estimates from the reduced income equation show that a one percentage point increase in the trade share is associated with an 11 percent increase in per capita income; the effect is highly, statistically significant. Furthermore, the results yield a

[33] A one percent increase in country size is associated with a 0.22% reduction in income per capita.

positive relationship between country size and income per capita indicating that a one percent increase in a country's total size is accompanied by a 0.15% increase in per capita income. An interesting result is that the sign on the coefficient of area is positive; the sign was negative for the OLS estimations and the first two IV estimations. One possible explanation is that while larger country size does decrease the amount of within-country trade, larger countries will have greater endowments of natural resources which will exert a positive impact on national income.

Next, the trade instrument from the expanded gravity equation is employed to test the relationship between trade and income per capita in the expanded income equation. The results of this estimation are reported in Column VI of Table 5. The constructed trade instrument, which is original to this study, continues to outperform the trade shares from the OLS estimation and the other IV estimations of the expanded income equation. However, the coefficient on the trade share is reduced when the geographic controls are included.[34] The point estimates now imply that a one percentage point increase in the trade share is only associated with a 2.7 percent increase in income per capita; although the coefficient on the trade share is only marginally significant. Additionally, the estimation generates a negative relationship between country size and income per capita. The coefficients on the geographic controls have the correct sign and yield effects very similar to the other estimations that include these two variables. In each of the estimations, a one percentage point increase in a country's average latitude is associated with an increase in income per capita of between 1.5 and 1.9 percent. A one percentage point increase in the share of a country's population in the tropical zone reduces income per capita by between 1.52 and 1.72 percent.

[34] As shown by Rodriguez and Rodrik (2001).

An interesting question might be to ask which of the two geographic controls is driving down the coefficient on the trade share. Columns VII and VIII of Table 5 show the results when each of the geographic controls are included separately in the income equation. When only the variable for latitude is included in the income equation, the coefficient on trade falls compared to the estimation of the income equation excluding the geographic variables (7.2% versus 11%); yet the estimate remains statistically significant. When only the variable capturing the exposure of a country's population to tropical climates is included in the income equation, the estimate of trade's impact on income per capita falls even further to 3.8% and the estimate is now only marginally significant (t-stat = 1.86). These results are consistent with the findings of Rodriguez and Rodrik (2001), which show that the trade effects are more affected by tropical exposure rather than the latitude of each country.

As a further test of the relationship between trade and income, a trade instrument was constructed from the expanded gravity equation using a data set that includes 11,346 observations of bilateral trade between countries. This trade share instrument includes many observations of bilateral trade that were excluded from the previous estimations and should better estimate the effects of trade on income. The results of the estimation are reported in Table 6. The first column in the table presents the results of the regression of log per capita income on a constant, the constructed trade share and the two size variables. The constructed trade share using the expanded data set exhibits a statistically significant, positive impact on per capita income with an estimated effect of 7.4% for a one percentage point increase in the constructed trade share. Further, country size exerts a moderate positive influence on income per capita; income per capita increases by about 0.1% for each one percent increase in country size.

Table 6 – Growth Equation Estimations – Expanded data set

Dependent Variable: Log of per capita GDP	I	II
Constant	5.18**	11.04**
	(1.25)	(1.24)
Log of Population i	0.13	-0.091
	(0.10)	(0.089)
Log of Area i	-0.035	-0.10
	(0.10)	(0.08)
Trade Share	0.074**	-0.0018
	(0.02)	(0.019)
Latitude	---	0.016**
		(0.005)
Tropics	---	-1.68**
		(0.27)
Observations	141	141
Adjusted R^2	0.11	0.40
Root MSE	1.52	1.24

Standard errors are in parentheses.
** significant at 5% level   * significant at 10% level

However, as has already been shown, the results change noticeably once the geographic controls are included in the model. Most notably, the coefficient on trade changes from being positive and highly significant to being negative and highly insignificant; the estimate of the coefficient on constructed trade falls from 7.4% down to a miniscule -0.18% once the geographic controls are included. These results run counter to the accepted intuition about the effects of trade on growth and indicate that trade is not an important determinant of income per capita and may exert a negative influence on growth once certain variables are controlled for.

e. Measures of Distance

Another test in this study deals with the distance variable. As all the literature on gravity models has shown, distance is the single most important determinant of the trade intensity between nations. What is odd is that there seems to be no consensus on how international distance should be measured. Since distance is so important it will be interesting to see how changing the way distance is measured might change the regression results.

The most common measure of distance is the great circle distance between the capital (or principal) cities of two countries.[35] Many studies rely on the distance between each country's most populous cities since it has been argued that the most populous city is the center of gravity for economic activity.[36] This method of measuring distance will make a difference for a country whose economic activity is concentrated in one area of the country; for example, in Canada where most activity is concentrated along the border with the U.S. rather than around the geographic center which is farther north. Yet, still other authors use the great circle distance between each country's geographic centers when measuring international distance.[37] Srivastava and Green (1986) employ a geodesic measure of the shortest distance between the borders of two countries, coded by a logarithmic nine-point scale.[38] Moreover, Kristian Gleditsch and Michael Ward (2001) have calculated and compiled what they call the Minimum Distance

[35] Frankel and Romer (1999), Irwin and Trevio (2002), Noguer and Siscart (2005), Rojid (2006)
[36] Melitz (2002, 2007), Adam and Cobham (2007).
[37] Rose (2000, 2005)
[38] 1 = contiguous, 2 = less than 500 miles, 3 = 500 – 999 miles, 4 = 1000 – 1,999 miles and so on

database which measures the actual distance between the closest points of two nations.[39]

Four separate measures of distance are considered by this paper.[40] The first two measures of distance are the basic city-to-city measures that have been widely employed in the literature on the gravity model. The distance between two countries' principal (most populous) cities is considered first.[41] As a comparison, the distance between two countries' capital cities is also considered. The next two distance measures are weighted measures. The weighted distance measures use city-level data to assess the geographic distribution of the population inside each nation. The idea behind the weighted measures is to calculate the distance between two countries based on the bilateral distances between the biggest cities of the countries with the inter-city distances being weighted by the share of each city to their country's overall population.

The general formula for the weighted distance measures was developed by Head and Mayer (2002) and is represented by the following equation:

$$\textbf{(9)} \qquad d_{ij} = \left(\sum_{k\in i}\left(\frac{pop_k}{pop_i}\right)\sum_{\ell\in j}\left(\frac{pop_\ell}{pop_j}\right)d_{k\ell}^{\theta}\right)^{1/\theta}$$

where pop_k designates the population of city k belonging to country i and pop_ℓ is the population of city ℓ in country j. The parameter θ measures the sensitivity of trade flows to bilateral distance between cities, $d_{k\ell}$. For the first weighted distance calculation, θ is set equal to 1. This reduces equation (9) to the distance measure employed by

[39] This measure will not be employed because the database limits distance pairs to countries that are within 950 kilometers of each other.
[40] Distance data available from the CEPII (www.cepii.fr)
[41] This is the measure of distance used in the gravity model estimated in Section IV.

Table 7 – Distance

	I	II	III	IV
Constant	-5.76**	-5.68**	-5.75**	-5.73**
	(0.72)	(0.73)	(0.72)	(0.72)
Log of Population i	0.091**	0.093**	0.091**	0.09**
	(0.031)	(0.031)	(0.031)	(0.031)
Log of Population j	0.73**	0.73**	0.73**	0.73**
	(0.03)	(0.03)	(0.03)	(0.03)
Log of Area i	-0.203**	-0.206**	-0.20**	-0.20**
	(0.025)	(0.025)	(0.025)	(0.025)
Log of Area j	-0.202**	-0.206**	-0.20**	-0.20**
	(0.025)	(0.025)	(0.025)	(0.025)
Log of Distance 1	-0.668**	---	---	---
(Most Populous)	(0.054)			
Log of Distance 2	---	-0.674**	---	---
(Capitals)		(0.054)		
Log of Distance 3	---	---	-0.68**	---
(Weighted Distance 1)			(0.054)	
Log of Distance 4	---	---	---	-0.68**
(Weighted Distance 2)				(0.053)
Border	1.01**	1.03**	1.08**	0.98**
	(0.21)	(0.21)	(0.21)	(0.21)
Landlocked	-0.012	-0.025	-0.015	-0.11
	(0.11)	(0.11)	(0.11)	(0.11)
Island	0.50**	0.49**	0.50**	0.50**
	(0.068)	(0.068)	(0.068)	(0.068)
Colony	0.55**	0.52**	0.54**	0.55**
	(0.21)	(0.21)	(0.21)	(0.21)
Common Colonizer	0.301	0.30	0.31	0.29
	(0.22)	(0.22)	(0.22)	(0.22)
Language	0.464*	0.49**	0.47**	0.46**
	(0.11)	(0.11)	(0.11)	(0.11)
Cultural Similarity	0.254**	0.25**	0.25**	0.24**
	(0.077)	(0.077)	(0.077)	(0.077)
Latitude i	-0.58**	-0.58**	-0.57**	-0.57**
	(0.13)	(0.13)	(0.13)	(0.13)
Latitude j	0.96**	0.96**	0.97**	0.97**
	(0.13)	(0.13)	(0.13)	(0.13)
Tropics i	-0.16**	-0.15*	-0.17*	-0.16*
	(0.089)	(0.089)	(0.089)	(0.089)
Tropics j	-1.54**	-1.53**	-1.55**	-1.55**
	(0.088)	(0.088)	(0.088)	(0.088)
Observations	3294	3294	3294	3294
Adjusted R-squared	0.38	0.38	0.38	0.38
Root MSE	1.89	1.89	1.89	1.89

Helliwell and Verdier (2001) and Anderson and van Wincoop (2003). Since much of the literature shows that θ is not equal to 1, the second weighted distance calculation sets θ equal to -1, which corresponds to the usual coefficient estimated from gravity models of bilateral trade flows.

Table 7 reports the results of the gravity equation estimations using each of the four distance measures. As can be seen from the table, each distance measure yields surprisingly similar results. Each distance measure is highly significant and they all exert a negative influence on the volume of bilateral trade between trading partners. The coefficients on the log of the distance measure are roughly equivalent and range from -0.67 for the two simple city-to-city measures to -0.68 for each of the weighted distance measures. Moreover, the other variables in the gravity equation stay approximately the same regardless of which distance measure is used. These results imply that there is virtually no difference among the four distance measures and that the trade share instruments constructed from each of the gravity estimations will yield similar effects when used in the income equation. Despite the findings that the four distance measures generate similar results, it may be worthwhile to test other measures of distance used throughout the gravity model literature to see if there are any systematic differences in the estimation of the model.

Concluding Remarks

This study investigates the degree to which international trade affects the standard of living in many of the world's economies. While this is a very old question, it has also proven a very difficult one to answer with any absolute certainty. This is due to the endogenous nature of trade which leads to bias in the estimation of the effect of trade on income. In an attempt to correct for the endogenous nature of trade and obtain unbiased estimators, this study focuses on each country's geographic components to create an exogenous value of the trade share.

A country's geographic characteristics are not a result of nation's level of income nor are they the result of any government policies. Some countries trade more simply because they are in proximity to well-populated countries; while other countries trade less because they are more isolated. Thus, the variation in trade that is due to geographic factors can serve to identify the effects of trade on income per capita.

In order to capture the geographic components of international trade, a gravity model of bilateral trade is estimated. This study first tests the simple gravity model developed by Frankel and Romer (1999) and then develops a more robust gravity model that includes variables to capture the effects of past colonial ties and cultural similarity as these factors may play an important role in the trade between two countries. From the results of the gravity estimations, a level of predicted trade is constructed to use as an instrument variable in an equation of income. This procedure is possible because, as is shown, there is a very high level of correlation between the actual trade-to-GDP ratio and each of the trade shares constructed in this study.

The results from estimations of the simple income equation consistently generate a positive and significant relationship between the trade shares and income per capita. Furthermore, in all but one case the IV estimations outperform the OLS estimates, lending evidence to the conjecture that OLS estimates are downwardly biased. Additionally, the estimates of the simple income equation generally show a moderate, positive relationship between country size and income. This suggests that within-country trade is an important determinant of income growth. Once international trade is controlled for, countries that are larger have more opportunities for intra-national trade and tend to have higher incomes. The point estimates indicate that a one percent increase in country size raises income between 0.001 and 0.18 percent.

However, the simple income equation fails to account for the possibility that geography can have an impact on income. Thus, two geographic controls are added to the income equation to control for a country's latitude and exposure to tropical climates. Once geography is controlled for, the results of the impact of trade on income change dramatically. In each case the coefficient on the trade share is reduced below the coefficient in the simple income equation; in two of the estimates the coefficient on the trade share is negative. Moreover, the coefficients for the constructed trade shares in each of the IV estimations are statistically insignificant. As shown by Rodriguez and Rodrik (2001), once geography is controlled for in the income equation, the positive effect of trade on income disappears. This property of the model is robust to each of the model specifications used in this study and indicates that there are some non-trade effects of geography that are impacting per capita income. Additionally, the results fail to demonstrate that there exists a positive effect of country size on income. In every estimation, a country's size exerts a negative, yet insignificant, impact on income per capita.

As an additional focus for this study, various measures of international distance are employed to determine if the different ways in which distances are measured are having any notable impacts on the gravity model results. This is an important question since there is no general consensus as to the best measure of distance. Four measures of distance are employed: 1) the great circle distance between capital cities, 2) the great circle distance between largest cities, 3) a weighted distance measure with $\theta = 1$, and 4) a weighted distance measure with $\theta = -1$.[42] Estimations of the gravity model developed in this study using each of the four distance measures show that the different distance measures yield surprisingly similar results. The choice of any of these distance measures does not significantly alter the results.

Overall, the IV estimates of the relationships between trade and income tend to outperform the results of the OLS estimations. However, further attention must be paid to the means through which geography affects income in order to better identify the relationship between trade and income per capita.

[42] Θ measures the sensitivity of trade flows to the bilateral distance between countries.

Chapter 3

The Dynamic, Causal Relationships between Exports, Imports, and Real Income

Introduction

For a long time, economists have been devoted to understanding the determinants of economic growth and the factors which facilitate faster growth. A number of possible variables that may affect economic growth have been considered and examined carefully. These variables include, but are not limited to, investment, saving, inflation volatility, government expenditures, and a host of other macroeconomic variables.[43] Perhaps one of the more important determinants of economic growth is the level of foreign trade. A central topic in both international trade and development economics is the potential impact of a country's level of trade on their rate of economic growth. The commonly held belief is that there is a strong, positive relationship between trade and economic growth. Trade is considered to be a means of achieving productive efficiency through the exploitation of economies of scale via specialization and access to larger markets.

The previous research into the role trade plays in economic growth has mainly concentrated on the export-led growth hypothesis.[44] Supporters of export-oriented policies cite the importance of export expansion as a key to economic growth. The development of the export sector allows countries to access a larger, global market and

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[43] For examples of these studies see Grier and Tullock (1989), Barro (1991), Mankiw, Romer, and Weil (1992) and Fischer (1993).

[44] See Michaely (1977), Balassa (1978), and Feder (1982) for a few early examples.

facilitates the spread of new technologies and capital. Advocates for the export-led growth hypothesis argue that promoting exports influences development by encouraging the production of goods specifically for export. This focus on exporting goods aids in the improvement of labor productivity as well as the level of skill employed in the export sector. The increase in productivity will then lead to a reallocation of resources from the inefficient non-traded sector to the more efficient traded good sector, and the economy as a whole will experience and increase in productivity due to spillover benefits from the trade sector.[45] The export sector, because it faces competition from both foreign and domestic firms, is more likely to promote and utilize internationally experienced managers and more highly skilled labor in order to remain competitive. Moreover, export expansion generates foreign exchange earnings which can be used to import intermediate goods that can increase capital formation and stimulate economic growth. The overall consensus is that a greater level of exports will improve the long-run growth potential of an economy.

Although many studies have demonstrated the theoretical relationship between trade and economic growth, the literature still disagrees about the magnitude and the causal direction of the relationship. Some studies argue that causality flows from exports to economic growth and denote this as the export-led growth hypothesis (higher exports lead to more rapid growth).[46] However, other studies have indicated cases where the causal flow is from economic growth to exports (higher growth causes the country to export more) and is designated as growth-led exports.[47] Economic growth can cause export growth if innovations and technical improvements create

[45] Krueger (1980)
[46] Jung and Marshall (1985), Ram (1987), Bahmani-Oskooee et al. (1991), Marin (1992), Serletis (1992)
[47] Afxentiou and Serletis (1991), Dodaro (1993), Oxley (1993)

well-developed markets which, in turn, improve the performance of exports in the trade sector. A third possibility noted in the literature is that there exists bi-directional causation between trade and economic growth.[48] In this case, export growth causes economic growth and this growth effect improves export performance through technical progress and the spinoff effects of trade.

The early work on the export-led growth theory mostly consisted of static, cross-country comparisons between nations and generally concluded that there was strong evidence in favor of export-led growth simply because these studies found income growth and export growth to be highly correlated.[49] Moschos (1989) notes, however, that these early studies may yield biased estimates due to an omitted variables problem and, consequently, generate spurious correlations. In order to accurately determine the direction of causality between exports and income one needs to look at time series data to understand how the variables have evolved and interacted over time.

A group of studies, beginning with Jung and Marshall (1985), have attempted to assess whether or not countries exhibit significant evidence of export-led growth by employing Granger causality tests on a time-series of data.[50] The Granger causality tests outperform the early cross-sectional tests because in testing for Granger causality only country-specific information is used to determine the nature of causation between two variables. Moreover, Granger causality tests do not rely on any structural stability of the coefficients across different countries, nor does the testing procedure assume any similarity in the production functions across the economies. This is a major failing of the cross-sectional studies that rely on an assumption of similar effects across countries.

[48] Chow (1987), Van den Berg and Schmidt (1994), Xu (1996)
[49] Michaely (1977), Tyler (1981), Kormendi and Meguire (1985)
[50] Kunst and Marin (1989), Dutt and Ghosh (1996), Ghartey (1993) are just a few studies employing Granger causality.

In section II the literature on the export-led growth hypothesis found using Granger causality tests will be surveyed. This brief survey will also examine certain problems with using Granger causality to test for causal relationships including the possibility of cointegration between exports and output. Next, the literature on the relationship between imports and economic growth will be added to the discussion of causal relationships to see what possible role imports may play in economic growth. As some of the literature has suggested, imports may play a significant role in the determination of economic growth in many countries. The importation of intermediate, capital goods may be a vital step in growth for developing economies because the technologies that accompany imports can spill over into the domestic market and spur additional growth in non-trade sectors. Section III will describe the methodology for testing the direction of the relationship between trade and growth employed in this study. The results of the estimations will be presented in section IV and section V will conclude.

Review of the Empirical Literature

a. The Export-led Growth Hypothesis

Tests for the presence of export-led growth rely heavily on the concept of Granger causality (Granger 1969). Using this framework, the test assesses whether exports provide any additional information in predicting economic growth once historical growth rates have been taken into account. According to Granger, X causes Y, given an information set that includes both X and Y, if Y_t can be better predicted by utilizing the past and present values of X along with the past values of Y than by not using the values of X in the regression.

In a simple bi-variate estimation let x_t represent exports and let y_t represent Real GDP. The following two equations are then estimated by ordinary least squares (OLS):

(1) $y_t = \sum_{j=1}^{p} a_j x_{t-j} + \sum_{j=1}^{p} b_j y_{t-j} + v_t$

(2) $x_t = \sum_{j=1}^{p} c_j x_{t-j} + \sum_{j=1}^{p} d_j y_{t-j} + u_t$

where p is the number of lags on each explanatory variable and u_t and v_t are serially uncorrelated, zero-mean error terms. The system of equations is then tested against the null hypotheses:

H_1: $a_j = 0$, j = 1,…, p exports fail to Granger-cause Real GDP:

H_2: $d_j = 0$, j = 1,…, p Real GDP fail to Granger-cause exports.

Granger causality can be established by testing the joint significance of the lags of the potential causal variable using an F-test. If the lags of variable x in equation (1) are found to be jointly significant, then it can be inferred that exports Granger-cause Real GDP.

If neither hypothesis is rejected, then exports and Real GDP are causally independent and there is no statistical relationship between exports and economic growth. If the first null hypothesis is rejected (exports *do* Granger-cause Real GDP) and the second hypothesis is not rejected, then this is cited as evidence for the export-led growth theory. However, if both hypotheses are rejected then there exists bi-directional causality between exports and Real GDP. As Islam (1998) and other authors have noted, the Granger test requires that the time series being estimated are stationary; however, many economic time series are likely to be non-stationary, so they may have to be differenced once in order to become stationary. Thus, it may be necessary to test the series in levels and in growth rates (first-differences).

Jung and Marshall (1985) were the first to apply Granger causality tests to the theory that increased exports were causing countries to grow at faster rates. The authors studied the relationship between the growth rate of real exports and the growth rate of Real GDP for 37 developing economies (LDCs). They then classify the countries in their sample according to four possible causal patterns: export promotion (export-led growth), internally generated exports (growth-led exports), export-reducing growth, and growth-reducing exports. In their study, Jung and Marshall were cognizant of the possibility that the variables may exert a negative influence on one another. They base their classifications on the sign of the sum of the coefficients of the lagged causal variables in the growth. Jung and Marshall find evidence of export-led growth in only four of the 37 countries in their sample (Indonesia, Egypt, Costa Rica, and Ecuador). Surprisingly, the authors find evidence of export-reducing growth in six of the countries in their sample. The faster economic growth of these six countries caused their volume of exports to decline; this was most likely due to increased domestic consumption of the previously exported goods. However, the majority of the economies in their sample, including some with high growth rates that have been attributed to export-promoting policies, provide no statistical support for any of the four classifications of causality.

The results of the Jung and Marshall study find weaker support for the export-led growth hypothesis than the results of previous cross-sectional studies. The authors attribute this discrepancy to the differences in estimation. Previous studies relied on international cross-section regressions which suffer from the questionable structural stability of the coefficients across countries. The approach employed by Jung and

Marshall is preferable because the estimation does not presume a strong similarity among the different economies; thus, the estimation only utilizes each individual country's time series when determining the direction of causation. Moreover, they attribute the weak support for export-led growth to a possible specification error due to missing variables which may be affecting both economic growth and exports.

Chow (1987) followed the work of Jung and Marshall by performing a similar analysis on eight of the most successful export-oriented newly industrialized countries (NICs).[51] Six of the eight countries also appeared in the sample used by Jung and Marshall. A difference in Chow's estimation, though, is the use of the growth rate of manufacturing output as a measure of industrial development and the use of Sims's (1980) version of the Granger causality test.[52] Chow finds evidence of bi-directional causality in six of the eight countries in the sample. However, Chow finds no significant causal pattern in Argentina and only finds evidence of causation from exports to growth in Mexico. A direct comparison of the results of the studies conducted by Chow and Jung and Marshall cannot be conducted because Chow does not report the signs of the causal relationships. Additionally, the differences in variables used in each study make any comparison difficult. However, results for four of the six economies that are common to both samples (Brazil, Korea, Mexico, and Taiwan) do differ across the two studies. Chow finds evidence of bi-directional causality in Brazil, Korea, and Taiwan and evidence of export-led growth in Mexico; Jung and Marshall find no statistical causal relationship for Brazil or Mexico. Jung and Marshall only find causality from

[51] Argentina, Brazil, Mexico, Korea, Singapore, Taiwan, Hong Kong, and Israel were examined.
[52] Three future values (leads) of each variable are included in the regression equation along with three lags.

output to exports in Korea and Taiwan and also find evidence of export-reducing growth in the case of Korea.

The discrepancy in the results of the early Granger causality tests and the apparent weak affirmation of the export-led growth hypothesis has encouraged further studies of the theoretical relationship between exports and economic growth using variations on the Granger test as well as employing alternate variables and country samples. Ram (1987) develops a model employing Real GDP, exports, the investment share in GDP, and population growth rates for 88 LDCs. Ram finds evidence of significant causation from exports to GDP in 38 countries and a positive but insignificant causal relationship for another 35 countries in the sample.

Bahmani-Oskooee, Mohtadi, and Shabsigh (1991) study causation between real exports and real GDP (1975 prices) for 20 developing economies that were originally included in the sample investigated by Jung and Marshall and find evidence of a causal relationship between exports and economic growth in ten of the countries sampled; however, they only find evidence of a unidirectional, positive relationship in two countries, Taiwan and Nigeria. Moreover, Bahmani-Oskooee et al. and Jung and Marshall draw different conclusions about the causal relationships in Korea, Taiwan, and Thailand. Bahmani-Oskooee et al. find some weak evidence for the export-led growth hypothesis in each country while Jung and Marshall find evidence of export-reducing growth in Korea, unidirectional causality from growth to exports in Taiwan, and internally generated exports in Thailand.

Ahmad and Kwan (1991) apply Granger causality tests to a sample of 47 African countries and find no evidence of export-led growth in any of the several model specifications they employ. In fact, they find little statistical evidence of any causal relationships in their model. Afxentiou and Serletis (1991) find no evidence of export-led growth in a set of 16 industrialized economies. However, they do find evidence of unidirectional causal relationship from output growth to export growth for Norway, Canada, and Japan; but there is a ten-year lag in the effect for Canada and Japan. Additionally, Afxentiou and Serletis find evidence of bidirectional causality between exports and output growth in the U.S. Since the seminal study by Jung and Marshall (1985), a great variety of techniques, data, and country sets have been used to assess the empirical relationship between exports and growth with almost as wide a variety of results.

b. Cointegration and Error-Correction

The studies reviewed in the previous section, while offering some weak support for the export-led growth hypothesis, suffer from some severe limitations. The correlations found using OLS regressions of the Granger causality test may be spurious because they fail to account for the dynamic properties of the time series data. The previous studies fail to account for possible unit roots in the data and the likelihood of cointegration between economic growth and the level of exports. Other problems facing the earlier studies are their arbitrary choice of the lag length for the variables in the Granger causality tests, the use of an F-test to interpret the causality tests[53], and the use of simple, bi-variate model specifications.

In order to draw meaningful results about the causal links between exports and economic growth, as many factors as possible must be considered in the information set. Many of the earlier studies suffer because of the omission of potentially important explanatory variables that may affect the export-growth relationship in the model. A few

[53] The F-test statistic is not valid if the time series are integrated. (Toda and Yamamoto 1995)

examples of these additional variables include an economy's level of imports, investment, and government expenditures. Furthermore, a testing procedure must be adopted to determine the number of lags to include in the model. Some models rely on Akaike Information Criteria (AIC) or Schwartz Information Criteria (SIC)[54] while others rely on the minimum final prediction error (FPE)[55] to determine the optimal number of lags.

The major problems with the data in the previous studies are the possibility of unit roots and cointegration. OLS will yield spurious relationships if the series are non-stationary; thus, each series must be tested for the possibility of a unit root with the augmented Dickey-Fuller (ADF, 1979) test, the Phillips-Perron test (1988) or any other unit root test. According to Engle and Granger (1987) two variables are said to be cointegrated if they share a common stochastic trend. Series that tend to move together for long periods of time may share a stochastic trend and are possibly cointegrated. Moreover, two variables that are non-stationary in their levels but stationary in their first differences are cointegrated if a stationary linear combination exists between the two variables. Because it is highly plausible that GDP and exports share a common stochastic trend, changes in GDP may be due partly to its movement with the trend value of exports. If this is the case the effects between exports and growth cannot be captured by the standard Granger causality test.

Wherever a cointegrating relationship is found in the data, an error-correction model (ECM) must be employed to account for the common trend (Engle and Granger, 1987). Causality from variable X to variable Y can be established if the coefficient of the one-period lagged error term of the cointegrating equation is found to be significant.

[54] Ahmad and Kwan (1991), Afxentiou and Serletis (1991), Shan and Tian (1998), Zestos and Tao (2002)
[55] Bahmani-Oskooee et al. (1991), Ghartey (1993), Islam (1998)

This is typically cited in the literature as long-run causality (Toda and Phillips, 1994). A simple bi-variate ECM in first differences can be represented as follows:

(3) $\Delta x_t = \alpha_0 + \alpha_x \theta_{t-1} + \sum_{i=1}^{r} \alpha_{1i} \Delta x_{t-i} + \sum_{i=1}^{s} \alpha_{2i} \Delta y_{t-i} + u_{1t}$

(4) $\Delta y_t = \beta_0 + \beta_y \theta_{t-1} + \sum_{i=1}^{r} \beta_{1i} \Delta x_{t-1} + \sum_{i=1}^{s} \beta_{2i} \Delta y_{t-1} + u_{2t}$

where Δx_t is the growth rate of exports, Δy_t is the growth rate of GDP, and θ_{t-1} is the one-period lagged error correction term. The coefficient on the error correction term is often referred to as the speed-of-adjustment parameter and reflects the response at which the cointegrated variables move back to their long-run equilibrium relation after a shock.

The system of equations is tested against the following null hypotheses:

H_1: $\alpha_{2i} = \alpha_x = 0$; GDP fails to Granger-cause exports;

H_2: $\beta_{1i} = \beta_y = 0$; Exports fail to Granger-cause GDP.

The null hypothesis of no causality can be rejected if the coefficients of the lagged causal variable are statistically significant according to an F-test and also if the coefficient of the one-period lagged error correction term is statistically significant according to a t-test. The ECM improves the estimation of the model because it allows for the identification of an additional source of causation stemming from the common trend in the underlying series. Standard Granger causality tests in this case are inappropriate because they ignore this channel of causality.

Afxentiou and Serletis (1991) and Kugler (1991) were early studies that tested for unit roots and cointegration in the series. Both of the studies attempted to assess the causal links between exports and economic growth for a set of industrialized countries. This was a distinct difference from previous studies which mainly focused on developing economies. Afxentiou and Serletis utilize the Phillips-Perron procedure to test for unit roots in the data and choose the lag-length of the model based on the Schwartz criterion. They find no evidence for the export-led growth hypothesis in any of the 16 nations that they studied; although they do find evidence of bi-directional causality between exports and growth for the United States. Kugler (1991) utilizes the procedure of Johansen and Juselius (1990)[56] to test for the presence of unit roots and selects the lag length of the model according to the Akaike Information Criteria. The author finds evidence of a cointegrating relationship between exports and economic growth in only two of the six countries in the sample (Germany and France).

Ahmad and Harnhirum (1996) studied causality between exports and economic growth for five countries of the Association of Southeast Asian Nations (ASEAN).[57] They employed a bi-variate vector autoregressive model (VAR) and tested for cointegration in four of the five countries.[58] They found that exports and economic growth were not cointegrated in the four countries. Furthermore, the results of the Granger causality tests from their VAR model yielded evidence of causality from GDP to exports (growth-led exports) for each of the four countries. These results ran contrary to the belief that the sampled countries were able to achieve economic growth by promoting policies of export expansion.

Dutt and Ghosh (1996) employed the methodology of the bi-variate ECM for a large sample of countries. For the countries in which they find evidence of cointegration they estimate a vector error correction (VEC) model. Standard Granger causality tests are used when no cointegrating relationship is found. Interestingly, the authors find no

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[56] The time series are modeled as a reduced rank regression for which the maximum likelihood estimates in the multivariate cointegration model are computed with Gaussian errors.
[57] Indonesia, Malaysia, Singapore, Thailand, and the Philippines
[58] all except Thailand where the two series were not integrated of the same order

evidence of causation between exports and GDP for Canada and they only find causation from GDP to exports for the United States. The results were mixed for the other countries in their sample with some countries exhibiting evidence of export-led growth, others displaying evidence of growth-led exports, a few displaying evidence of bi-directional causality, and the rest of the sample exhibited no significant causal relationship.

Islam (1998) tested for cointegration using the ECM for 15 Asian countries. The author finds evidence of a cointegrating relationship between the causal variables (GDP, exports, imports, investments, and government expenditures) in a multivariate framework for five of the fifteen countries. Causality in these five countries is estimated using the ECM and a multivariate Granger model is employed for the remaining countries. The results of a bi-variate, benchmark causality test indicates that growth in exports caused economic growth in eight of the fifteen countries; reverse causality from economic growth to exports was found in three of these countries. The error correction results show that growth in exports caused economic growth in all of the countries for which a cointegrating relationship was found. This causality can be attributed to the common trend in the estimated variables or to the lagged responses of the explanatory variables. The combined results of the multivariate Granger causality tests and the error-correction test support causation from exports to growth in 13 of the 15 countries sampled with seven of the 13 also showing evidence of reverse causation. Islam finds evidence of bi-directional causality in nearly 50% of the countries in the study, well above the numbers that have been previously reported. Overall, the use of unit root and cointegration tests improves the estimation of the causal relationships among the variables investigated by the aforementioned studies.

c. The Role of Imports

With very few exceptions, previous studies of export-led growth have failed to address the role that imports may play in the causal relationship between trade and income. As Riezman, Whiteman, and Summers (1996) have stated, the omission of import growth may mask significant causality between exports and income or may yield spurious correlations. Imports may play the role of a confounding variable in the causal ordering because imports have the potential to affect both income and the level of exports for an economy. Failure to take imports into account may lead to misleading or incorrect results.

A second problem arises when imports are included as a component of a country's total trade. Causality tests based on total trade shares rely on the assumption that the coefficients on exports and imports are constant, that they have the same effects in the model. As shown by Krishna and Norman (1999), output growth was best explained by models that include exports and imports as separate variables in 70% of their sampled countries.

An early attempt to control for the effects of imports was conducted by Serletis (1992) who tested the export-led growth theory for Canada. After controlling for imports, Serletis found that export growth caused GNP growth over the full sample (1870 – 1985). At the same time, however, no evidence was found that import growth caused either export growth or GNP growth.

Riezman et al. (1996) take imports into account in their estimations of the causal relationship and find stronger support for the export-led growth hypothesis than previous bi-variate studies for a large sample of countries. Specifically, when they compared their results to the results of Jung and Marshall, Riezman et al. find evidence of export-led growth in nine of the 37 countries in the sample utilized Jung and Marshall compared to just four countries displaying evidence of export-led growth in the original study. When Riezman et al. conducted bi-variate Granger causality tests on a sample of 126 countries they found evidence of export-led growth in only 16 countries. However, once imports were controlled for in their model, the authors found evidence of export-led growth in 30 of the sample countries.

An expansion in imports can play a complimentary role in stimulating economic growth. In many small, open economies, imports provide many of the factors of production that are then employed in both the export sector and the non-trade sector. Additionally, as noted by Awokuse (2008), the transfer of technologies from developed economies to the developing economies through imports can serve as an important source of economic growth. Furthermore, endogenous growth models have shown that imports can be a channel for long-run economic growth because they provide foreign technology and knowledge to domestic firms.[59] Therefore, in many cases, foreign imports are a major source of technology-intensive intermediate goods which can be applied across the domestic economy. Imports may also affect productivity growth through import competition. An increase in import penetration exposes domestic firms to foreign competition which can spur innovation in the domestic economy in response to this higher level of competition (MacDonald, 1994).

A study by Thangavelu and Rajaguru (2004) investigates the links between exports, imports and productivity growth[60] in nine rapidly developing Asian economies for the years 1960-1996. All three variables were tested for unit roots and were found to

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59 Grossman and Helpman (1991), Coe and Helpman (1995)

60 Productivity is defined as real manufacturing value added divided by the number of workers in the manufacturing sector at 1987 prices.

be first-difference stationary. Since the variables are I(1), the authors test for cointegration to determine if a linear combination of one or more variables displays a long-run relationship. Each of the nine countries has at least one cointegrating relationship among the variables so the authors estimate a tri-variate VECM. Their results do support previous findings that exports and imports have qualitatively different effects on labor productivity growth.

Awokuse (2008) investigates the correlations between trade and economic growth in Argentina, Columbia, and Peru, placing an emphasis on both the role of exports and the role of imports. The author notes that imports may play a significant role in economic growth because rapid export expansion is usually associated with rapid import growth and studies that ignore imports may be subject to an omitted variable bias. Previous studies that have included the countries sampled by Awokuse have had mixed results. Van den Berg and Schmidt (1994) found a significant, positive relationship between exports and economic growth in Columbia and Peru but found no evidence of causality for Argentina. Jung and Marshall (1985) found no significant correlations in Columbia and Argentina but found evidence of export-reducing growth in Peru. Riezman et al. (1996) found no evidence of causality in any of the three countries sampled by Awokuse.

In the case of Argentina, Awokuse could not find support for the export-led growth hypothesis nor could he find any indication of short-run or long-run causation from exports to GDP growth. However, Awokuse does confirm short-run causality from imports to GDP growth and reverse causality from GDP growth to imports in Argentina. For Columbia, the error-correction term was statistically significant indicating long-run correlation from exports and imports to GDP growth; however, he finds no causality from exports to GDP growth in the short run but does find that causality runs from imports to GDP in the short run. Awokuse reports this result as stressing the importance of imports to economic growth to both the short run and the long run in Columbia. Similarly for Peru Awokuse finds no support for the export-led growth hypothesis in the short run but does find causation from imports to GDP growth. Overall, Awokuse finds no justification for the export-led growth hypothesis in any of the three countries and suggests that imports have played a more important role in the economic growth of these three countries than exports. Studies that ignore the role that imports play cannot capture the true effects that trade has on economic growth.

Modeling Methodology

This study follows the model of Awokuse (2008) in which exports and imports are included in an expanded production function. The production function applied by Awokuse has the basic form:

(5) $Y = [F(K, L); X, M]$

where Y is real GDP; K, L, X, and M represent real gross capital, labor, real exports, and real imports, respectively. Previous studies have included exports in the aggregate production function, but Awokuse also includes a term to control for the effects imports may have on economic growth.

This study varies from the structure of Awokuse (2008) in the use of an expanded production function. Additionally, unlike a majority of the studies discussed in the previous section which focused primarily on developing economies[61], this study will test for Granger causality among the variables for a set of countries in the Organization for

[61] Exceptions include Afxentiou and Serletis (1991), Kugler (1991), and Marin (1992)

Economic Co-operation and Development (OECD). The general production function is of the following form:

(6) $Y_{it} = F(kstock_{it}, hstock_{it}, labor_{it}, exports_{it}, imports_{it,})$

The variable, $kstock_{it}$, is the capital stock measured by the level of gross domestic investment. $Hstock_{it}$ is the stock of human capital, and $Labor_{it}$ measures the total labor force of the economy.

The data on GDP, gross domestic investment, exports, and imports are taken from the OECD country statistical profiles and cover the period 1970 – 2006 for 21 developed economies. The data were reported by the OECD in current U.S. dollars and were deflated to obtain the real values of the variables at 2005 constant prices. The data on human capital comes from Barro and Lee (2010) and is measured by the total average years of schooling for the population 25 years and older. However, Barro and Lee only report their human capital measures at five-year intervals. A constant growth rate between the recorded intervals is assumed to obtain the intermediate year values for the human capital measure.

The following multivariate VAR model will be estimated for each country in this study to determine the nature and direction of causality between the trade variables and income growth:[62]

(7) $$Income_t = a_0 + \sum_{j=1}^{p} a_{1j} income_{t-j} + \sum_{j=1}^{p} a_{2j} kstock_{t-j} + \sum_{j=1}^{p} a_{3j} labor_{t-j} + \sum_{j=1}^{p} a_{4j} hstock_{t-j} + \sum_{j=1}^{p} a_{5j}\, exports_{t-j} + \sum_{j=1}^{p} a_{6j} imports_{t-j} + \varepsilon_t$$

[62] Exports and imports are entered separately into the equation because we do not assume that they have similar effects on income. Krishna et al. (1999), Thangavelu and Rajaguru (2004), Awokuse (2008)

$$(8)\ Exports_t = b_0 + \sum_{j=1}^{p} b_{1j} income_{t-j} + \sum_{j=1}^{p} b_{2j} kstock_{t-j} + \sum_{j=1}^{p} b_{3j} labor_{t-j} + \sum_{j=1}^{p} b_{4j} hstock_{t-j} + \sum_{j=1}^{p} b_{5j}\, exports_{t-j} + \sum_{j=1}^{p} b_{6j} imports_{t-j} + u_t$$

$$(9)\ Imports_t = c_0 + \sum_{j=1}^{p} c_{ij} income_{t-j} + \sum_{j=1}^{p} c_{2j} kstock_{t-j} + \sum_{j=1}^{p} c_{3j} labor_{t-j} + \sum_{j=1}^{p} c_{4j} hstock_{t-j} + \sum_{j=1}^{p} c_{5j} exports_{t-j} + \sum_{j=1}^{p} c_{6j} imports_{t-j} + v_t$$ [63]

Using a multivariate VAR model, the production function is first tested in levels and in first differences for the presence of unit roots and cointegration. If a cointegrating relationship between the trade variables and income is found in the data, a vector error correction model (VECM) will be used to test for the nature of causality. If no cointegrating relationships are found, then the previously described model will be tested using the standard Granger causality F-test in a multivariate VAR framework.

Empirical Results

a. Unit Root Tests

Before any cointegration or Granger causality tests can be performed, the time-series properties of the variables must be examined. Specifically, the variables in question must be tested for the possibility that they contain a unit root. This is an important step in the estimation procedure since the standard Granger causality testing procedure can only be performed if all the variables in question are stationary. However, many macroeconomic variables may be non-stationary and integrated of order I(1) or higher. A cursory examination of the plots of the variables in levels suggests that the series may possess a stochastic trend and are thus potentially non-

[63] Each variable in the production function has an equation relating its own past values and the past values of the other variables to its contemporaneous value. Only the three equations central to this study are provided above.

stationary. However, formal unit root tests are required in order to make any definitive conclusions about the nature of the variables.

Two separate univariate, unit root tests are conducted for each of the variables for the twenty-one OECD countries in the data set. First, the augmented Dickey-Fuller (ADF, 1979) test is applied. The ADF test carries a null hypothesis of non-stationarity (unit root). However, it has been well documented in the literature that the ADF test has a relatively low power for correctly identifying the presence of unit roots in certain circumstances. As an additional check of the data, the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS, 1992) test is also employed to test for the presence of unit roots. The KPSS test differs from the ADF test in that the null hypothesis of the KPSS test is that the variable is stationary. Thus, the combination of the ADF and KPSS tests allows for the testing of both the null hypotheses of non-stationarity and stationarity, respectively. This combined approach is very robust to confirming the existence of unit roots in the data.

Table 1 reports the test statistics for both the ADF and KPSS tests. Overall, the combination of the two tests suggests that the variables are non-stationary in their levels. Moreover, the results of the two tests confirm that the variables in question are first-difference stationary and are thus integrated of order I(1). The lone exception in the data was the variable measuring human capital. Initial unit root testing of the human capital variable for each country indicated that the variable was non-stationary in levels and non-stationary after taking the first difference. The results of the unit root tests

Table 1. Tests for unit roots

	Australia		Austria		Canada		Denmark	
Variable	*ADF*	*KPSS*	*ADF*	*KPSS*	*ADF*	*KPSS*	*ADF*	*KPSS*
Levels								
Real GDP	-1.94	0.846*	-2.47	0.852*	-3.13	0.851*	-2.77	0.843*
Capital	-1.60	0.801*	-2.46	0.821*	-2.58	0.815*	-0.83	0.692**
Human Capital	-1.86	0.582**	-2.37	0.677**	-1.48	0.740*	-2.19	0.782*
Labor	-2.01	0.851*	-2.23	0.826*	-3.72	0.822*	-1.35	0.709**
Exports	-2.21	0.846*	-3.69	0.845*	-2.00	0.849*	-3.94	0.839*
Imports	-1.55	0.849*	-3.32	0.828*	-3.85	0.856*	-3.71	0.796*
1st Differences								
Real GDP	-5.23*	0.124	-4.52*	0.376	-4.11*	0.163	-6.35*	0.069
Capital	-3.77*	0.231	-6.08*	0.151	-3.41**	0.112	-4.59*	0.127
Human Capital	-3.22**	0.152	-3.38**	0.156	-3.24**	0.240	-3.06**	0.047
Labor	-3.19**	0.136	-5.06*	0.117	-1.56	0.149	-4.91*	0.378
Exports	-4.40*	0.102	-4.49*	0.089	-4.54*	0.101	-4.04*	0.107
Imports	-5.64*	0.091	-4.17*	0.123	-5.16*	0.129	-4.05*	0.088

	Finland		France		Germany		Greece	
Variable	*ADF*	*KPSS*	*ADF*	*KPSS*	*ADF*	*KPSS*	*ADF*	*KPSS*
Levels								
Real GDP	-2.91	0.833*	-3.39	0.847*	-1.36	0.846*	-1.96	0.818*
Capital	-3.22	0.321	-1.34	0.803*	-2.41	0.704**	-2.26	0.484**
Human Capital	-2.76	0.774*	-1.44	0.832*	-2.00	0.813*	-2.16	0.843*
Labor	-2.73	0.627**	-3.04	0.849*	-2.15	0.760*	-2.64	0.826*
Exports	-3.74	0.835*	-2.88	0.816*	-3.79	0.837*	-4.06	0.779*
Imports	-2.41	0.807*	-2.74	0.795*	-3.12	0.822*	-2.89	0.819*
1st Differences								
Real GDP	-3.53**	0.102	-4.38*	0.284	-4.23*	0.257	-4.42*	0.166
Capital	-3.90*	0.075	-3.99*	0.078	-3.98*	0.089	-4.85*	0.106
Human Capital	-3.51**	0.048	-3.86*	0.135	-3.40**	0.183	-3.43**	0.070
Labor	-3.09**	0.266	-6.05*	0.053	-5.23*	0.099	-5.60*	0.108
Exports	-4.74*	0.114	-3.79*	0.161	-4.14*	0.109	-5.48*	0.213
Imports	-4.10*	0.108	-4.00*	0.155	-4.12*	0.11	-5.25*	0.09

* and ** denote rejection of the null hypothesis at the 1% and 5% level respectively.

Table 1. Tests for unit roots (continued)

	Iceland		Ireland		Italy		Japan	
Variable	*ADF*	*KPSS*	*ADF*	*KPSS*	*ADF*	*KPSS*	*ADF*	*KPSS*
Levels								
Real GDP	-2.11	0.823*	-1.39	0.829*	-1.41	0.830*	-0.43	0.826*
Capital	-1.10	0.652**	-1.57	0.710**	-2.99	0.783*	-1.34	0.694**
Human Capital	-1.11	0.520**	-0.89	0.763*	-2.53	0.606**	-2.73	0.713**
Labor	-0.77	0.843*	1.37	0.791*	-2.28	0.633**	-2.05	0.798*
Exports	-3.64	0.767*	-2.73	0.845*	-1.42	0.829*	-2.43	0.804*
Imports	-1.68	0.802*	-2.08	0.829*	-3.12	0.823*	-2.47	0.799*
1st Differences								
Real GDP	-4.77*	0.113	-3.69*	0.31	-5.00*	0.049	-3.64*	0.065
Capital	-5.01*	0.161	-2.43	0.22	-4.45*	0.118	-3.37**	0.216
Human Capital	-3.65*	0.094	-4.22*	0.055	-1.85	0.378	-4.42*	0.223
Labor	-5.46*	0.313	-4.19*	0.122	-3.15**	0.120	-2.92	0.435
Exports	-3.06**	0.220	-4.31*	0.221	-3.81*	0.156	-5.76*	0.415
Imports	-4.53*	0.114	-3.86*	0.099	-4.11*	0.135	-3.96*	0.179

	Netherlands		New Zealand		Norway		Portugal	
Variable	*ADF*	*KPSS*	*ADF*	*KPSS*	*ADF*	*KPSS*	*ADF*	*KPSS*
Levels								
Real GDP	-2.04	0.838*	-1.04	0.826*	-0.58	0.845*	-2.02	0.851*
Capital	-2.03	0.781*	-2.64	0.582**	-0.91	0.728**	-3.13	0.793*
Human Capital	-1.18	0.810*	-3.03	0.792*	-2.23	0.841*	-1.28	0.714**
Labor	-2.91	0.834*	-3.05	0.844*	-1.77	0.814*	-2.71	0.816*
Exports	-1.41	0.819*	-2.70	0.846*	-2.35	0.833*	-3.11	0.837*
Imports	-1.72	0.797*	-1.88	0.833*	-2.39	0.758*	-1.29	0.838*
1st Differences								
Real GDP	-3.09*	0.091	-3.47*	0.092	-3.28**	0.232	-3.69*	0.170
Capital	-4.11*	0.144	-3.73*	0.081	-2.87	0.105	-3.03**	0.153
Human Capital	-5.49*	0.207	-3.93*	0.219	-4.05*	0.165	-5.94*	0.168
Labor	-4.92*	0.133	-5.60*	0.059	-4.52*	0.373	-6.15*	0.110
Exports	-3.98*	0.138	-3.77*	0.100	-4.11*	0.155	-4.62*	0.094
Imports	-4.36*	0.110	-5.44*	0.111	-4.38*	0.099	-5.21*	0.080

* and ** denote rejection of the null hypothesis at the 1% and 5% level respectively.

Table 1. Tests for unit roots (continued)

	Spain		Sweden		Switzerland	
Variable	*ADF*	*KPSS*	*ADF*	*KPSS*	*ADF*	*KPSS*
Levels						
Real GDP	-0.22	0.85*	-1.98	0.84*	-2.16	0.84*
Capital	-1.38	0.77*	-2.53	0.53**	-3.15	0.31
Human Capital	-1.89	0.83*	-1.79	0.85*	-2.03	0.59**
Labor	2.75	0.82*	-2.50	0.65**	-2.59	0.79*
Exports	-2.03	0.85*	-2.59	0.84*	-3.36	0.82*
Imports	-3.67	0.85*	-2.95	0.78*	-3.43	0.81*
1st Differences						
Real GDP	-2.71	0.14	-5.07*	0.06	-4.19*	0.07
Capital	-3.08**	0.23	-3.77*	0.08	-3.97*	0.06
Human Capital	-3.98*	0.09	-3.78*	0.12	-3.88*	0.15
Labor	-3.61**	0.10	-3.76*	0.21	-2.99**	0.12
Exports	-3.76*	0.21	-4.37*	0.09	-3.92*	0.13
Imports	-3.99*	0.08	-4.09*	0.09	-4.18*	0.12

	United Kingdom		United States	
Variable	*ADF*	*KPSS*	*ADF*	*KPSS*
Levels				
Real GDP	-1.92	0.84*	-1.42	0.85*
Capital	-2.60	0.78*	-1.86	0.03*
Human Capital	-2.03	0.84*	-2.04	0.76*
Labor	-2.03	0.81*	-1.75	0.83*
Exports	-2.03	0.82*	-1.84	0.82*
Imports	-0.03	0.84*	-0.83	0.84*
1st Differences				
Real GDP	-3.88*	0.14	-4.73*	0.06
Capital	-2.38	0.06	-5.21*	0.08
Human Capital	-3.87*	0.25	-3.63**	0.07
Labor	-3.22**	0.10	-4.93*	0.09
Exports	-4.26*	0.12	-4.68*	0.10
Imports	-4.12*	0.10	-5.58*	0.23

* and ** denote rejection of the null hypothesis at the 1% and 5% level respectively.

reveal that the variable is integrated of order I(2); the variable is stationary after second-differencing. In order to estimate the multivariate VAR model, test for cointegration, and apply the Granger causality test each variable in the system must be integrated of the same order. To ensure that the human capital variable is integrated of order I(1) the growth rate is used in the model rather than the level.

b. Testing for Cointegration and Granger Causality (2 lags)

In the previous section it was shown that the variables in the model are all integrated of order one. This conclusion implies the possibility that cointegrating relationships exist among the variables in the model. If a cointegrating relationship exists among the variables, then a standard VAR estimation will yield biased results. A VECM model[64] must be employed whenever a cointegrating relationship is found to account for the common trend and the long-run relationships among the variables. Only then can the Granger causality test be utilized to assess any short-run or long-run relationships among the variables in question. If no evidence supporting the existence of a cointegrating relationship is found, then the standard multivariate VAR model and Granger causality tests can be applied.

The cointegration test results were obtained using CATS in RATS, version 2 (Dennis et al., 2005). Table 2 reports the trace test statistics for cointegration based on a VAR with two lags. The test statistics were obtained using the Bartlett small sample correction developed and discussed by Johansen (2000, 2002). The trace test determines the number of cointegrating relationships that exist among the variables for each country. The number of cointegrating vectors is denoted by r in the table. The trace statistic tests the null hypothesis that there are at most r cointegrating relations among the variables. When determining the cointegrating rank of the model we stop at the first rank (r) where we fail to reject the null hypothesis at the 5% confidence level.

The results reported in Table 2 indicate that no cointegrating relationships exist among the variables for each country. The lone exception is Japan where one

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[64] As described in section 2b.

Table 2: Cointegration Rank Test (lags = 2)

	Australia	Austria	Canada	Denmark	Finland	France
Cointegrating Rank	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*
r = 0	80.112	85.968	75.956	77.278	91.592	77.56
r ≤ 1	53.368	24.771	43.847	48.851	50.302	59.297
r ≤ 2	9.331	17.599	15.575	18.532	28.528	35.95
r ≤ 3	3.713	7.291	9.023	11.005	17.469	19.244
r ≤ 4	0.473	3.973	3.575	5.329	10.319	4.597
r ≤ 5	0.678	1.369	1.005	2.797	2.496	2.031

	Germany	Greece	Iceland	Ireland	Italy	Japan
Cointegrating Rank	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*
r = 0	81.152	93.699	90.098	72.801	83.886	117.045*
r ≤ 1	51.185	36.442	31.323	53.366	54.207	73.842
r ≤ 2	23.910	14.256	29.682	53.394	21.365	37.034
r ≤ 3	9.174	6.792	7.597	9.308	11.035	19.434
r ≤ 4	5.685	1.792	3.713	10.372	5.419	9.050
r ≤ 5	2.962	0.986	0.652	6.101	1.322	4.101

	Netherlands	New Zealand	Norway	Portugal	Spain	Sweden
Cointegrating Rank	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*
r = 0	91.999	98.310	70.863	81.144	35.113	90.202
r ≤ 1	59.509	67.911	36.350	51.851	19.481	55.672
r ≤ 2	36.902	44.537	22.425	15.203	13.201	35.883
r ≤ 3	3.628	31.712	13.408	6.518	8.393	19.995
r ≤ 4	2.825	18.198	3.105	2.313	4.447	10.114
r ≤ 5	1.717	0.651	0.279	1.626	1.474	1.459

	Switzerland	United Kingdom	United States
Cointegrating Rank	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*
r = 0	91.273	98.071	83.370
r ≤ 1	67.772	59.973	43.076
r ≤ 2	37.756	39.668	21.277
r ≤ 3	13.141	24.462	12.735
r ≤ 4	8.148	11.688	5.640
r ≤ 5	4.325	3.243	3.131

* indicates rejection of the null hypothesis at the 5% level.

cointegrating relationship is established. This indicates that a VECM model must be estimated for Japan; the other countries in the sample can be estimated using the standard VAR model framework. Furthermore, Granger causality tests require that all the variables are stationary. Since the results of the ADF and KPSS unit root tests confirm that all of the variables are non-stationary in their levels, the VAR model is estimated in first difference.

Table 3 (a – u) reports the results of the Granger causality tests based on the VAR estimations with two lags. Granger causality from an independent variable to the dependent variable is established if the lags of the independent variable are jointly significant using an F-test. In an attempt to save space and make the results straightforward to read, only the F-statistic for the joint significance of each independent variable and the corresponding p-value are recorded in Table 3. Each column in the table represents the VAR equation for each of the six variables in the system; each row represents the independent variables in the VAR system. A significant value of the F-statistic indicates that there is a causal relationship between an independent variable and the dependent variable. The VAR estimations reveal some valuable insights into

Table 3a: Granger Causality Tests (2 lags)

Australia	*Dependent Variables*					
Independent Variables	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	1.21	0.03	0.70	2.71*	1.65
		(0.32)	(0.973)	(0.509)	(0.091)	(0.217)
Capital	3.35*	---	1.74	2.10	0.10	1.33
Stock	(0.056)		(0.202)	(0.148)	(0.907)	(0.288)
Labor	0.79	1.35	---	0.10	2.85*	0.40
	(0.469)	(0.281)		(0.906)	(0.081)	(0.679)
Human	7.29**	2.07	1.05	---	4.72**	0.81
Capital	(0.004)	(0.153)	(0.368)		(0.021)	(0.46)
Exports	3.33*	0.05	0.54	0.45	---	2.02
	(0.061)	(0.951)	(0.594)	(0.644)		(0.159)
Imports	0.47	0.06	0.19	0.28	8.67**	---
	(0.634)	(0.942)	(0.832)	(0.761)	(0.002)	

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses).

Table 3b: Granger Causality Tests (2 lags)

Austria	*Dependent Variables*					
Independent Variables	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.54 (0.592)	1.91 (0.175)	1.14 (0.34)	0.38 (0.691)	0.86 (0.438)
Capital Stock	1.92 (0.173)	---	0.70 (0.51)	0.92 (0.413)	0.66 (0.529)	0.93 (0.411)
Labor	1.27 (0.301)	0.38 (0.69)	---	0.39 (0.683)	0.68 (0.517)	0.56 (0.578)
Human Capital	0.94 (0.407)	1.38 (0.274)	0.89 (0.427)	---	0.22 (0.805)	0.01 (0.991)
Exports	0.52 (0.602)	0.57 (0.575)	3.72** (0.042)	2.26 (0.131)	---	0.05 (0.952)
Imports	0.52 (0.605)	0.48 (0.623)	3.45* (0.052)	1.34 (0.284)	0.27 (0.764)	---

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses).

Table 3c: Granger Causality Tests(2 lags)

Canada	*Dependent Variables*					
Independent Variables	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.61 (0.552)	0.51 (0.609)	0.83 (0.452)	0.28 (0.761)	0.02 (0.979)
Capital Stock	0.29 (0.75)	---	1.22 (0.315)	0.67 (0.525)	0.17 (0.845)	1.33 (0.286)
Labor	0.20 (0.823)	0.56 (0.579)	---	0.88 (0.432)	0.13 (0.88)	0.10 (0.904)
Human Capital	5.39** (0.013)	2.94* (0.076)	5.82** (0.01)	---	0.88 (0.43)	1.90 (0.176)
Exports	1.17 (0.332)	0.45 (0.647)	4.29** (0.028)	3.32* (0.057)	---	0.18 (0.834)
Imports	0.24 (0.786)	0.13 (0.88)	0.53 (0.596)	1.39 (0.273)	0.71 (0.502)	---

Results are the F-statistic of the joint significance of the lags of each independent variable. . * and ** indicate significance at the 10% and 5% level (p-values are in parentheses).

Table 3d: Granger Causality Tests (2 lags)

Denmark	*Dependent Variables*					
Independent Variables	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	9.58**	0.39	0.80	1.15	3.08*
		(0.001)	(0.683)	(0.462)	(0.334)	(0.068)
Capital Stock	10.62**	---	1.45	2.44	0.74	2.30
	(0.001)		(0.259)	(0.113)	(0.49)	(0.126)
Labor	10.59**	7.54**	---	2.55	0.58	3.04*
	(0.001)	(0.004)		(0.103)	(0.567)	(0.07)
Human Capital	0.33	0.98	1.51	---	0.60	0.46
	(0.723)	(0.393)	(0.245)		(0.559)	(0.64)
Exports	2.83*	2.58	0.16	1.03	---	0.50
	(0.083)	(0.101)	(0.85)	(0.374)		(0.613)
Imports	4.41**	3.36*	0.07	0.45	0.30	---
	(0.026)	(0.055)	(0.931)	(0.642)	(0.748)	

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses).

Table 3e: Granger Causality Tests (2 lags)

Finland	*Dependent Variables*					
Independent Variables	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	1.66	1.05	4.30**	0.31	1.21
		(0.216)	(0.368)	(0.028)	(0.741)	(0.319)
Capital Stock	1.50	---	0.43	3.97**	0.58	0.61
	(0.247)		(0.654)	(0.035)	(0.568)	(0.554)
Labor	0.23	1.61	---	5.17**	1.14	0.64
	(0.796)	(0.225)		(0.015)	(0.339)	(0.54)
Human Capital	2.60*	2.08	0.12	---	0.07	0.09
	(0.1)	(0.151)	(0.889)		(0.933)	(0.911)
Exports	1.01	0.71	0.71	1.47	---	1.45
	(0.381)	(0.506)	(0.502)	(0.253)		(0.258)
Imports	0.26	0.24	0.18	1.47	0.39	---
	(0.777)	(0.786)	(0.84)	(0.253)	(0.681)	

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses).

the causal patterns among exports, imports, and GDP. The results present strong evidence in support of the Export-led Growth hypothesis (causation running from exports to GDP) for France, Italy, New Zealand, and the United States.[65] Weaker support for the Export-led Growth hypothesis is found for the Netherlands (p-value = 0.058) and Denmark (p-value = 0.083).[66] The remaining countries in this study exhibit no causal relationship of exports on GDP. However, the findings from the estimation of the model for Germany indicate that there is a strong causal pattern running from GDP to exports (GDP Granger causes exports); this has been referred to in the literature as Growth-led Exports. Furthermore, Australia shows weak evidence of bi-directional causality between exports and GDP.[67]

The results further suggest that imports do play an important role in determining economic growth in some of the sampled countries. Specifically, strong support for causation from imports to GDP is found in France, Denmark, and New Zealand while

Table 3f: Granger Causality Tests (2 lags)

France	*Dependent Variables*					
Independent Variables	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	2.00 (0.161)	0.07 (0.935)	1.07 (0.361)	0.05 (0.949)	0.51 (0.609)
Capital Stock	4.11** (0.032)	---	0.55 (0.584)	0.53 (0.596)	0.38 (0.69)	1.71 (0.207)
Labor	0.48 (0.627)	0.57 (0.573)	---	5.65** (0.011)	0.41 (0.67)	0.43 (0.657)
Human Capital	1.59 (0.228)	1.26 (0.304)	0.39 (0.684)	---	1.69 (0.21)	4.18** (0.03)
Exports	3.63** (0.045)	7.04** (0.005)	0.66 (0.529)	1.19 (0.324)	---	7.22** (0.004)
Imports	6.68** (0.006)	7.43** (0.004)	0.48 (0.624)	1.29 (0.297)	0.10 (0.387)	---

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses).

[65] The lagged differences are significant at the 5% level.
[66] The lagged differences are significant at the 10% level.
[67] Exports→GDP (p-value = 0.061); GDP→Exports (p-value = 0.091)

Table 3g: Granger Causality Tests (2 lags)

Germany	*Dependent Variables*					
Independent Variables	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.18	1.11	0.87	3.99**	5.20**
		(0.84)	(0.348)	(0.433)	(0.035)	(0.015)
Capital	0.40	---	1.10	0.73	4.94**	3.44*
Stock	(0.672)		(0.354)	(0.494)	(0.018)	(0.052)
Labor	0.43	0.25	---	0.33	2.66*	2.07
	(0.654)	(0.782)		(0.719)	(0.094)	(0.152)
Human	1.73	0.34	0.44	---	0.36	0.47
Capital	(0.202)	(0.718)	(0.65)		(0.703)	(0.633)
Exports	1.71	1.64	2.11	0.34	---	1.77
	(0.206)	(0.219)	(0.147)	(0.718)		(0.196)
Imports	0.93	1.43	2.36	0.57	2.13	---
	(0.41)	(0.262)	(0.12)	(0.574)	(0.145)	

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses).

Table 3h: Granger Causality Tests (2 lags)

Greece	*Dependent Variables*					
Independent Variables	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.08	0.21	1.14	2.17	1.06
		(0.925)	(0.811)	(0.341)	(0.14)	(0.364)
Capital	0.56	---	0.79	0.64	2.17	1.07
Stock	(0.581)		(0.466)	(0.536)	(0.14)	(0.363)
Labor	2.23	1.70	---	0.54	0.13	0.80
	(0.134)	(0.207)		(0.591)	(0.88)	(0.463)
Human	0.57	0.07	0.11	---	2.31	1.34
Capital	(0.574)	(0.936)	(0.896)		(0.125)	(0.285)
Exports	0.08	0.17	0.31	0.31	---	0.16
	(0.92)	(0.847)	(0.737)	(0.735)		(0.851)
Imports	0.94	0.06	0.006	0.30	0.33	---
	(0.407)	(0.946)	(0.994)	(0.747)	(0.726)	

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses).

Table 3i: Granger Causality Tests (2 lags)

Iceland	*Dependent Variables*					
Independent Variables	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.65	0.22	0.09	1.40	1.71
		(0.532)	(0.805)	(0.917)	(0.269)	(0.206)
Capital Stock	1.05	---	1.74	0.51	2.02	1.79
	(0.367)		(0.2)	(0.607)	(0.158)	(0.193)
Labor	0.68	3.43*	---	0.22	0.67	7.82**
	(0.517)	(0.052)		(0.801)	(0.524)	(0.003)
Human Capital	1.27	0.59	3.77**	---	0.80	1.11
	(0.301)	(0.563)	(0.041)		(0.462)	(0.348)
Exports	1.58	0.54	0.21	0.16	---	2.31
	(0.23)	(0.589)	(0.815)	(0.856)		(0.125)
Imports	0.23	0.23	1.80	0.38	0.88	---
	(0.797)	(0.793)	(0.19)	(0.687)	(0.43)	

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses).

Table 3j: Granger Causality Tests (2 lags)

Ireland	*Dependent Variables*					
Independent Variables	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.03	0.35	0.66	1.92	0.85
		(0.971)	(0.708)	(0.525)	(0.173)	(0.444)
Capital Stock	0.09	---	0.17	1.28	0.72	0.29
	(0.918)		(0.844)	(0.299)	(0.501)	(0.749)
Labor	1.21	0.21	---	0.13	0.38	0.23
	(0.319)	(0.808)		(0.879)	(0.691)	(0.793)
Human Capital	1.49	0.18	0.01	---	1.66	0.54
	(0.249)	(0.837)	(0.99)		(0.216)	(0.59)
Exports	1.16	1.34	1.09	0.27	---	1.29
	(0.332)	(0.284)	(0.356)	(0.766)		(0.297)
Imports	1.55	0.61	1.37	0.09	2.40	---
	(0.237)	(0.552)	(0.276)	(0.915)	(0.116)	

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses).

Table 3k: Granger Causality Tests (2 lags)

Italy	*Dependent Variables*					
Independent Variables	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.02	0.87	1.67	0.02	0.05
		(0.978)	(0.436)	(0.213)	(0.977)	(0.952)
Capital Stock	0.63	---	3.23*	0.50	0.09	0.07
	(0.654)		(0.061)	(0.617)	(0.913)	(0.933)
Labor	0.20	0.26	---	0.17	0.24	0.16
	(0.823)	(0.775)		(0.847)	(0.788)	(0.851)
Human Capital	0.73	2.87*	5.72**	---	0.78	1.12
	(0.492)	(0.08)	(0.011)		(0.471)	(0.346)
Exports	4.30**	4.84**	0.75	0.05	---	1.77
	(0.028)	(0.019)	(0.484)	(0.949)		(0.285)
Imports	2.80*	1.72	1.18	0.30	0.95	---
	(0.085)	(0.204)	(0.327)	(0.74)	(0.405)	

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses).

Table 3l: Granger Causality Tests (2 lags)

Japan	*Dependent Variables*					
Independent Variables	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.28	4.27	6.86**	13.19**	3.10
		(0.871)	(0.119)	(0.032)	(0.0014)	(0.213)
Capital Stock	4.08	---	1.95	0.64	7.24**	1.94
	(0.13)		(0.378)	(0.728)	(0.027)	(0.378)
Labor	6.30**	4.69*	---	1.51	13.79**	9.53**
	(0.043)	(0.096)		(0.471)	(0.001)	(0.009)
Human Capital	2.78	1.39	2.08	---	7.86**	4.93*
	(0.249)	(0.50)	(0.353)		(0.02)	(0.085)
Exports	1.60	3.71	0.26	0.49	---	1.28
	(0.449)	(0.156)	(0.876)	(0.783)		(0.527)
Imports	2.30	4.83*	1.31	4.52	0.01	---
	(0.316)	(0.09)	(0.518)	(0.104)	(0.998)	
Error Correction Term	0.087	0.065	0.02	-0.007**	0.964**	0.84**
	[1.63]	[0.53]	[1.27]	[-2.27]	[5.21]	[2.85]

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses). t-statistics are reported for the error-correction term.

Table 3m: Granger Causality Tests (2 lags)

Netherlands	*Dependent Variables*					
Independent Variables	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	4.66**	0.23	1.08	0.10	0.19
		(0.022)	(0.794)	(0.358)	(0.903)	(0.827)
Capital Stock	0.89	---	2.99*	2.14	1.29	1.12
	(0.425)		(0.073)	(0.144)	(0.297)	(0.347)
Labor	1.25	0.04	---	2.37	1.22	1.61
	(0.307)	(0.962)		(0.119)	(0.316)	(0.225)
Human Capital	3.10*	0.26	1.40	---	0.65	0.36
	(0.067)	(0.77)	(0.27)		(0.534)	(0.704)
Exports	3.30*	2.37	1.43	2.02	---	0.40
	(0.058)	(0.119)	(0.263)	(0.159)		(0.674)
Imports	3.09*	2.85*	1.06	2.29	0.85	---
	(0.068)	(0.081)	(0.366)	(0.127)	(0.442)	

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses).

Table 3n: Granger Causality Tests (2 lags)

New Zealand	*Dependent Variables*					
Independent Variables	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.82	3.26*	0.39	1.99	0.57
		(0.453)	(0.059)	(0.68)	(0.163)	(0.574)
Capital Stock	2.50	---	2.51	0.82	1.39	0.60
	(0.108)		(0.107)	(0.456)	(0.272)	(0.556)
Labor	2.52	0.29	---	0.48	4.45**	1.62
	(0.106)	(0.751)		(0.626)	(0.025)	(0.223)
Human Capital	3.30*	0.13	0.75	---	0.85	0.69
	(0.058)	(0.88)	(0.487)		(0.441)	(0.515)
Exports	5.02**	2.00	2.31	0.77	---	8.85**
	(0.017)	(0.162)	(0.126)	(0.477)		(0.002)
Imports	6.92**	0.99	0.68	0.48	0.15	---
	(0.005)	(0.389)	(0.515)	(0.623)	(0.859)	

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses).

Table 3o: Granger Causality Tests (2 lags)

Norway	*Dependent Variables*					
Independent Variables	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.15 (0.863)	0.91 (0.417)	0.24 (0.792)	0.66 (0.525)	0.18 (0.833)
Capital Stock	0.39 (0.682)	---	2.69* (0.093)	0.19 (0.825)	0.86 (0.437)	1.21 (0.319)
Labor	0.50 (0.611)	0.33 (0.72)	---	0.73 (0.495)	0.24 (0.79)	0.08 (0.927)
Human Capital	0.21 (0.812)	0.14 (0.875)	0.45 (0.644)	---	0.22 (0.801)	0.06 (0.94)
Exports	0.70 (0.506)	0.28 (0.755)	0.15 (0.859)	0.09 (0.914)	---	0.78 (0.471)
Imports	0.30 (0.742)	0.43 (0.658)	0.38 (0.688)	0.12 (0.886)	0.41 (0.67)	---

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses).

somewhat weaker confirmation of the Import-led Growth hypothesis is established for Italy (p-value = 0.085) and the Netherlands (p-value = 0.068). A test for causation from GDP to imports suggests that increased economic growth has led to growth in the volume of imports for both Germany and the United Kingdom. Moreover, the results reveal evidence of bi-directional causality between imports and GDP for Denmark.[68] Overall, five countries (Denmark, France, Italy, Netherlands, and New Zealand) demonstrate causal relations from exports to GDP as well as imports to GDP, indicating that the total volume of trade is an important determinant for growth in each of these countries.

It is also worth investigating the individual equations for both exports and imports to determine the nature of the interactions between these two variables. Put simply, this is a test to ascertain if any causal relationships exist from exports to imports or vice

[68] Imports→GDP (p-value = 0.026); GDP→Imports (p-value = 0.068)

Table 3p: Granger Causality Tests (2 lags)

Portugal	*Dependent Variables*					
Independent Variables	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.08	0.81	0.29	0.34	1.01
		(0.924)	(0.461)	(0.767)	(0.716)	(0.382)
Capital	2.06	---	0.83	0.96	0.38	0.75
Stock	(0.154)		(0.453)	(0.40)	(0.687)	(0.484)
Labor	2.62*	1.16	---	1.60	1.49	0.17
	(0.098)	(0.333)		(0.226)	(0.248)	(0.844)
Human	0.623	0.46	2.32	---	4.01**	1.85
Capital	(0.544)	(0.635)	(0.124)		(0.034)	(0.183)
Exports	0.45	1.61	0.62	0.46	---	2.98*
	(0.647)	(0.225)	(0.547)	(0.639)		(0.074)
Imports	0.25	2.11	0.77	0.49	4.75**	---
	(0.783)	(0.148)	(0.476)	(0.619)	(0.021)	

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses).

Table 3q: Granger Causality Tests (2 lags)

Spain	*Dependent Variables*					
Independent Variables	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.03	0.76	0.18	0.88	0.41
		(0.968)	(0.482)	(0.841)	(0.43)	(0.672)
Capital	0.41	---	1.50	1.47	0.77	0.43
Stock	(0.67)		(0.246)	(0.254)	(0.475)	(0.655)
Labor	2.56	1.28	---	0.09	0.02	0.52
	(0.102)	(0.299)		(0.913)	(0.978)	(0.605)
Human	2.66*	2.96*	3.04*	---	0.38	0.36
Capital	(0.095)	(0.075)	(0.07)		(0.686)	(0.702)
Exports	0.35	0.47	2.01	1.24	---	2.58*
	(0.711)	(0.634)	(0.16)	(0.311)		(0.1)
Imports	0.28	0.29	1.50	2.48	2.04	---
	(0.761)	(0.751)	(0.247)	(0.109)	(0.156)	

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses).

Table 3r: Granger Causality Tests (2 lags)

Sweden *Independent Variables*	*Dependent Variables* GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.67 (0.524)	0.99 (0.387)	3.50** (0.049)	0.81 (0.459)	0.58 (0.571)
Capital Stock	1.56 (0.234)	---	0.64 (0.539)	0.67 (0.522)	0.39 (0.682)	0.03 (0.975)
Labor	3.83** (0.039)	0.96 (0.402)	---	1.84 (0.184)	0.19 (0.831)	0.17 (0.848)
Human Capital	0.92 (0.415)	0.25 (0.781)	0.21 (0.813)	---	0.75 (0.483)	1.04 (0.372)
Exports	0.39 (0.679)	0.54 (0.594)	0.28 (0.76)	0.72 (0.499)	---	2.74* (0.089)
Imports	0.18 (0.837)	0.52 (0.603)	0.63 (0.543)	2.17 (0.141)	0.76 (0.481)	---

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses).

Table 3s: Granger Causality Tests (2 lags)

Switzerland *Independent Variables*	*Dependent Variables* GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	1.28 (0.30)	0.97 (0.396)	0.94 (0.407)	1.53 (0.24)	0.24 (0.786)
Capital Stock	1.61 (0.225)	---	1.74 (0.201)	0.35 (0.71)	1.63 (0.221)	1.69 (0.21)
Labor	0.44 (0.651)	0.02 (0.985)	---	0.05 (0.948)	0.51 (0.605)	0.61 (0.552)
Human Capital	2.11 (0.147)	0.15 (0.865)	1.07 (0.362)	---	0.26 (0.773)	0.44 (0.65)
Exports	0.63 (0.543)	1.05 (0.367)	0.58 (0.568)	1.05 (0.369)	---	4.23** (0.029)
Imports	0.48 (0.626)	1.69 (0.209)	0.13 (0.878)	0.72 (0.499)	3.29* (0.058)	---

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses).

Table 3t: Granger Causality Tests (2 lags)

United Kingdom	*Dependent Variables*					
Independent Variables	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	1.20	0.23	3.58**	1.18	3.68**
		(0.322)	(0.796)	(0.047)	(0.327)	(0.044)
Capital Stock	0.18	---	0.33	1.24	0.25	0.83
	(0.837)		(0.726)	(0.31)	(0.783)	(0.449)
Labor	0.75	0.74	---	1.97	0.49	0.29
	(0.483)	(0.49)		(0.166)	(0.621)	(0.75)
Human Capital	0.06	1.11	0.62	---	2.13	0.60
	(0.939)	(0.35)	(0.549)		(0.146)	(0.56)
Exports	0.01	0.32	2.38	0.37	---	0.04
	(0.99)	(0.727)	(0.118)	(0.693)		(0.96)
Imports	0.56	0.07	1.15	1.93	0.40	---
	(0.582)	(0.932)	(0.337)	(0.171)	(0.677)	

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses).

Table 3u: Granger Causality Tests (2 lags)

United States	*Dependent Variables*					
Independent Variables	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	1.88	1.50	0.34	0.61	1.45
		(0.178)	(0.247)	(0.717)	(0.552)	(0.258)
Capital Stock	0.79	---	0.17	1.59	0.17	0.04
	(0.466)		(0.847)	(0.229)	(0.845)	(0.96)
Labor	1.16	1.12	---	3.38*	0.41	1.24
	(0.335)	(0.346)		(0.054)	(0.672)	(0.309)
Human Capital	3.63**	2.40	2.08	---	1.33	1.02
	(0.045)	(0.116)	(0.151)		(0.286)	(0.377)
Exports	4.86**	2.12	1.22	0.62	---	1.11
	(0.019)	(0.146)	(0.315)	(0.548)		(0.348)
Imports	0.79	0.81	0.38	1.33	0.60	---
	(0.466)	(0.457)	(0.691)	(0.286)	(0.558)	

Results are the F-statistic of the joint significance of the lags of each independent variable* and ** indicate significance at the 10% and 5% level (p-values are in parentheses).

versa. The results indicate that Granger causality goes from exports to imports in six of the countries[69], and Granger causality goes from imports to exports in three countries.[70]

69 France, New Zealand, Portugal, Spain, Sweden, and Switzerland
70 Australia, Portugal, Switzerland

On the whole, the results suggest that imports do play an important role in the nature of the causal patterns between trade and GDP, but that, overall, exports have tended to play a more significant role in the economic growth of the sampled countries.

From the tests for cointegration, it was reported that one cointegrating vector was established for Japan. Because of the existence of a cointegrating vector in the data, the VAR equations must be modified to include an error-correction term in order to more precisely study the dynamic relationships among the variables. Within the framework of the VECM there is an additional, long-run channel through which Granger causality can emerge. The advantage of the VECM model is that it allows for the study of both short- and long-run causation. A significant coefficient on the lagged error-correction term (ECT) implies that past equilibrium errors play a role in determining current outcomes. The results for Japan show that there is short-run and long-run causality from GDP to exports as evidenced by the jointly significant lags of GDP and the statistically significant error correction term. According to the results, Japan does not show reverse causality from exports to GDP implying that economic growth was responsible for the expansion of Japan's export sector rather than the commonly held belief that an expansion of exports was a major contributor to Japan's rapid growth.

Since the model that is estimated for this study employs a modified neo-classical production function to include a set of control variables, it may be interesting to examine what causal patterns emerge among these other variables. This is a step largely ignored by the export-led growth literature but has the potential to provide valuable insights into the relative importance of the determinants of economic growth. Of the 21 countries used in this study, only three (Australia, Denmark, France) display a causal pattern from capital to GDP, four countries (Denmark, Japan, Portugal, Sweden) have causality from labor to GDP, and six countries (Australia, Canada, Finland, New Zealand, Spain, United States) show causality from growth in the human capital measure to GDP. This is a very surprising result as accepted theories of growth have consistently shown that these three variables are important contributors to economic growth; therefore, we should expect a higher incidence of causality from these variables to GDP.

c. Testing for Cointegration and Granger Causality (1 lag)

An important question for both cointegration tests and Granger causality tests relates to the choice of lag-length in the model specification. The choice of lag-length in the model can have a fundamental impact on the conclusions that are made following the test for cointegration and also the conclusions draw about the nature and direction of any causal relationships (Gujarati, 2003). In the previous section the model was estimated and Granger causality tests were performed with two lags in the data. As an additional test of the relationships among exports, imports, and GDP, the model is re-estimated for the possibility of cointegration among the variables with a lag length of one.[71]

Table 4 reports the Bartlett small sample correction trace statistics based on a VAR with one lag. From the results of the cointegration tests it is obvious that the model is greatly affected by the change in the lag length. When the model was estimated with two lags in the data, only Japan showed any evidence of a cointegrating relationship

[71] Akaike Information Criteria (AIC) indicates that the optimal number of lags is one; however, a lag length restriction test cannot rule out the inclusion of the additional lag. Therefore, both a two-lag and a one-lag model are estimated.

among the variables. Now, every country in the sample confirms the existence of at least one cointegrating relationship, if not more. Five of the countries in the sample

Table 4: Cointegration Rank Test (lags = 1)

	Australia	Austria	Canada	Denmark	Finland	France
Cointegrating Rank	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*
r = 0	180.491*	119.511*	155.859*	131.205*	130.242*	151.352*
r ≤ 1	90.899*	67.371	62.717	78.396*	75.677	91.684*
r ≤ 2	53.664	41.232	43.400	52.639	40.808	56.154*
r ≤ 3	28.698	26.106	25.068	31.107	24.033	29.709
r ≤ 4	9.552	16.201	13.611	13.986	12.483	12.311
r ≤ 5	3.869	6.538	4.916	5.907	9.142	3.615
	Germany	**Greece**	**Iceland**	**Ireland**	**Italy**	**Japan**
Cointegrating Rank	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*
r = 0	154.043*	124.188*	131.892*	144.516*	168.889*	155.299*
r ≤ 1	91.016*	66.725	82.581*	77.465*	82.041*	88.933*
r ≤ 2	42.653	40.705	40.578	44.921	40.923	55.339*
r ≤ 3	24.271	20.296	20.397	27.655	19.038	25.937
r ≤ 4	13.295	10.108	8.046	13.581	7.635	14.370
r ≤ 5	4.990	4.982	1.488	3.317	1.443	4.723
	Netherlands	**New Zealand**	**Norway**	**Portugal**	**Spain**	**Sweden**
Cointegrating Rank	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*
r = 0	159.839*	149.715*	142.625*	116.685*	149.623*	122.777*
r ≤ 1	83.747*	88.573*	76.820*	69.930	76.927*	83.020*
r ≤ 2	49.583	45.460	50.955	43.618	45.717	53.347
r ≤ 3	26.668	26.117	28.511	25.494	24.227	25.216
r ≤ 4	14.701	12.398	13.275	11.287	12.700	14.866
r ≤ 5	5.776	3.706	6.183	3.031	3.469	5.085
	Switzerland	**United Kingdom**	**United States**			
Cointegrating Rank	*Trace Statistics*	*Trace Statistics*	*Trace Statistics*			
r = 0	123.746*	136.126*	199.476*			
r ≤ 1	79.485*	86.212*	89.226*			
r ≤ 2	49.903	47.617	41.736			
r ≤ 3	28.222	23.476	21.740			
r ≤ 4	12.759	8.590	7.856			
r ≤ 5	4.090	2.047	3.025			

* indicates rejection of the null hypothesis at the 5% level.

indicate the presence of one cointegrating vector[72], fourteen countries show evidence of two cointegrating vectors[73], and two countries are found to have three cointegrating vectors in the data.[74] The presence of cointegrating relationships in the data necessitates the estimation of the error-correction model (ECM) for each country.

A six-variable VECM model is estimated for every country to assess the dynamic relationships among the variables. The results of the Granger causality tests are reported in Table 5 (a – u). Again, as in Table 4, each column represents one of the six VECM equations and each row designates each of the independent variables including the error correction term(s). In these estimations, the dynamic relationships between exports, imports, and GDP are the main focus; however, some attention needs to be paid to the relationships that exist among the other control variables as these are commonly held to be growth-causing variables.

Analogous to the VAR estimation with two lags, the VECM estimation with one lag also provides support for the Export-led Growth hypothesis for a set of the countries in the sample. Overall, five countries show strong support for short-run causation running from exports to GDP as determined by the results of an F-test on the lag of real exports in the real GDP equation. These countries are Canada, France, Germany, Iceland, and the United States.[75] As mentioned earlier, a significant, one-period lagged error correction term in the VECM provides an additional, long-run channel for Granger causality. The estimations for Canada, Iceland, and the United States yield error correction terms that are statistically insignificant implying that the relationships

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[72] These countries are: Austria, Canada, Finland, Greece, and Portugal.

[73] Australia, Denmark, Germany, Iceland, Ireland, Italy, Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, United Kingdom, and United States

[74] France and Japan

[75] Only France and the United States showed evidence in support of Export-led Growth in the 2-lag VAR.

Table 5a: Granger Causality Tests (1 lag)

Australia	*Dependent Variable*					
Independent Variable	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.37	0.19	1.47	5.50**	1.84
		(0.543)	(0.667)	(0.225)	(0.02)	(0.175)
Capital Stock	1.46	---	0.14	2.59	1.69	1.71
	(0.227)		(0.71)	(0.11)	(0.193)	(0.19)
Labor	0.76	0.10	---	0.96	2.41	0.04
	(0.385)	(0.751)		(0.327)	(0.121)	(0.841)
Human Capital	14.49**	3.47*	0.27	---	0.01	1.80
	(0.0002)	(0.062)	(0.606)		(0.917)	(0.18)
Exports	0.10	0.40	1.21	0.01	---	2.13
	(0.75)	(0.529)	(0.272)	(0.936)		(0.144)
Imports	0.65	1.88	0.01	0.01	9.46**	---
	(0.42)	(0.17)	(0.926)	(0.924)	(0.002)	
Error Correction Term	-0.038	0.47	-0.078**	-0.007	-0.86**	-0.43
	[-0.46]	[1.67]	[-2.43]	[-0.54]	[-2.42]	[-0.96]
	0.024	-0.37*	0.053**	0.0053	0.44	0.40
	[0.38]	[-1.75]	[2.17}	[0.53]	[1.65]	[1.15]

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses). t-statistics are reported for the error-correction term.

Table 5b: Granger Causality Tests (1 lag)

Austria	*Dependent Variable*					
Independent Variable	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	3.08*	0.89	4.30**	9.13**	6.46**
		(0.08)	(0.345)	(0.038)	(0.003)	(0.011)
Capital Stock	0.03	---	0.99	9.45**	1.33	0.11
	(0.858)		(0.319)	(0.002)	(0.249)	(0.735)
Labor	1.90	0.08	---	3.68*	0.38	0.001
	(0.168)	(0.779)		(0.055)	(0.537)	(0.98)
Human Capital	0.20	6.21**	1.33	---	1.09	0.50
	(0.656)	(0.013)	(0.249)		(0.296)	(0.48)
Exports	2.28	0.50	1.40	11.60**	---	1.73
	(0.131)	(0.48)	(0.237)	(0.0007)		(0.188)
Imports	1.89	0.003	0.02	8.16**	0.64	---
	(0.169)	(0.945)	(0.88)	(0.004)	(0.424)	
Error Correction Term	-0.126	0.041	-0.023	0.01**	0.70**	0.711**
	[-1.01]	[0.32]	[-0.68]	[3.70]	[2.40]	[2.37]

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses). t-statistics are reported for the error-correction term.

Table 5c: Granger Causality Tests (1 lag)

Canada	*Dependent Variable*					
Independent Variable	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.003	0.97	0.78	1.54	0.49
		(0.968)	(0.325)	(0.378)	(0.214)	(0.485)
Capital	0.62	---	0.48	0.03	0.28	0.09
Stock	(0.43)		(0.491)	(0.852)	(0.598)	(0.766)
Labor	3.04*	0.85	---	0.84	0.01	0.52
	(0.081)	(0.357)		(0.359)	(0.914)	(0.471)
Human	10.31**	4.48**	3.88**	---	1.66	4.10**
Capital	(0.0013)	(0.034)	(0.05)		(0.198)	(0.043)
Exports	6.33**	0.38	11.37**	4.11**	---	0.54
	(0.012)	(0.538)	(0.0007)	(0.043)		(0.461)
Imports	2.62	1.06	2.23	1.07	0.03	---
	(0.106)	(0.304)	(0.135)	(0.301)	(0.862)	
Error	-0.01	-0.013	-0.012**	0.0003	0.021	-0.0006
Correction	[-1.28]	[-0.53]	[-4.69]	[0.98]	[0.64]	[-0.02]
Term						

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses). t-statistics are reported for the error-correction term.

Table 5d: Granger Causality Tests (1 lag)

Denmark	*Dependent Variable*					
Independent Variable	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.27	0.94	0.13	2.22	1.59
		(0.60)	(0.333)	(0.718)	(0.136)	(0.207)
Capital	3.87**	---	5.05**	0.13	3.32	2.64
Stock	(0.05)		(0.025)	(0.721)	(0.07)	(0.104)
Labor	0.26	0.81	---	0.72	5.18**	4.59**
	(0.613)	(0.367)		(0.395)	(0.023)	(0.032)
Human	0.03	0.48	8.06**	---	1.37	0.39
Capital	(0.873)	(0.486)	(0.005)		(0.241)	(0.535)
Exports	0.38	0.06	1.78	1.86	---	2.90*
	(0.538)	(0.808)	(0.182)	(0.173)		(0.09)
Imports	3.29*	0.40	0.37	1.56	0.43	---
	(0.07)	(0.525)	(0.545)	(0.211)	(0.512)	
Error	-0.018	-0.186	0.087**	0.01	0.37**	0.157
Correction	[-0.38]	[-1.06]	[4.01]	[0.94]	[1.98]	[0.64]
Term	-0.023	0.10	-0.065**	-0.017*	0.014	0.048
	[-0.54]	[0.63]	[-3.34]	[-1.76]	[0.09]	[0.21]

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses). t-statistics are reported for the error-correction term.

Table 5e: Granger Causality Tests (1 lag)

Finland	*Dependent Variable*					
Independent Variable	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	5.24** (0.022)	6.19** (0.013)	2.28 (0.131)	4.16** (0.042)	5.93** (0.015)
Capital Stock	0.13 (0.719)	---	0.19 (0.662)	4.80** (0.029)	3.08* (0.08)	4.98** (0.026)
Labor	0.64 (0.422)	0.002 (0.966)	---	0.01 (0.910)	0.19 (0.66)	0.43 (0.514)
Human Capital	1.45 (0.229)	2.62 (0.106)	0.14 (0.707)	---	0.35 (0.551)	0.04 (0.844)
Exports	0.01 (0.934)	0.003 (0.945)	0.31 (0.58)	3.60* (0.06)	---	0.18 (0.674)
Imports	0.07 (0.80)	0.05 (0.818)	0.06 (0.802)	2.73* (0.099)	0.12 (0.728)	---
Error Correction Term	0.004 [0.05]	0.127 [0.69]	0.041* [1.71]	-0.10** [-2.81]	0.235 [0.80]	-0.128 [-0.38]

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses).t-statistics are reported for the error-correction term.

between exports and GDP are short-lived and do not persist over the long run. A significant error correction term for France and Germany, on the other hand, implies that the causal nature between exports and GDP has a long-run component.

The results of the estimations also indicate that some countries exhibit reverse causality from growth in GDP to growth in exports (Growth-led Exports). Australia, Austria, Finland, Portugal, and Sweden[76] display a short-run causal pattern from GDP to exports. Finland and Sweden only show evidence of short-run causality because of their insignificant error correction terms. For Australia, Austria, and Portugal a significant error correction term implies a long-run causal relationship exists between real GDP and exports.

[76] Sweden is at the 10% confidence level.

Imports also continue to play an important role in the growth relationship. Overall, four countries show short-run causality from imports to GDP.[77] For each of these four countries, the causal relationship between imports and GDP is only important over the short run and is not a persistent, long-run phenomenon. Moreover, four countries also show reverse causation from GDP to growth in imports (Austria, Finland, United Kingdom, and the United States). Austria and the United States have statistically significant error correction terms indicating that there is both a short-run and a long-run causal relationship between GDP and imports. Finland and the United Kingdom only show evidence of short-run causality running from GDP to imports. Nonetheless, the

Table 5f: Granger Causality Tests (1 lag)

France	*Dependent Variable*					
Independent Variable	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	5.29**	0.02	0.70	3.74*	1.15
		(0.022)	(0.898)	(0.403)	(0.053)	(0.284)
Capital	17.17**	---	0.51	0.08	0.95	0.06
Stock	(0.000)		(0.477)	(0.778)	(0.331)	(0.809)
Labor	0.35	0.01	---	8.88**	0.67	0.41
	(0.554)	(0.909)		(0.003)	(0.412)	(0.524)
Human	1.80	1.59	0.52	---	0.99	2.58
Capital	(0.180)	(0.207)	(0.472)		(0.321)	(0.108)
Exports	8.37**	7.19**	0.39	0.42	---	2.71*
	(0.004)	(0.007)	(0.532)	(0.516)		(0.10)
Imports	14.03**	10.34**	0.04	0.37	0.06	---
	(0.0002)	(0.0013)	(0.841)	(0.542)	(0.812)	
Error	-0.193**	-0.04	0.062**	-0.01	0.507	0.766*
Correction	[-2.86]	[-0.33]	[2.20]	[-0.72]	[1.22]	[1.88]
Term	-0.084*	-0.293**	0.046**	-0.009	-0.129	-0.094
	[-1.73]	[-3.39]	[2.29]	[-0.88]	[-0.43]	[-0.32]
	0.466	0.134	-0.361**	0.047	-1.003	-2.84
	[1.64]	[0.27]	[-3.08]	[0.77]	[-0.58]	[-1.67]

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses). t-statistics are reported for the error-correction term.

[77] France and Germany at the 5% level, Denmark and New Zealand at the 10% level.

Table 5g: Granger Causality Tests (1 lag)

Germany	*Dependent Variable*					
Independent Variable	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	1.25	0.29	0.12	1.01	0.81
		(0.264)	(0.588)	(0.729)	(0.315)	(0.37)
Capital	3.90**	---	0.62	0.004	0.20	0.31
Stock	(0.05)		(0.429)	(0.954)	(0.653)	(0.576)
Labor	1.41	0.01	---	0.004	0.01	0.18
	(0.235)	(0.907)		(0.968)	(0.931)	(0.668)
Human	0.94	0.11	0.72	---	0.49	0.52
Capital	(0.332)	(0.742)	(0.396)		(0.484)	(0.473)
Exports	9.07**	1.05	2.31	0.02	---	0.06
	(0.003)	(0.305)	(0.129)	(0.885)		(0.806)
Imports	6.98**	0.23	3.16*	0.09	0.94	---
	(0.008)	(0.631)	(0.076)	(0.765)	(0.332)	
Error	0.077**	0.066	0.037	0.028	0.274**	0.285**
Correction	[5.38]	[1.37]	[0.61]	[1.51]	[2.00]	[2.12]
Term	-0.068*	-0.445**	0.278*	0.013	-0.649*	-0.794**
	[-1.94]	[-3.80]	[1.87]	[0.30]	[-1.95]	[-2.43]

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses). t-statistics are reported for the error-correction term.

Table 5h: Granger Causality Tests (1 lag)

Greece	*Dependent Variable*					
Independent Variable	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.05	1.36	5.19**	0.85	0.57
		(0.818)	(0.244)	(0.023)	(0.358)	(0.45)
Capital	2.89*	---	1.95	1.45	3.15*	0.15
Stock	(0.09)		(0.163)	(0.228)	(0.076)	(0.70)
Labor	6.35**	5.40**	---	1.37	0.06	0.63
	(0.012)	(0.02)		(0.242)	(0.814)	(0.429)
Human	1.34	0.11	0.20	---	0.42	0.14
Capital	(0.247)	(0.741)	(0.657)		(0.515)	(0.706)
Exports	0.06	1.05	0.01	1.05	---	0.02
	(0.812)	(0.306)	(0.917)	(0.305)		(0.876)
Imports	2.56	0.17	0.05	1.49	0.01	---
	(0.109)	(0.677)	(0.829)	(0.223)	(0.922)	
Error	0.182**	0.348	-0.053	-0.019	1.10**	0.258
Correction	[2.27]	[1.18]	[-1.17]	[-1.50]	[3.41]	[0.76]
Term						

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses). t-statistics are reported for the error-correction term.

Table 5i: Granger Causality Tests (1 lag)

Iceland	*Dependent Variable*					
Independent Variable	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	2.33	0.01	0.08	0.12	0.21
		(0.127)	(0.923)	(0.777)	(0.734)	(0.644)
Capital	2.47	---	0.94	0.09	3.40*	0.86
Stock	(0.116)		(0.333)	(0.758)	(0.07)	(0.354)
Labor	4.41**	5.40**	---	0.28	0.05	1.82
	(0.036)	(0.02)		(0.594)	(0.817)	(0.18)
Human	3.49*	2.78*	3.20*	---	0.15	0.64
Capital	(0.062)	(0.096)	(0.074)		(0.70)	(0.425)
Exports	4.15**	4.83**	0.08	0.07	---	19.90**
	(0.042)	(0.03)	(0.781)	(0.789)		(0.000)
Imports	1.27	0.01	0.001	0.26	25.72**	---
	(0.26)	(0.904)	(0.988)	(0.611)	(0.000)	
Error	-0.161	0.02	-0.024	0.0001	1.645**	0.171
Correction	[-1.59]	[0.05]	[-0.25]	[0.06]	[4.17]	[0.36]
Term	-0.11*	-0.265	0.009	-0.001	-1.49**	-0.041
	[-1.77]	[-1.13]	[0.15]	[-0.77]	[-6.19]	[-0.14]

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses). t-statistics are reported for the error-correction term.

Table 5j: Granger Causality Tests (1 lag)

Ireland	*Dependent Variable*					
Independent Variable	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.31	0.23	1.67	0.31	0.004
		(0.575)	(0.63)	(0.20)	(0.579)	(0.961)
Capital	0.94	---	0.14	4.16**	0.003	2.01
Stock	(0.332)		(0.707)	(0.041)	(0.978)	(0.157)
Labor	0.08	0.20	---	0.05	0.04	0.46
	(0.782)	(0.656)		(0.818)	(0.833)	(0.50)
Human	2.39	0.20	0.57	---	0.39	0.28
Capital	(0.123)	(0.656)	(0.449)		(0.533)	(0.60)
Exports	0.86	0.53	0.09	1.04	---	1.46
	(0.355)	(0.466)	(0.771)	(0.308)		(0.227)
Imports	0.59	0.33	0.16	2.02	3.29*	---
	(0.442)	(0.568)	(0.69)	(0.155)	(0.07)	
Error	-0.107	-0.42	0.02	0.011**	-0.753**	-1.47**
Correction	[-0.93]	[-1.16]	[0.33]	[1.99]	[-1.99]	[-4.22]
Term	0.032	0.185	0.036	-0.005**	0.136	0.484**
	[0.69]	[1.29]	[1.46]	[-2.29]	[0.90]	[3.50]

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses).t-statistics are reported for the error-correction term.

results do indicate that imports belong in the growth equation because of the nature of causality as evidenced by the F-tests.

An examination of the results also shows that there exists significant causality running from growth in exports to growth in imports as well as from import growth to export growth. Overall, three countries show short-run causality from imports to exports (Australia, Ireland, New Zealand), three countries indicate short-run causality from exports to imports (Denmark, France, Sweden), and four countries display evidence of bi-directional causality between exports and imports (Iceland, Portugal, Spain, Switzerland). In addition to the finding of short-run Granger causality from imports to exports, Australia, Ireland, and New Zealand also display evidence of long-run causality as shown by a statistically significant error correction term. In contrast, none of the three countries which show short-run causality from exports to imports evidences any

Table 5k: Granger Causality Tests (1 lag)

Italy	*Dependent Variable*					
Independent Variable	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.44	0.002	0.65	0.09	0.09
		(0.506)	(0.98)	(0.422)	(0.758)	(0.771)
Capital	0.47	---	1.05	2.63	0.34	0.48
Stock	(0.493)		(0.306)	(0.105)	(0.558)	(0.49)
Labor	0.59	0.16	---	2.47	0.08	0.19
	(0.442)	(0.689)		(0.116)	(0.775)	(0.663)
Human	2.75*	0.16	0.50	---	0.15	0.03
Capital	(0.097)	(0.692)	(0.479)		(0.697)	(0.874)
Exports	0.23	1.70	0.78	1.11	---	0.79
	(0.635)	(0.193)	(0.377)	(0.292)		(0.374)
Imports	0.003	3.37*	0.04	0.001	1.18	---
	(0.967)	(0.067)	(0.842)	(0.997)	(0.278)	
Error	-0.37*	-0.267	0.23**	0.027**	-0.038	-1.16
Correction	[-1.84]	[-0.64]	[2.06]	[2.04]	[-0.05]	[-1.29]
Term	0.27**	0.40*	-0.095	-0.008	0.356	1.38**
	[2.44]	[1.74]	[-1.57]	[-1.11]	[0.83]	[2.80]

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses). t-statistics are reported for the error-correction term.

Table 5l: Granger Causality Tests (1 lag)

Japan	*Dependent Variable*					
Independent Variable	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.55	2.94*	4.08**	0.27	0.03
		(0.46)	(0.087)	(0.043)	(0.605)	(0.856)
Capital	0.01	---	1.15	0.84	0.05	0.05
Stock	(0.94)		(0.284)	(0.36)	(0.826)	(0.818)
Labor	5.55**	5.60**	---	5.67**	0.07	0.55
	(0.02)	(0.018)		(0.017)	(0.795)	(0.46)
Human	0.54	2.33	0.45	---	0.26	1.21
Capital	(0.464)	(0.127)	(0.504)		(0.61)	(0.272)
Exports	0.20	0.39	4.59**	1.17	---	0.95
	(0.657)	(0.531)	(0.032)	(0.28)		(0.329)
Imports	0.17	0.82	0.19	2.00	1.04	---
	(0.684)	(0.364)	(0.66)	(0.157)	(0.31)	
Error	0.104**	0.256**	0.017**	0.003*	0.29*	0.592**
Correction	[3.75]	[4.83]	[2.05]	[1.87]	[1.94]	[2.91]
Term	0.06*	-0.021	0.022**	-0.006**	0.08	-0.121
	[1.82]	[-0.34]	[2.23]	[-2.64]	[0.44]	[-0.50]
	-0.67**	-1.31**	-0.23**	0.02	-0.31	-1.53
	[-3.57]	[-3.65]	[-4.07]	[1.63]	[-0.31]	[-1.12]

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses). t-statistics are reported for the error-correction term.

Table 5m: Granger Causality Tests (1 lag)

Netherlands	*Dependent Variable*					
Independent Variable	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.58	0.91	0.002	0.43	0.01
		(0.445)	(0.341)	(0.976)	(0.511)	(0.937)
Capital	1.41	---	0.09	5.27**	5.94**	4.86**
Stock	(0.235)		(0.761)	(0.022)	(0.015)	(0.028)
Labor	1.59	0.22	---	0.04	0.54	0.80
	(0.207)	(0.636)		(0.834)	(0.463)	(0.37)
Human	0.04	0.45	0.004	---	5.37**	4.42**
Capital	(0.841)	(0.504)	(0.953)		(0.021)	(0.036)
Exports	1.32	1.23	0.09	2.58	---	1.15
	(0.25)	(0.267)	(0.765)	(0.108)		(0.284)
Imports	1.45	1.28	0.002	2.40	2.40	---
	(0.23)	(0.259)	(0.978)	(0.121)	(0.121)	
Error	-0.046	0.099	-0.063	-0.007**	-1.00**	-0.97**
Correction	[-0.81]	[0.76]	[-1.25]	[-3.18]	[-3.63]	[-3.04]
Term	0.045	-0.083	0.144	0.014**	1.68**	1.71**
	[0.46]	[-0.37]	[1.63]	[3.40]	[3.52]	[3.08]

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses). t-statistics are reported for the error-correction term.

Table 5n: Granger Causality Tests (1 lag)

New Zealand	*Dependent Variable*					
Independent Variable	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.97	2.46	0.19	1.82	0.76
		(0.325)	(0.117)	(0.67)	(0.177)	(0.382)
Capital	2.30	---	5.46**	0.44	8.06**	2.39
Stock	(0.13)		(0.02)	(0.507)	(0.005)	(0.122)
Labor	0.12	0.01	---	0.02	1.97	5.75**
	(0.73)	(0.925)		(0.887)	(0.16)	(0.017)
Human	2.20	0.20	1.21	---	3.30*	0.004
Capital	(0.138)	(0.657)	(0.271)		(0.07)	(0.962)
Exports	0.08	1.99	0.34	4.39**	---	0.90
	(0.78)	(0.158)	(0.561)	(0.036)		(0.343)
Imports	3.66*	1.30	0.08	11.68**	4.40**	---
	(0.056)	(0.254)	(0.78)	(0.0006)	(0.036)	
Error	0.098	0.494	0.161	0.029**	0.628**	0.854**
Correction	[1.49]	[1.58]	[1.13]	[2.79]	[2.01]	[2.12]
Term	-0.005	-0.053	-0.014	-0.003	-0.435**	-0.093
	[-0.28]	[-0.61]	[-0.37]	[-1.14]	[-5.03]	[-0.84]

Results are the F-statistic of the joint significance of the lags of each independent variable* and ** indicate significance at the 10% and 5% level (p-values are in parentheses). t-statistics are reported for the error-correction term.

Table 5o: Granger Causality Tests (1 lag)

Norway	*Dependent Variable*					
Independent Variable	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.53	4.25**	0.88	1.64	0.13
		(0.466)	(0.04)	(0.349)	(0.20)	(0.715)
Capital	0.15	---	0.92	0.72	0.004	0.13
Stock	(0.70)		(0.34)	(0.40)	(0.961)	(0.723)
Labor	0.15	6.57**	---	0.15	0.01	1.83
	(0.70)	(0.01)		(0.695)	(0.915)	(0.176)
Human	0.97	0.29	0.001	---	1.22	0.11
Capital	(0.324)	(0.59)	(0.99)		(0.27)	(0.735)
Exports	0.30	0.41	1.68	0.23	---	0.77
	(0.582)	(0.52)	(0.194)	(0.63)		(0.381)
Imports	0.17	0.04	0.02	0.51	0.49	---
	(0.677)	(0.85)	(0.876)	(0.477)	(0.485)	
Error	0.001	0.168	0.088**	-0.017	0.326	0.157
Correction	[0.01]	[1.11]	[2.87]	[-1.31]	[1.16]	[0.53]
Term	0.021	-0.39**	-0.031	0.023**	0.08	-0.13
	[0.24]	[-2.89]	[-1.13]	[2.00]	[0.32]	[-0.49]

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses). t-statistics are reported for the error-correction term.

Table 5p: Granger Causality Tests (1 lag)

Portugal	*Dependent Variable*					
Independent Variable	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.004 (0.958)	4.69** (0.03)	0.03 (0.855)	3.88** (0.049)	2.40 (0.122)
Capital Stock	10.54** (0.0012)	---	1.87 (0.172)	0.01 (0.917)	2.56 (0.11)	1.73 (0.189)
Labor	0.54 (0.464)	1.00 (0.318)	---	1.38 (0.241)	0.12 (0.729)	0.08 (0.778)
Human Capital	0.72 (0.395)	1.40 (0.237)	2.18 (0.14)	---	0.40 (0.526)	0.97 (0.324)
Exports	0.04 (0.85)	1.27 (0.26)	0.04 (0.843)	0.05 (0.816)	---	5.53** (0.019)
Imports	0.49 (0.485)	2.79 (0.095)	1.17 (0.279)	0.002 (0.978)	16.99** (0.000)	---
Error Correction Term	0.113** [2.90]	0.363** [3.90]	-0.081** [-2.34]	-0.0012 [-0.23]	0.45** [3.10]	0.434** [2.26]

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses). t-statistics are reported for the error-correction term.

long-run causal relationship between the variables. Moreover, the causal patterns of the four countries that demonstrate bi-directional causality between exports and imports are mixed. Only for Portugal and Switzerland is a significant error correction term estimated for the relationship between imports and exports as well as between exports and imports. Spain only reveals a short-run causal pattern between exports and imports while in Iceland, imports Granger-cause exports in both the short run and the long run but exports only Granger-cause imports in the short-run. All in all, the causal relationships that exist between imports and GDP and between exports and imports confirm that imports are an important causal variable and should be included separately from exports in any examination of the effect of trade on growth.

Furthermore it is important to examine the causal relationships that may exist among the other control variables and real GDP as these controls are held to be growth-causing variables in the neo-classical growth literature. The estimations only yield five instances where the real capital stock Granger-causes real GDP. The results for Denmark indicate that only short-run Granger causality exists between the capital stock and GDP. For the remaining countries (France, Germany, Greece, Portugal), the statistically significant error correction term implies that a long-run relationship exists between growth in the capital stock and economic growth.[78] In addition, three countries show evidence of causality from the labor force to real GDP. Causality from the labor force to GDP exists in the short run and the long run for Greece and Japan; only short-run causality exists for Iceland. The final control variable is the measure of human capital. Canada and Sweden demonstrate the short-run channel for causation from

Table 5q: Granger Causality Tests (1 lag)

Spain	*Dependent Variable*					
Independent Variable	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	1.51	0.09	0.65	0.87	0.31
		(0.219)	(0.76)	(0.422)	(0.351)	(0.578)
Capital	0.08	---	0.05	1.21	1.26	0.45
Stock	(0.772)		(0.831)	(0.271)	(0.262)	(0.504)
Labor	1.84	1.15	---	0.09	0.07	0.47
	(0.175)	(0.283)		(0.761)	(0.788)	(0.494)
Human	0.72	1.20	2.33	---	0.79	1.44
Capital	(0.40)	(0.272)	(0.127)		(0.373)	(0.23)
Exports	1.13	0.14	0.39	0.52	---	4.84**
	(0.287)	(0.706)	(0.533)	(0.47)		(0.028)
Imports	0.30	0.40	0.44	0.89	10.13**	---
	(0.583)	(0.529)	(0.505)	(0.345)	(0.0015)	
Error	-0.272*	-0.59	0.016	-0.044	1.04	-1.28
Correction	[-1.93]	[-1.61]	[0.15]	[-0.51]	[1.35]	[-1.24]
Term	0.053	-0.03	-0.062	0.027	-0.744	0.352
	[0.60]	[-0.13]	[-0.94]	[0.49]	[-1.51]	[0.54]

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses). t-statistics are reported for the error-correction term.

[78] France displays bi-directional causality between capital and GDP.

Table 5r: Granger Causality Tests (1 lag)

Sweden	*Dependent Variable*					
Independent Variable	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.004	0.74	3.44*	3.53*	0.17
		(0.95)	(0.391)	(0.064)	(0.06)	(0.682)
Capital	0.28	---	1.68	4.46**	0.07	0.33
Stock	(0.594)		(0.195)	(0.035)	(0.797)	(0.568)
Labor	0.26	0.17	---	0.20	0.10	0.39
	(0.61)	(0.678)		(0.652)	(0.75)	(0.531)
Human	4.89**	0.62	0.05	---	2.85*	0.58
Capital	(0.027)	(0.431)	(0.819)		(0.091)	(0.446)
Exports	0.98	1.86	2.73*	1.33	---	4.08**
	(0.322)	(0.173)	(0.099)	(0.25)		(0.043)
Imports	0.02	1.26	1.44	3.18*	0.71	---
	(0.876)	(0.262)	(0.23)	(0.075)	(0.40)	
Error	0.098	0.249	0.051	0.013	0.546	-0.045
Correction	[1.19]	[0.93]	[1.64]	[1.34]	[1.40]	[-0.10]
Term	0.01	-0.094	-0.031**	0.008*	-0.025	0.157
	[0.26]	[-0.77]	[-2.20]	[1.92]	[-0.14]	[0.77]

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses). t-statistics are reported for the error-correction term.

Table 5s: Granger Causality Tests (1 lag)

Switzerland	*Dependent Variable*					
Independent Variable	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	0.12	2.16	0.07	0.18	0.56
		(0.733)	(0.141)	(0.795)	(0.674)	(0.453)
Capital	2.30	---	0.39	1.14	0.01	0.66
Stock	(0.13)		(0.531)	(0.287)	(0.943)	(0.417)
Labor	0.19	0.01	---	5.03**	5.63**	4.41**
	(0.66)	(0.94)		(0.025)	(0.018)	(0.036)
Human	0.83	0.42	0.28	---	0.001	0.07
Capital	(0.363)	(0.519)	(0.60)		(0.99)	(0.794)
Exports	2.60	5.06**	0.68	1.69	---	11.34**
	(0.107)	(0.024)	(0.411)	(0.193)		(0.0008)
Imports	2.02	4.97**	0.41	1.91	10.55**	---
	(0.155)	(0.026)	(0.52)	(0.167)	(0.0012)	
Error	0.045	0.118	-0.014	0.024**	0.86**	0.948**
Correction	[0.96]	[1.08]	[-0.43]	[3.01]	[5.84]	[6.37]
Term	0.088	0.239	-0.023	0.046**	1.62**	1.80**
	[0.99]	[1.16]	[-0.36]	[3.05]	[5.85]	[6.43]

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses). t-statistics are reported for the error-correction term.

Table 5t: Granger Causality Tests (1 lag)

United Kingdom	*Dependent Variable*					
Independent Variable	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	6.86**	0.003	4.60**	2.68	7.21**
		(0.009)	(0.967)	(0.032)	(0.102)	(0.007)
Capital	0.01	---	0.34	0.09	0.91	2.41
Stock	(0.943)		(0.562)	(0.766)	(0.34)	(0.121)
Labor	0.24	0.17	---	2.80*	0.45	0.44
	(0.621)	(0.678)		(0.095)	(0.50)	(0.506)
Human	0.10	1.89	0.16	---	0.93	0.003
Capital	(0.756)	(0.169)	(0.689)		(0.335)	(0.957)
Exports	0.01	0.33	2.89*	6.37**	---	0.01
	(0.935)	(0.566)	(0.09)	(0.012)		(0.94)
Imports	0.52	0.13	1.64	16.55**	0.40	---
	(0.47)	(0.717)	(0.20)	(0.000)	(0.526)	
Error	0.005	-0.052	-0.0012	0.005**	-0.074	-0.06
Correction	[0.25]	[-1.10]	[-0.17]	[5.71]	[-0.91]	[-0.74]
Term	0.06	-0.076	-0.0007	0.008**	0.0016	0.292
	[1.09]	[-0.55]	[-0.03]	[2.90]	[0.01]	[1.22]

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses). t-statistics are reported for the error-correction term.

Table 5u: Granger Causality Tests (1 lag)

United States	*Dependent Variable*					
Independent Variable	GDP	Capital Stock	Labor	Human Capital	Exports	Imports
GDP	---	1.11	4.01**	0.02	0.05	2.91*
		(0.291)	(0.045)	(0.894)	(0.831)	(0.088)
Capital	0.07	---	0.01	0.82	1.00	0.08
Stock	(0.787)		(0.925)	(0.366)	(0.318)	(0.771)
Labor	2.60	2.73*	---	2.77*	0.05	2.09
	(0.107)	(0.099)		(0.096)	(0.828)	(0.148)
Human	2.83*	5.91**	0.01	---	0.65	0.97
Capital	(0.092)	(0.015)	(0.933)		(0.419)	(0.325)
Exports	5.75**	7.81**	1.00	0.04	---	0.04
	(0.017)	(0.005)	(0.318)	(0.845)		(0.844)
Imports	0.30	0.09	4.55**	0.03	1.08	---
	(0.586)	(0.768)	(0.034)	(0.873)	(0.30)	
Error	0.029	0.128**	0.029**	0.005	-0.075	0.213**
Correction	[1.35]	[2.35]	[6.19]	[1.03]	[-0.71]	[2.14]
Term	-0.025	-0.188**	-0.031**	-0.007	0.168	-0.261*
	[-0.80]	[-2.41]	[-4.61]	[-1.08]	[1.10]	[-1.83]

Results are the F-statistic of the joint significance of the lags of each independent variable. * and ** indicate significance at the 10% and 5% level (p-values are in parentheses). t-statistics are reported for the error-correction term.

human capital to GDP. Of the three countries that display short-run causality from human capital to GDP at the 10% confidence level, Iceland and the United States only indicate a short-run relationship; a significant error correction term for Italy implies that the relationship has a long-run trend component.

By and large, the results on the VECM estimations do lend some support to the Export-led Growth hypothesis by indicating a causal relationship from exports to GDP for five of the countries in the sample. The causal relationship between exports and real GDP only persists in the short run for Canada, Iceland, and the United States; a significant error correction term implies that there is a long-run relationship between the two variables for France and Germany. Moreover, the results suggest that imports are an important variable in the causal pairings and should be controlled for to more accurately predict the effects of trade on GDP. A surprising result of the estimations is that relatively little evidence is found to support causation from capital, labor, and human capital to growth in real GDP. Since these variables have been consistently shown to be strong determinants of economic growth, one would expect to find a higher incidence of causation from each of these variables to GDP. It can be plausibly inferred from this result that the current estimation framework may have some shortcomings when attempting to capture the true relationships among the variables because the underlying relationships may be non-linear.

Concluding Remarks

The purpose of this study is to determine if causal relationships exist between trade and income growth when other growth-affecting variables are controlled for in a generalized production function. The effects that physical capital, human capital, and labor force growth have on income growth have been well documented in the neoclassical growth literature. Thus, the focus is on the effect trade has on income growth. Testing the direction of causality between total trade and income will be in line with estimations of the effect trade has on income in an endogenous growth model.

This study utilizes a time-series analysis of twenty-one individual OECD countries from 1970-2006 rather than a cross-country analysis since cross-country studies necessarily impose restrictions that the effects of each variable are the same in each country. The time-series approach is more appropriate because it allows for quantitative differences to emerge as trade affects countries in varying ways. Moreover, rather than only focusing on the relationships between exports and GDP growth as many past studies have done, this study also includes a country's level of imports to further clarify the causal orderings in addition to variables that control for the physical capital stock, the human capital stock, and the amount of labor.

The data was first tested for the presence of unit roots and non-stationarity since Granger causality tests require that the variables are stationary. The ADF and KPSS unit root tests confirm that the variables are non-stationary in their levels and stationary in their first differences. Next the data is tested for the possibility of cointegration among the variables. This is an important step because two variables that are integrated of the same order may be cointegrated if they share a common stochastic trend (Engle and Granger, 1987). In the presence of cointegration, standard Granger causality tests are insufficient for assessing the dynamic relationships among the variables and can lead to misleading or spurious results. This study tests for cointegration under two different lag lengths in the model. First, cointegration is tested for a model with two lags in the data and then the model is retested when only one lag is present in the system of equations.

The reason that the two lag lengths are tested is two-fold. First, it is interesting to see how the estimations are affected by the choice of lag length, and second, lag-length determination tests yielded conflicting results. Akaike Information Criteria indicated that one lag in the data was optimal for the estimation; however, a lag length restriction test implied that the higher lagged model is appropriate.

When the model was estimated using two lags in the data, only one country, Japan, showed any evidence of a cointegrating relationship. For Japan an error-correction term was added to the VAR model to capture the potential long-run relationships among the variables. A standard VAR model was employed for the remaining countries in the sample. Overall, the estimations lend support to the Export-led Growth hypothesis (exports Granger-cause GDP growth) for six of the countries in this study. Moreover, five countries show evidence in support of the Import-led Growth hypothesis. Bi-directional causality was supported in two countries; Australia shows bi-directional causality between exports and GDP, and Denmark shows bi-directional causality between imports and GDP. Furthermore, the results of the estimations indicate that imports do play an important role in determining economic growth but that export growth has been a more important determinant of growth for the countries over the sample period.

Since the control variables employed in this study are growth-causing variables in the neo-classical growth model, the causal relationships from these variables to real GDP are also examined. The results of the Granger causality tests show that the capital stock only Granger-causes GDP for three countries in the sample. Moreover, labor and human capital Granger-cause GDP for four and six countries, respectively. These results seem surprisingly low considering how important the variables are in the literature on neo-classical growth and may stem from the failure of the methods employed in this study to capture the true, dynamic relationships among these variables.

As an additional test, the model is re-examined with one lag present in the data to discover if there are any systematic differences in the results due to the choice of lag length. The first striking distance is seen in the tests for cointegration. When two lags were included in the model only one country showed signs of possessing a cointegrating relationship among the variables. With only one lag in the data every country shows signs of at least one cointegrating vector in the data, if not more. The number of cointegrating vectors ranged from 1 to 3 with a majority of the countries in the sample showing evidence of having two cointegrating relationships.

Due to the evidence that indicates the existence of cointegrating relationships among the variables for every country, the standard VAR is modified to include the error correction term. An appropriate VECM model is estimated for each country to capture the dynamic relationships that exist among the variables. This procedure is necessary because standard Granger causality tests are misleading in the presence of cointegration and may not capture the true causal relationships among the variables. The VECM specification of the model is able to identify two potential sources of Granger causality. The first source is through a test of the joint significance of the lagged variables using an F-test and is commonly referred to as “short-run” Granger causality. The second source of causality flows from the one-period, lagged error correction term. A significant error correction term implies that past equilibrium errors play a role in determining the current outcomes of the variables and has been cited as “long-run” causality.

Overall, the Export-led Growth hypothesis is supported for five of the countries in the sample (Canada, France, Germany, Iceland, and the United States). Of those countries, only France and Germany exhibit evidence in support of long-run Granger causality as shown by a statistically significant error correction term. Moreover, four countries demonstrate causality from imports to economic growth. Long-run causality is supported for France and Germany, while short-run causality is supported for Denmark and New Zealand at the 10% confidence level. Finally, five countries demonstrate reverse causality from GDP to exports (Growth-led Exports) and four countries establish causality from GDP to imports (Growth-led Imports). Australia, Austria, and Portugal have a long-run relationship from GDP to exports; Austria and the United States have a long-run relationship from GDP to imports.

The results also indicate that there exist significant causal relationships between exports and imports; four countries exhibit bi-directional causality between exports and imports. The test statistics confirm a long-run causal relationship between exports and imports for Portugal and Switzerland. Spain only displays short-run causality, while Iceland shows a long-run relationship from imports to exports but only a short-run relationship from exports to imports. Three countries have a causal relationship from imports to exports and three other countries have a causal relationship from exports to imports. The results indicate that imports are an important variable in the model and need to be included in any study that attempts to assess the impact of trade on economic growth.

As with the estimation of the model with two lags, it is again important to examine the causal relationships that exist among the control variables which are growth-causing factors in neo-classical literature. Five countries show a causal relationship from the capital stock to GDP. Three countries have a causal relationship from labor to GDP and five countries have a causal relationship from human capital to GDP. Again, these results seem surprisingly low given the relative importance of these variables in the growth literature.

As an extension of this study, if it is possible, the import variable should be decomposed into consumption imports and intermediate imports to assess the effect that trade in both types of goods may have on economic growth. The a priori assumption is that increasing the importation of intermediate goods should have a significant, positive effect on economic growth since this trade will serve to increase the economy's capital stock. It can plausibly be assumed that imports of consumption goods will not have a positive effect on growth and may even have a slight negative effect because this type of trade can divert spending away from the domestic market. However, this needs to be tested further to determine the true effect since it may be the case that greater penetration of imported consumption goods can spur innovation in the domestic economy as firms react to the greater foreign competition.

Chapter 4

Does Trade Openness Predict Long-run Economic Growth?

Introduction

The extent to which liberalizing trade affects economic growth and performance is a hotly debated and contentious issue in the area of development economics. During the 1950s and 1960s many developing economies adopted import substitution and other protectionist trade policies. The origins of these protectionist policies are found in the work of Raul Prebisch (1950) and Hans Singer (1950) and are based on two fundamental premises. First, a deterioration in the international price of raw materials and commodities would result in an ever widening gap between rich economies and poor economies; and second, in order to become industrialized, the developing economies needed to protect their emerging manufacturing sectors.[79]

However, the debt crisis faced by many developing nations in 1982 indicated that the protectionist policies that these countries had followed since the end of World War II were no longer sustainable. This is most clearly seen when the poor performance of the Latin American nations that followed import substitution policies is compared to the rapidly growing East Asian nations, many of whom followed outward oriented trade policies (see Table 1). During the 1980s economists began to more vocally advocate for the adoption of outward oriented trade policies as an engine for growth. The reasons for the shift in trade policy are many and varied but include the poor performance of

[79] This reasoning is closely related to the infant industry argument for restricting trade.

import substitution policies (Krueger, 1997), the weight of empirical evidence which suggested a positive relationship between trade openness and economic growth, and the external pressures of World Bank and IMF policies which required trade liberalization and other reforms as a condition for loans.[80]

Table 1: Average Annual Growth Rates of Real GDP per capita

Source: ERS International Macroeconomic Data Set

	1970 – 2006	1970 – 1985	1986 - 2006
Central America and Caribbean			
Barbados	1.36	1.13	1.52
Costa Rica	1.97	1.04	2.64
Dominican Republic	2.97	2.87	3.05
El Salvador	0.82	-1.04	2.14
Guatemala	1.06	0.93	1.16
Haiti	-0.88	0.57	-1.91
Honduras	0.99	1.57	0.57
Jamaica	0.27	-1.52	1.54
Mexico	1.72	2.55	1.12
Nicaragua	-1.41	-2.05	-0.95
Panama	1.63	1.59	1.66
Trinidad and Tobago	2.96	3.62	2.49
Average	**1.12**	**0.94**	**1.25**
South America			
Argentina	0.89	-0.44	1.84
Bolivia	0.69	0.03	1.15
Brazil	2.04	3.54	0.96
Chile	2.94	0.72	4.52
Colombia	1.96	2.17	1.81
Ecuador	1.93	3.79	0.60
Guyana	0.80	-0.90	2.00
Paraguay	1.67	3.85	0.10
Peru	0.60	0.01	1.03
Uruguay	1.65	0.39	2.55
Venezuela	-0.20	-1.52	0.74
Average	**1.36**	**1.06**	**1.57**
Sub-Saharan Africa			
Benin	0.45	0.46	0.45
Botswana	5.83	8.95	3.61
Burkina Faso	1.27	1.56	1.06
Burundi	-0.34	1.11	-1.38

[80] From 1980-1989, 79% of World Bank and IMF loans carried trade policy conditions (Greenaway, 1998).

Cameroon	1.20	4.71	-1.30
Central African Republic	-1.25	-0.96	-1.46
Congo, Democratic Republic	-3.24	-1.86	-4.22
Congo, Republic	1.40	4.92	-1.12
Ethiopia	0.22	-2.43	2.10
Gabon	1.15	3.47	-0.50
Gambia	0.52	1.04	0.15
Ghana	0.21	-2.44	2.10
Guinea	0.86	0.65	1.02
Ivory Coast	-1.11	-0.43	-1.59
Kenya	1.80	2.38	1.39
Lesotho	3.30	3.75	2.97
Liberia	-2.53	-2.25	-2.73
Madagascar	-1.38	-2.41	-0.64
Malawi	0.84	1.55	0.34
Mali	1.18	0.81	1.45
Mauritania	1.24	-0.45	2.44
Mauritius	4.31	4.24	4.36
Niger	-1.20	-2.00	-0.62
Nigeria	0.79	-0.49	1.70
Rwanda	1.02	1.42	0.73
Senegal	0.45	-0.33	1.00
Sierra Leone	-0.25	-0.32	-0.19
South Africa	0.41	-0.04	0.73
Sudan	1.70	-0.53	3.30
Swaziland	1.80	1.86	1.75
Tanzania	0.86	0.04	1.45
Togo	-0.44	-0.28	-0.56
Uganda	1.16	-0.84	2.58
Zambia	-1.17	-1.89	-0.66
Zimbabwe	-0.61	0.65	-1.51
Average	**0.58**	**0.67**	**0.52**
North Africa and Middle East			
Algeria	1.28	2.67	0.29
Cyprus	4.62	7.29	2.70
Egypt	3.06	3.90	2.45
Iran	0.56	-0.58	1.37
Iraq	3.88	1.49	5.59
Israel	2.07	2.49	1.78
Jordan	3.52	7.92	0.38
Malta	4.91	7.11	3.34
Morocco	2.16	2.49	1.93
Syria	2.38	4.31	1.00
Tunisia	3.16	3.81	2.70
Average	**2.87**	**3.9**	**2.14**

South Asia			
India	3.19	1.68	4.26
Nepal	1.39	0.83	1.79
Pakistan	2.34	2.55	2.19
Sri Lanka	3.18	2.88	3.39
Average	**2.53**	**1.99**	**2.91**
East Asia and Pacific			
China	7.51	5.97	8.61
Fiji	1.58	1.38	1.73
Indonesia	4.14	4.97	3.55
Japan	2.40	3.08	1.91
Korea	5.78	5.92	5.67
Laos	2.32	0.54	3.58
Malaysia	4.07	4.43	3.82
Mongolia	1.16	1.85	0.66
Philippines	1.25	0.83	1.54
Singapore	5.14	6.10	4.45
Taiwan	5.89	6.53	5.43
Thailand	4.58	4.13	4.90
Average	**3.82**	**3.81**	**3.82**
Europe and Central Asia			
Bulgaria	2.08	2.12	2.04
Hungary	2.70	3.54	2.11
Poland	2.86	2.17	3.36
Romania	1.82	3.84	0.37
Turkey	2.39	2.02	2.64
Average	**2.37**	**2.74**	**2.10**
Advanced Economies			
Australia	1.84	1.56	2.04
Austria	2.37	2.82	2.05
Belgium	2.20	2.44	2.03
Canada	2.01	2.43	1.71
Denmark	1.60	1.69	1.54
Finland	2.59	2.96	2.32
France	1.90	2.20	1.68
Germany	1.88	2.32	1.56
Greece	2.24	2.31	2.19
Iceland	2.77	3.87	1.99
Ireland	4.13	2.76	5.10
Italy	2.01	2.60	1.59
Luxembourg	3.36	2.07	4.28
Netherlands	1.78	1.66	1.87
New Zealand	1.34	1.17	1.46
Norway	2.67	3.70	1.94

Portugal	2.67	2.91	2.49
Spain	2.42	2.01	2.71
Sweden	1.89	1.68	2.05
Switzerland	0.96	1.02	0.91
United Kingdom	2.14	1.91	2.30
United States	2.08	2.20	1.99
Average	**2.22**	**2.29**	**2.17**

Over the last 30 years there has been an unprecedented wave of unilateral trade reforms as markets around the world have become more integrated and countries have adapted their trade policies to participating in the global market. In response, numerous research studies have been conducted and directed to establish what role openness to trade has in promoting economic growth. The common belief is that more open countries will grow faster than economies that restrict trade. Under "new" growth theory developed by Romer (1986) and Lucas (1988), support exists for the theory that trade can have a positive impact on economic growth. Romer (1992), Grossman and Helpman (1991), and Barro and Sala-i-Martin (1995) have argued that countries that are more open have a greater ability to absorb technological advances produced in leading nations. Trade openness provides access to many imported goods embodying new technologies which can be exploited to increase the size of the market for a country's output. New growth theories, however, do not predict that trade will unambiguously increase economic growth. Empirical estimations are needed in order to resolve the debate of whether or not trade openness positively affects economic growth.

Despite the shift to more outward oriented trade policies and the conclusions of "new" growth theory, evidence suggests that the benefits from trade reforms have not been as large as predicted.[81] Moreover, the evidence shows that the response to trade

[81] Taylor (1991), Winters (2004)

liberalization has varied across countries. Some nations have benefited from freer trade and other countries have been adversely affected by trade reforms. Nonetheless, numerous empirical studies have established a positive relationship between trade openness and economic growth. However, liberalization skeptics, including Krugman (1994), Rodrik (1995), and Rodriguez and Rodrik (2001), have argued that the effects of openness on growth are tenuous at best and non-existent at worse. In fact, Krugman (1994) argues that the high rate of economic growth in many of the East Asian economies was spurred primarily by the high level of investments generated through domestic savings. As Krugman notes, "If there is a secret to Asian growth, it is simply deferred gratification, the willingness to sacrifice current satisfaction for future gain."

The main problem with the empirical literature is that there is no clear definition of trade openness or what it means to liberalize trade. Several strategies have been employed to overcome the measurement problem of trade openness. First, various studies have attempted to construct a subjective measure of trade openness.[82] The subjective measures of trade openness are not cross-country comparable and thus fail to show whether trade openness is beneficial to growth. A second strategy has been to decompose the effects of trade on economic growth in two stages. In the first stage it is assumed that trade liberalization encourages a higher level of exports. In the second stage, researchers test whether higher exports or a higher growth rate in exports have been associated with more rapid economic development.[83] Neither approach has been totally satisfactory since they have led to many conflicting results. An example of the conflicting results of openness studies is seen in how different studies classify South

[82] Most notably the NBER project conducted by Krueger and Bhagwati, the 1987 *World Development Report* from the World Bank, and Papageorgiou et al. (1991).
[83] Michaely (1977), Balassa (1978, 1982)

Korea. In some studies South Korea is considered a prime example of the positive effects of outward-oriented trade policies[84]; while other studies classify South Korea as a semi-closed economy and an example for how a small economy should avoid rapid trade liberalization if it wishes to grow.[85]

Nonetheless, more studies have attempted to construct alternative measures of trade openness in order to quantify the extent to which trade openness affects growth. These measures include the Outward Orientation Index (World Bank, 1987), the Sachs and Warner Openness Index (Sachs and Warner, 1995), the Average Black Market Premium (Barro and Lee, 1994), the Average Import Tariff, and the Average Coverage of Non-tariff Barriers[86] among others. Studies that have surveyed some of the many openness measures show that there exists some positive relationship between openness and growth when other factors are controlled for. The most common control factors are measures of the stocks of capital (physical and human) and labor.

The purpose of this study is to add to the growing empirical literature relating trade openness to economic growth by constructing and testing a new measure of trade openness which seeks to depict the overall restrictiveness of each country's trade policy. The measure constructed in this study follows the methods of Leamer (1988) in which the trade index is based on the deviation of each country's actual levels of trade with a level of trade predicted from a gravity model of bilateral trade flows. An initial level of openness is calculated and included in a growth equation to determine the extent, if any, that openness predicts future growth and the direction of the relationship.

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[84] World Bank (1987), Greenaway and Nam (1988)
[85] Sachs (1987), Collins and Park (1988), Wade (1994)
[86] Data from UNCTAD and reported by Barro and Lee (1994)

Section II will survey some of the literature on trade openness and economic growth to show the conclusions and limitations faced by many of the current measures of openness. The openness measure, which measures trade restrictiveness, for this study will be constructed and discussed in section III. Section IV will investigate the relationship between economic growth and trade openness and Section V will provide some concluding remarks.

Review of the Empirical Literature

The nature of the relationship between trade openness and economic growth is still a debated topic with a clear consensus yet to emerge. This is partly due to the lack of a clear definition of openness or trade liberalization as it applies to trade policies. An ideal measure of openness would include all the barriers that distort trade including all tariff and non-tariff barriers. The difficulty in measuring trade barriers makes the construction of an appropriate openness index a challenging task. Several index measures of openness have been developed in the literature and tested in endogenous growth models with varying results and varying success. Moreover, what is abundantly clear is that there are no perfect measures of trade openness and that the main question in the literature is which methods are most likely to produce the best results.

The most basic measure of trade openness is a country's trade share; exports plus imports divided by GDP. Studies that have used this measure have generally found evidence of a strong relationship between openness and growth even when controlling for other factors including capital and labor.[87] The problem with using this simple measure is that trade shares are often an imperfect proxy for trade policy. Also,

[87] Balassa (1985)

Frankel and Romer (1999), Rodriguez and Rodrik (2001), and Irwin and Trevio (2002) have raised the issue that trade shares are endogenous to economic growth and that this endogeneity must be controlled before any useful conclusions can be made.

Other, more direct measures of trade policy have also been proposed in the literature. These measures include average tariff rates and coverage ratios for non-tariff barriers. The problem with these measures is the difficulty in aggregating tariffs and non-tariff barriers into a single index. Studies that employ these administrative measures of trade policy have reported mixed empirical results. Lee (1993) and Edwards (1998) both find a significant, negative relationship between tariff rates and economic growth. Conversely, Sala-i-Martin (1997) and Clemens and Williamson (2001) conclude that the relationship is weak at best. Additionally, Rodriguez and Rodrik (2001) attempt to replicate Edwards' (1998) results and find evidence of a positive and significant relationship between average tariff rates and total factor productivity (TFP) for a set of 43 countries from 1980-1990.

However, studies of this nature may be flawed due to the use of cross-sectional averages of the data which make it difficult to control for cross-country differences or even differences in the same country over time. Furthermore, measuring the impact of trade policies may prove difficult because trade policy may also be endogenous to economic growth. Countries that have faster rates of economic growth may decide to pursue more open trade policies. Moreover, countries that enact policies to restrict trade may also, in turn, adopt other growth-restricting policies.

A number of studies, including Harrison (1996), Sala-i-Martin (1997), and Edwards (1998) have used the black market premium as a measure of the severity of trade restrictions. The authors report a negative and significant relationship between the black market premium and economic growth. However, Levine and Renelt (1992) note that the black market premium is highly correlated with other bad policies and economic outcomes like high inflation and severe external debt. Thus, the black market premium gives a misleading measure of trade restrictions.

Ann Harrison (1996), in an effort to identify the relationship between trade openness and growth, tests a number of available openness measures with a general production function framework in order to verify that the different measures of openness yield similar results. Output in her model is expressed as a function of the capital stock, the years of primary and secondary education as a proxy for human capital formation, the labor force, arable land, and technological change. Openness measures in this model framework affect output through their effect on technological change which is represented as growth in output after controlling for increases in the other productive factors.

Harrison then tests seven different measures of trade openness to assess the relationship between openness and growth. The first measure is an annual index of trade liberalization for 1960-1984 derived from information on exchange rate and commercial policies calculated by Papageorgiou et al. (1991). The second index employs a measure of tariff and non-tariff barriers (Thomas and Nash, 1991). Next is the black market premium which is defined as the deviation of the black market rate from the official exchange rate. Other measures include a country's trade share, an index representing the movement toward international prices[88], and a price distortion index.[89] When the model was run using period averages for the openness measures,

[88] Bhalla and Lau (1992)
[89] Dollar (1991)

the results obtained turned out to be insignificant. The most important factors for growth were growth in the capital stock and the labor force.

Because of the unpromising results of the estimation, Harrison reevaluates the model using annual data for some of the variables. To control for unobserved country-specific differences, Harrison estimates a fixed effects (FE) model. The results of the model yield a stronger relationship between the different openness measures and growth with four measures significant at the 10% level. The movement toward greater openness positively affects economic growth and greater distortions[90] negatively affect growth.

Yanikkaya (2003) employs a similar approach to Harrison (1996) when attempting to determine the impacts of various openness measures. Yanikkaya utilizes a model where the growth rate of output is expressed as a function of some initial value of output, the levels of physical capital per person and human capital per person, and a vector of control variables which include the measures of openness, the number of war deaths, the type of government regime, tropical climate, and access to waterways. The author then splits the openness measures into two groups. The first group is calculated using trade volumes and includes the trade share in GDP, import penetration ratios, and export shares in GDP. Yanikkaya includes measures of each country's trade with all OECD countries, a second measure of each country's trade with non-OECD countries, and the ratio of each country's bilateral trade with the U.S. The second group of openness measures is based on various trade restrictions. This group includes total tariffs, total export duties, and taxes on international trade as measures of trade policy.

[90] Measured by the Black market premium and the Dollar index

Results of the initial estimations show that countries with higher trade shares are likely to grow faster than other countries. Also, Yanikkaya concludes that access to new goods and technologies are not as important to growth as access to markets that results in the exploitation of economies of scale and comparative advantage. This is shown in the positive and significant coefficients on the terms of trade with OECD countries as well as the terms of trade with non-OECD countries. Furthermore, countries that trade more with the U.S. tend to grow faster than countries with lower levels of trade with the U.S.

More recently, Sarkar (2008) employed a panel-data format to investigate the relationship between trade openness and growth. Sarkar employs data from 51 less-developed countries (LDCs) from 1981-2002. Each country's trade share in GDP was used as the measure of openness. Sarkar concludes that countries with higher trade shares tended to experience higher real growth. As a further test, the author split the countries into four overlapping groups. First, each country was defined as "open" or "closed" based on their trade shares.[91] Second, each country was classified as "rich" or "poor" based on their average per capita Real GDP. When separate regressions were estimated for each group, Sarkar found that only for the 11 rich and highly trade-dependent (open) economies is a higher trade share associated with higher economic growth.

Additionally, Sarkar (2008) examined the openness-growth relationship in a time series for individual LDCs. The results indicated that there was no positive long-term relationship between openness and growth from 1961-2002. The results found by

[91] A country is defined as open if the trade share ≥ 50%

Sarkar seem to cast some doubt on the academic consensus that trade openness promotes economic growth.

Due to the volume of studies dealing directly with measures of trade openness in a growth equation, a number of studies have instead asked whether the act of liberalizing trade has any influence on the long-run growth path of world economies. Greenaway, Morgan, and Wright (2002), and Foster (2008) conduct studies on the effect that liberalizing trade has on economic growth when controlling for other growth-causing factors in a panel data framework. In both studies real GDP per capita is regressed on the initial level of real GDP per capita, an initial level of human capital, the ratio of investment to GDP, and a dummy variable which equals 1 in the year or years for which a country initializes liberal trade reforms.[92,93]

The results of both studies indicate that overall trade liberalization has a positive impact on economic growth, but, they note, this effect tends to work with a lag. This makes some intuitive sense since trade liberalization is a gradual process and is not categorized as an immediate move to free trade. Further, Foster (2008) concludes that the countries with the lowest rates of output growth benefit the most from trade liberalization in the long run but that these countries are also the most likely to suffer some negative, short-run effects of liberalization. This finding is troubling because the negative effects that the countries experience in the short run could potentially lead to a reversal of the liberalized policies and a loss of the long-term benefits unless the reforms are anchored by international support.

Since trade volumes tend to be positively correlated with growth, one can conclude that any barrier to trade should have a negative effect on growth due to their

[92]Human capital is measured as the average years of secondary schooling
[93] Greenaway et al. also include a terms of trade index and lagged values of real GDP per capita

possible trade-reducing effects. The consensus is that trade barriers are detrimental to growth; however, growth studies indicate that the relationship is not so straightforward or unambiguous. Certain studies have even shown that countries can benefit from trade restrictions under certain conditions. Yanikkaya shows in his results that developing countries with higher average tariff rates grow faster than developing countries with lower tariff rates. A possible explanation of this positive relationship is that the existence of tariffs causes the factors of production to be reallocated to the country's area of comparative advantage which is being protected by trade restrictions. The results lend credence to the belief that developing countries can benefit from certain trade restrictions if these restrictions lead to a more efficient allocation of resources in the domestic market.

The purpose of this study is to add to the growing literature on trade and growth by constructing a measure of trade openness, or trade restrictiveness, and then testing whether or not the prevailing beliefs that trade openness is beneficial to growth are confirmed or if the results confirm the minority view that trade restrictions can be beneficial to growth in some circumstances. Explicitly, this study tests whether an initial level of openness has any significant impact, either positive or negative, on long-run economic growth once other growth-causing factors are controlled for in the model.

Empirical Methodology

a. *Measuring Trade Openness*

In this study an openness measure is constructed following the approach developed by Leamer (1988). In his paper, Leamer estimates a predicted level of trade in a model without trade barriers. The openness measure index he constructs is based on the deviation of the actual level of recorded trade with the level of predicted trade from a general equilibrium model for 183 commodities at the three digit SITC level of aggregation in 1982. He argues that, implicitly, trade barriers should be a) the only important omitted variable and b) uncorrelated with the included variables. This openness measure should, therefore, be correlated with measures of trade policy.

Edwards (1992) applied Leamer's index and found a positive and significant impact of openness on growth. However, Pritchett (1991) concludes that Leamer's index is inversely related to other measures of openness including import penetration, quotas, and tariffs. According to Pritchett, if Leamer's measure concludes that an economy is open, then they also tend to have high tariffs and quotas, or low import penetration. As Leamer notes, "in the absence of direct measures of trade barriers, it will be impossible to determine the degree of openness for most countries with much subjective confidence."

This study follows the basic idea developed by Leamer of estimating a model to predict trade in the absence of trade barriers or trade policy but constructs the openness measure with a different method that should be highly correlated with trade policies. The level of predicted trade is derived from the gravity model of bilateral trade developed by Frankel and Romer (1999). The volume of trade predicted by the gravity model is independent of a country's trade policies because trade in the basic gravity model only depends on a country's geographic characteristics including the distance from their trading partners, a country's size and population as well as the size and population of a country's trading partners.

The following log-linear gravity equation of bilateral trade will be estimated to construct the predicted value of trade in the absence of any trade barriers:

(1) $\ln(\tau_{ij}/GDP_i) = \alpha_0 + \alpha_1 \ln D_{ij} + \alpha_2 \ln N_i + \alpha_3 \ln A_i + \alpha_4 \ln N_j + \alpha_5 \ln A_j + \alpha_6(L_i + L_j) + \alpha_7 B_{ij} + \alpha_8 Lat_i + \alpha_9 Lat_j + \alpha_{10} Trop_i + \alpha_{11} Trop_j + \alpha_{12}(I_i + I_j) + \alpha_{13} ComCol_{ij} + \alpha_{14} Colony_{ij} + \alpha_{15} CulSim_{ij} + \alpha_{16} Lang_{ij} + \varepsilon_{ij}$

The variables in the model include the common geographic components included in the gravity model literature.[94] These common variables are the distance between two trading partners (D_{ij}), the land areas of each trading partner (A_i, A_j), the population of each country (N_i, N_j), whether either of the countries in the trading pair is landlocked (L_i, L_j), and if the countries share a common border (B_{ij}). Gravity model studies have all consistently shown that these common variables are all important determinants of the volume of trade between two countries.

Additional control variables are included in the gravity equation to capture the effects that other geographic characteristics, cultural similarity, and historical connections have on the trade between two countries. Historical connections between trading partners exist if the countries were ever colonized by the same mother country ($ComCol_{ij}$) or if one country ever colonized the other country in the trading pair ($Colony_{ij}$).[95] Cultural similarity is defined as two countries having a common dominant religion ($CulSim_{ij}$) and a common official, or dominant, language ($Lang_{ij}$).[96] Finally, additional geographic components are included in the gravity equation that were absent from earlier studies but included by Rodriguez and Rodrik (2001) and Noguer and Siscart (2005) as additional channels through which geography affects trade. These variables include the average latitude (Lat_i, Lat_j) of each country and the percentage of

[94] Frankel and Romer (1999), Irwin and Trevio (2002), Noguer and Siscart (2005)
[95] Adapted from Rose (2000, 2005) and Adam and Cobham (2007)
[96] The importance of cultural similarity for trade between two countries has been documented by Beckerman (1956), Srivastava and Green (1986), and Yu and Zeitlow (1995).

each country's land in the tropical zone ($Trop_i$, $Trop_j$).[97] As noted by MacArthur and Sachs (2001), a more appropriate measure of tropical exposure is the percentage of a country's population living in the tropical zone; however, the lack of data availability prohibits the use of this measure.

Once the gravity model equation is estimated, a country's predicted trade share is calculated as the sum of the exponential of the predicted bilateral trade flows from country i to all trading partners, j. The gravity equation (1) can be rewritten in the following form:

(2) $\ln(\tau_{ij}/GDP_i) = \mathbf{a}'\mathbf{X}_{ij} + e_{ij}$

where **a** is the vector of coefficients and $\mathbf{X}_{ij}$ is the vector of all the right-hand-side variables in the gravity equation. The estimate of the geographic component of country i's overall trade share is

(3) $\hat{T}_i = \sum_{j \neq i} e^{\hat{a}' X_{ij}}$

where $\hat{T}_i$ is the trade-to-GDP ratio predicted by the gravity model.

The next step is to construct the measure of trade openness employed by this study. Following Leamer (1988), trade openness is defined as the deviation of the level of predicted trade from the actual level of trade. However, calling the statistic developed in this study a measure of trade openness is misleading. Instead, the statistic measures the degree of trade restrictiveness. The method of constructing this measure is to first construct a predicted, or "natural", level of trade in the absence of trade policy. Next, the predicted level of trade is subtracted from the actual level of trade to remove all of the trade which is explained by the gravity model:

[97] Taken from Gallup, Sachs, and Mellinger (1999)

(4) Actual Trade = Predicted Trade + Residual Trade

(5) Actual Trade – Predicted Trade = Residual Trade

Residual trade is the level of trade due to trade policy and measures the effect of policies on overall trade. The level of residual trade is used in this study as an indicator of trade restrictiveness. The trade restrictiveness measure is constructed so that if the trade restrictiveness measure is positive, this implies that a country is trading at a level below what is predicted by the gravity model and has more restrictive trade policies when compared to an average country.[98] If the trade restrictiveness indicator is negative, then a country has fewer trade protections and trades more than is predicted by the gravity model. The larger the value of the measured indicator, the more restrictive are a country's overall trade policies and the less open that economy is to trade.

This study will test two versions of the restrictiveness measure. The first measure is based on the gross difference between actual trade shares and the predicted trade shares. The second measure creates a value for trade restrictiveness based on the percentage deviation of predicted trade from the actual trade shares. These measures of restrictiveness are in line with the criteria set forth by Leamer that trade barriers are uncorrelated with the variables included in the predicted model and that trade barriers and trade policy represent the only important omitted variables. Because the gravity model does not include any policy or trade barrier considerations, the constructed measures of trade restrictions should represent the levels of trade affected directly by trade policy. If T is the actual trade share and T* is the predicted trade share from the gravity model, then the restrictiveness measures are constructed as follows:

[98] All countries have some degree of trade restrictions.

(6) Trade Restrictiveness 1 = -(T – T*)

(7) Trade Restrictiveness 2 = -(T – T*)/T* x 100

Table 2 reports the actual trade shares, the predicted trade shares, and both restrictiveness measures for a set of 112 countries in 1970. The first column in the table contains the actual trade shares of each country and is defined as the sum of exports plus imports divided by GDP. The data on actual trade shares for 1970 are obtained from the World Development Indicators Database compiled by the World Bank. The trade shares range from a low of 2.51% for Romania to a high of 190.23% for Panama.

Table 2: Trade Shares and Trade Restrictiveness

	Actual Trade Shares	Predicted Trade Shares	Trade Restrictiveness 1	Trade Restrictiveness 2
Central America and Caribbean				
Barbados	138.13	69.34	-68.79	-99.21
Costa Rica	63.21	25.15	-38.06	-151.33
Dominican Republic	41.82	31.83	-9.99	-31.38
El Salvador	49.38	26.50	-22.88	-86.36
Guatemala	36.35	25.12	-11.23	-44.72
Haiti	31.49	30.35	-1.14	-3.77
Honduras	62.02	24.13	-37.89	-157.05
Jamaica	70.65	43.55	-27.10	-62.24
Mexico	17.4	10.97	-6.43	-58.65
Nicaragua	55.92	23.30	-32.62	-140.03
Panama	190.23	25.43	-164.80	-648.19
Trinidad and Tobago	84.44	46.19	-38.25	-82.79
South America				
Argentina	10.34	12.19	1.85	15.14
Bolivia	48.95	19.29	-29.66	-153.73
Brazil	14.48	10.47	-4.01	-38.32
Chile	28.63	14.25	-14.38	-100.91
Colombia	30.13	16.06	-14.07	-87.59
Ecuador	37.46	20.06	-17.40	-86.71
Guyana	113.46	32.81	-80.65	-245.83
Paraguay	31.04	20.15	-10.89	-54.06
Peru	33.89	16.04	-17.85	-111.23

Uruguay	29.08	22.41	-6.67	-29.77
Venezuela	37.82	18.11	-19.71	-108.84
Sub-Saharan Africa				
Benin	39.64	37.45	-2.19	-5.86
Botswana	85.57	31.13	-54.44	-174.86
Burkina Faso	21.6	28.80	7.20	25.01
Burundi	22.31	35.92	13.61	37.90
Cameroon	50.88	25.32	-25.56	-100.91
Central African Republic	73.5	31.08	-42.42	-136.52
Congo, Democratic Republic	33.68	20.26	-13.42	-66.26
Congo, Republic	92.5	48.93	-43.57	-89.03
Ethiopia	27.99	15.88	-12.11	-76.22
Gabon	87.71	35.75	-51.96	-145.35
Gambia	78.7	46.68	-32.02	-68.59
Ghana	44.02	31.70	-12.32	-38.86
Guinea	52.95	27.11	-25.84	-95.29
Ivory Coast	64.88	31.20	-33.68	-107.94
Kenya	60.49	27.77	-32.72	-117.81
Lesotho	61.1	27.76	-33.34	-120.10
Liberia	114.15	30.34	-83.81	-276.20
Madagascar	40.75	22.15	-18.60	-83.97
Malawi	63.4	32.96	-30.44	-92.34
Mali	30.67	24.77	-5.90	-23.83
Mauritania	65.77	25.22	-40.55	-160.74
Mauritius	101.02	56.45	-44.57	-78.97
Niger	28.87	27.43	-1.44	-5.24
Nigeria	19.62	21.96	2.34	10.65
Rwanda	26.74	41.79	15.05	36.01
Senegal	56.44	27.57	-28.87	-104.73
Sierra Leone	54.9	33.71	-21.19	-62.87
South Africa	47.14	14.86	-32.28	-217.33
Sudan	32.74	30.76	-1.98	-6.43
Swaziland	130.34	33.62	-96.72	-287.70
Tanzania	35.95	24.96	-10.99	-44.06
Togo	88.42	32.19	-56.23	-174.70
Uganda	43.47	33.80	-9.67	-28.60
Zambia	90.47	28.96	-61.55	-212.88
Zimbabwe	30.85	30.34	-0.51	-1.68
North Africa and Middle East				
Algeria	51.23	28.36	-22.87	-80.62
Cyprus	60.42	63.13	2.71	4.30

Egypt	32.94	22.85	-10.09	-44.15
Iran	38.91	15.51	-23.40	-150.79
Iraq	88.32	27.21	-61.11	-224.60
Israel	78.6	38.85	-39.75	-102.30
Jordan	49	42.16	-6.84	-16.23
Malta	129.32	86.67	-42.65	-49.20
Morocco	39.22	22.84	-16.38	-71.73
Syria	39.36	37.11	-2.25	-6.06
Tunisia	46.74	36.30	-10.44	-28.76
South Asia				
India	8.1	19.31	11.21	58.05
Nepal	13.21	24.06	10.85	45.10
Pakistan	22.44	27.68	5.24	18.94
Sri Lanka	54.05	31.77	-22.28	-70.11
East Asia and Pacific				
China	5.31	7.29	1.978	27.14
Fiji	89.01	37.20	-51.81	-139.26
Indonesia	28.42	14.17	-14.25	-100.51
Japan	20.39	16.16	-4.23	-26.15
Korea	37.44	22.87	-14.57	-63.67
Laos	11.53	35.12	23.59	67.17
Malaysia	78.72	25.28	-53.44	-211.44
Mongolia	58.8	77.08	18.28	23.71
Philippines	42.62	26.41	-16.21	-61.39
Singapore	60.3	55.74	-4.56	-8.18
Taiwan	40.32	45.21	4.89	10.81
Thailand	34.4	18.02	-16.38	-90.93
Europe and Central Asia				
Bulgaria	73.49	38.88	-34.62	-89.05
Hungary	62.58	32.37	-30.21	-93.32
Poland	20.13	37.33	17.20	46.07
Romania	2.51	22.05	19.54	88.62
Turkey	10.32	30.79	20.47	66.48
Advanced Economies				
Australia	26.11	13.53	-12.58	-92.98
Austria	58.05	54.62	-3.43	-6.29
Belgium	98.94	85.62	-13.32	-15.56
Canada	42.5	22.22	-20.28	-91.24
Denmark	60.1	34.88	-25.22	-72.30
Finland	50.3	43.58	-6.77	-15.41

France	30.9	41.44	10.54	25.44
Germany	25.97	50.33	24.36	48.41
Greece	26.12	32.89	6.77	20.59
Iceland	88.24	28.22	-60.02	-212.66
Ireland	76.84	86.36	9.52	11.02
Italy	31.35	23.21	-8.14	-35.10
Luxembourg	162.58	142.51	-20.07	-14.08
Netherlands	92.74	60.48	-32.26	-53.35
New Zealand	29.56	17.51	-12.05	-68.86
Norway	73.62	24.37	-49.25	-202.09
Portugal	45.88	25.27	-20.61	-81.54
Spain	25.78	24.02	-1.76	-7.35
Sweden	47.96	27.56	-20.40	-74.01
Switzerland	62.99	65.43	2.44	3.73
United Kingdom	43.76	42.59	-1.17	-2.76
United States	11.27	10.60	-0.67	-6.36

The predicted trade shares from the gravity model of bilateral trade are reported in column 2 of Table 2. The predicted trade shares are capturing geographically and size dependent, natural levels of trade without regards to any trade barriers or other trade policies. The predicted trade shares range from a low of 7.29% of GDP for China to a high of 142.51% of GDP for Luxembourg. These results are not surprising since the literature on the gravity model of trade has consistently shown that the level of trade between two countries i and j is negatively related to their distance from one another as well as the size (both in area and population) of country i. In fact, the low predicted trade share for China illustrates this fact as China is relatively distant from many of its major trading partners and is also one of the largest countries in terms of population and land area. Luxembourg, on the other hand, is a relatively small country that is in very close proximity to many of its trading partners in Europe.

An examination of the predicted trade shares for the other countries further illustrates these relationships. The largest countries in the world rank at the bottom in terms of their predicted trade shares. The United States ranks 110th (10.6%), Brazil ranks 111th (10.47%), Australia is 107th (13.52%), Argentina is 108th (12.19%), India ranks 94th (19.31%), and Canada ranks 87th (22.22%). Additionally, the smaller countries in the world tend to rank highest according to the predicted trade shares indicating that these countries tend to be more reliant on trade for many of the goods consumed by their citizens; whereas the larger countries possess a greater quantity of resources and tend to have more expansive manufacturing and agricultural sectors and are less dependent on trade. Of the smallest countries in the data set, Malta ranks 2nd (86.67%), Barbados ranks 6th (69.34%), Cyprus is 8th (63.13%), Mauritius is 10th (56.45%), and Singapore ranks 11th (55.74%).

Columns 3 and 4 of Table 2 report the two restrictiveness measures constructed for this study. Column 3 records trade restrictiveness as the difference between a country's actual trade share and their predicted trade share. Column 4 reports trade restrictiveness as the percentage deviation of predicted trade from actual trade. Subsequently, a country is generally classified as being "open" if their actual trade share is unusually great when compared to the predicted level (negative restrictiveness measure). This is determined if, with the first restrictiveness measure, there is a large difference and, with the second restrictiveness measure, there is a large percentage deviation. A country is classified as being "closed" if both restrictiveness measures are positive. If the restrictiveness measure is close to zero this means that the majority of a country's trade is well explained by the gravity model and they have an average level of trade protection. A positive value of the trade restrictiveness measure indicates that the economy is trading less than they could when only considering geographic, historical, and cultural trade connections. These countries have the most restrictive trade policies of the economies in the sample.

According to both restrictiveness measures employed in this study, Panama is the most open country in the sample with measured values of -164.8 and -648.19, respectively. As noted earlier, Panama was also the country with the highest actual trade share. The country with the highest constructed difference restrictiveness measure is Germany with a value of 24.36. Romania has the highest percentage restrictiveness measure with a value of 88.62.[99] Overall, 21 countries in the sample have constructed openness values that are greater than zero (19% of the sample) indicating a relatively high degree of protectionist trade policies. Out of all 112 countries in the sample the United States ranks as the 23rd (-0.67) and 29th (-6.36) least open country for each of the restrictiveness measures used in this study.

b. Trade Openness and Economic Growth

The restrictiveness measures constructed in this study employ the predicted levels of trade from the gravity model developed previously since the geographic components of trade are for the most part uncorrelated with trade policies. Therefore, the deviation of actual trade from the predicted value should be correlated with the trade policies adopted by each country and can be utilized in a growth model to determine the impact that trade policy has on growth.

The restrictiveness measures constructed in the previous section are included in an endogenous growth model in order to determine whether the measure of trade policies in an initial, starting year has any power to predict economic growth into the future. The main question asked by this study is do countries that are more open (less restrictive) at the beginning of sampled time period have economic growth rates that are

[99] Romania had the lowest actual trade share.

systematically higher than countries that begin the period as closed (more restrictive) economies.

The model employed by this study takes a form similar to that of Barro (1991), Easterly and Levine (1997), and Sachs (1997). Economic growth in the model is defined as the average annual growth rate of per capita real GDP from 1970 – 2006. Real GDP per capita is measured in 2005 constant U.S. dollars and is available from the ERS International Macroeconomic Data set provided by the U.S. Department of Agriculture. In the model, per capita economic growth (GR_i) over the sample period will be explained by the initial, 1970 value of real GDP per capita, measures of both human and physical capital, the labor force and the restrictiveness measures.[100] The growth equation takes the following general form:

$$\textbf{(8)} \qquad GR_i = \alpha_0 + \alpha_1 Y_{70,i} + \alpha_2 HStock_{70,i} + \alpha_3 KStock_{70,i} + \alpha_4 Labor_{70,i} + \alpha_5 Open_{70,i} + \varepsilon_i$$

In neoclassical growth models[101] it has been consistently shown that a country's per capita growth rate is inversely related to their starting level of Real GDP per capita. If two countries are similar in all respects except for their levels of income, neoclassical growth models predict that the poorer of the two countries will grow at a faster rate. Thus, there is a force that promotes convergence in real GDP per capita across countries. The main facet of convergence is the diminishing returns to capital. Poor countries have low levels of capital per worker and consequently have high marginal products of capital; thereby, these countries tend to grow at higher rates. Barro (1991) shows that when other factors are controlled for, there is a strong negative relationship

[100] As an additional test, dummy variables for Sub-Saharan Africa and Latin America were included in the growth equation. While both of these variables display negative, significant effects on the per capita growth rate, they do not greatly alter the estimates of the remaining variables.
[101] See Solow (1956), Cass (1965) and Koopmans (1965)

between the average annual growth rate of per capita real GDP from 1960 to 1985 and the 1960 level of real GDP per capita in a sample of 98 countries. Barro cites this as evidence in favor of the theory of conditional income convergence but qualifies his findings by noting that poor countries will only catch up to the more advanced economies if they also have relatively high levels of initial human capital per person. The level of Real GDP per capita in 1970 is included in the growth equation to test for the evidence of conditional convergence among the countries in the sample.

As additional controls, initial levels of human capital, physical capital, and labor are included in the growth equation. As Barro (1991), Romer (1990) and other studies have shown, human capital plays an important role in growth models. In Romer (1990), human capital is a key resource in the research sector; thus, he concludes, countries with a higher initial stock of human capital will experience a more rapid introduction of new goods and tend to grow faster over time. A larger stock of human capital also makes it easier for a country to absorb new goods or technologies that were developed elsewhere; a follower country with a high level of human capital will grow faster because it catches up more rapidly to the technological leaders.[102] The average total years of schooling for the population 25 years and older is employed to proxy for the level of human capital. At first, the contemporaneous measure of human capital is employed in the growth equation; however, it can be argued that the effects of lagged human capital accumulation are more important to determining economic growth. To determine if this argument is true, the values of human capital in 1965 and 1960 are also used independently as additional checks of the data.

[102] Nelson and Phelps (1966)

Two separate measures of the stock of physical capital are tested independently. First, physical capital is proxied by the ratio of investments to Real GDP per capita. The data is available from the Penn World Tables 7.0. Data for this variable is available for the full set of countries. Additionally, a second proxy for physical capital is tested. This second variable is the level of capital per worker in 1970 and is taken from Easterly and Levine (2001); however, this data is only available for 81 of the 112 countries in the data set. Because of the difficulty in obtaining complete data on the size of the labor force of each country, the total population 15 years and older is used as a proxy for all of the potential workers available in each economy. The level of labor is used to control for scale effects and country size.

Empirical Results

a. Average Annual Growth: 1970 – 2006

An initial measure of restrictiveness for 1970 is included in the growth equation (8) in an effort to establish the predictive quality of trade restrictions for future growth. This model estimation is significant because the results may show the implications for countries that decide to reduce trade restrictions. The idea, a priori, is that countries that begin with a lower level of trade restrictions will tend to grow more and grow faster. This hypothesis will be estimated for the long-run from 1970-2006 using the full set of 112 countries and then the reduced set of 81 countries. Afterward, the growth model will be re-estimated on a shorter time span (1970-1985) to establish whether the effects of trade restrictiveness are long-lived or are only important over the shorter time period.

The first estimation is a baseline model where trade openness is approximated by the actual trade share as this has been one of the more common openness measures in the trade and growth literature. Second, the actual trade shares are replaced by the predicted trade shares as a second baseline test to demonstrate if any useful information about long run growth can be obtained from simple trade share measures of openness. Finally, each of the two trade policy measures are tested to determine if one measure outperforms the other and if any of the measures yield any important information about economic growth.

Table 3 reports the various regression estimations when the actual trade share of GDP is used as a measure of trade openness. The independent variables are entered in levels. The regressions represented in columns 1 - 3 of Table 3 are taken over the full sample of countries and generally confirm some of the basic findings of Barro (1991). In each of the three regressions, there is a statistically significant[103], negative relationship between the level of real GDP per capita in 1970 and the average growth rate of real GDP per capita over the full time frame. This finding lends support to the theory of conditional convergence which states that countries with higher levels of real GDP per capita at the start of the period tended to grow at a slower pace on average. Specifically, an increase of $1000 in the level of Real GDP per capita is associated with a -0.05 percentage point reduction in the average growth rate of real GDP per capita (-0.06 percentage points for column 2).

Further, the results show that the level of human capital is an important determinant of per capita growth both in the contemporaneous sense as well as when human capital is lagged 5 and 10 years behind the start of the time period. A one-year increase in the average total years of schooling is associated with between a 0.27 and

[103] At the 10% confidence level.

0.3 percentage point increase in the per capita growth rate. This coincides with the findings of Barro and others who conclude that countries with higher levels of human

Table 3: Regressions for per capita Growth 1970 - 2006: Actual Trade Shares

Dependent variable: Average Annual Growth Rate of per Capita Real GDP 1970-2006						
	I	II	III	IV	V	VI
Constant	0.165	0.152	0.195	-1.061	-1.14	-1.35
	(0.377)	(0.382)	(0.383)	(1.39)	(1.39)	(1.38)
GDP 1970	-0.05*	-0.06*	-0.05*	-0.06*	-0.06	-0.05
	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)
School 1970	0.272**	---	---	0.162	---	---
	(0.082)			(0.119)		
School 1965	---	0.295**	---	---	0.154	---
		(0.089)			(0.124)	
School 1960	---	---	0.284**	---	---	0.111
			(0.092)			(0.124)
Labor	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
INV	0.028**	0.029**	0.030**	---	---	---
	(0.012)	(0.012)	(0.012)			
K per worker	---	---	---	0.251	0.267	0.305
				(0.184)	(0.183)	(0.18)
Actual Trade	0.0014	0.0016	0.0019	0.0025	0.0026	0.0027
	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)
Sample Size	112	112	112	81	81	81
Adjusted R-squared	0.239	0.237	0.228	0.216	0.212	0.205
Root MSE	1.514	1.521	1.531	1.44	1.44	1.45

* and ** denote significance at the 10% and 5% level, respectively. Standard errors are in parentheses. GDP 1970 coefficient is multiplied by 1000. Labor coefficient is multiplied by 1,000,000.

capital embodied in their workers do grow faster over time. Additionally, the results indicate strong positive relationships between per capita economic growth and increases in both the population aged 15 years and older and the investment-to-GDP ratio. These results confirm that the labor force and capital are both vital determinants of long-run economic growth.

A surprising result of the model is that while the trade-to-GDP ratio in 1970 has a positive influence on per capita growth, the effects are relatively small and statistically insignificant. According to the results, a one percentage point increase in the starting trade-to-GDP ratio leads to between a 0.0014 and 0.0019 percentage point increase in the per capita growth rate. These results seem to suggest that trade openness as measured by the actual trade shares is not an important determinant of long-run economic growth.

Columns 4 – 6 in Table 3 report the regression results for the reduced sample of 81 countries with the Easterly and Levine (2001) capital per worker data. The results of these estimations are notably different from the full-sample regressions. Now, only the estimation in column 4 shows a significant relationship between initial GDP per capita and per capita growth. Moreover, none of the measures of human capital are found to be significant in any of the estimations although they do still indicate that a positive relationship exists between human capital accumulation and per capita growth rates. The results also indicate that the initial value of the trade-to-GDP ratio has a positive effect on per capita growth; however, this effect continues to be statistically insignificant.

Next, the actual trade shares in the model are replaced by the trade shares predicted from the gravity model as a measure of trade openness. The results from the full-sample and reduced-sample regressions using the predicted trade shares to measure openness are reported in Table 4. Columns 1 – 3 report the full sample estimates of the growth model. Overall, these regressions yield stronger results than the regressions that employed the actual trade shares. The results continue to show support for conditional convergence[104]. A $1000 increase in Real GDP per capita reduces the per capita growth rate between -0.07 and -0.08 percentage points.

[104] The relationship between real GDP per capita in 1970 and the per capita growth rate is significant at the 5% level.

Moreover, the results continue to confirm that the initial level of human capital is an important determinant of long-run growth. A one-year increase in the average years of schooling generates between a 0.28 and 0.31 percentage point increase in the growth rate of real GDP per capita. Countries with higher levels of initial human capital grew faster over the entire period, on average.

Table 4: Regressions for per capita Growth 1970 - 2006: Predicted Trade Shares

Dependent variable: Average Annual Growth Rate of per Capita Real GDP 1970-2006

	I	II	III	IV	V	VI
Constant	-0.25	-0.27	-0.24	-1.91	-1.98	-2.17
	(0.376)	(0.382)	(0.383)	(1.363)	(1.36)	(1.35)
GDP 1970	-0.07**	-0.08**	-0.07**	-0.08**	-0.08**	-0.08**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)
School 1970	0.279**	---	---	0.175	---	---
	(0.08)			(0.114)		
School 1965	---	0.306**	---	---	0.169	---
		(0.087)			(0.119)	
School 1960	---	---	0.302**	---	---	0.137
			(0.090)			(0.119)
Labor	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**
	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)
INV	0.021*	0.023*	0.023*	---	---	---
	(0.012)	(0.012)	(0.012)			
K per worker	---	---	---	0.265	0.281	0.313*
				(0.175)	(0.173)	(0.17)
Predicted Trade	0.02**	0.021**	0.022**	0.03**	0.03**	0.03**
	(0.008)	(0.008)	(0.008)	(0.011)	(0.011)	(0.011)
Sample Size	112	112	112	81	81	81
Adjusted R-squared	0.279	0.279	0.272	0.284	0.281	0.275
Root MSE	1.47	1.48	1.49	1.37	1.38	1.38

* and ** denote significance at the 10% and 5% level, respectively. Standard errors are in parentheses. GDP 1970 coefficient is multiplied by 1000. Labor coefficient is multiplied by 1,000,000.

The investment-to-GDP ratio, as a proxy for the initial level of capital, and the population aged 15 years and older, as a proxy for the labor force, also continue to be strong positive determinants of long-run economic growth. The significance of the investment-to-GDP ratio (a one percentage point increase leads to a roughly 0.02

percentage point increase in the per capita growth rate) is not surprising. Investment levels tend to be persistent over time; high investment ratios now are correlated with higher future investment. Thus, the countries that began the period with a high investment ratio will grow more rapidly as investments continue to grow over time.

The main difference between the regressions in Table 4 and Table 3 is that the predicted trade shares show a strong, positive relationship with per capita growth. Specifically, a one percentage point increase in the predicted trade-to-GDP ratio is associated with between a 0.02 and 0.022 percentage point increase in the per capita growth rate. When looking at the data one can see evidence of this positive relationship between trade shares and per capita growth. The top 5 countries ranked by their predicted trade shares have an average growth rate of 3.15% while the bottom 5 countries have and average growth rate of 2.84 percent. This result confirms the findings of Frankel and Romer (1999), which show that the predicted trade shares indicate a larger impact of trade on economic growth over using each country's actual trade share.

The statistically significant, positive effect of the predicted trade shares on growth persist when the reduced sample is employed. In fact, the relationship strengthens as now a one percentage point increase in the predicted trade share is associated with a 0.03 percentage point increase in the per capita growth rate. Furthermore, the strong, negative relationship between the rate of economic growth and the initial level of per capita Real GDP also persists with a $1000 increase in Real GDP per capita leading to a 0.08 percentage point reduction in the per capita growth rate. However, as in the first use of the reduced data set, the measure of human capital is found to be insignificant as well as the initial level of capital per worker (except column 6).

While the previous regressions indicate a positive relationship between a country's overall trade shares and per capita growth, that relationship is not consistent for each of the trade share measures, nor do the results provide any real information on how trade openness through trade policies and restrictions affect economic growth. To that end Tables 5 and 6 report the results of using both of the restrictiveness measures developed in this study.

Table 5 reports the results for the full sample and reduced sample regressions when trade restrictiveness is measured as the difference between a country's actual trade share and their trade share predicted by the gravity model. This specification of the model continues to show the strong, negative relationship between initial real GDP per capita and the per capita growth rate that is a key conclusion of neoclassical growth models. Moreover, the models estimated in columns 1 - 3 also continue to indicate the strong, positive relationship between economic growth and the initial amount of human capital. The model consistently indicates that a one year increase in the average years of schooling will increase the per capita growth rate between 0.28 and 0.31 percentage points.

The most interesting aspect of the model is that the estimation implies a positive relationship between per capita economic growth and the trade restrictiveness measure. The results imply that a one percentage point increase in the measure of trade restrictiveness (more restrictive trade policy) will increase the per capita growth rate by 0.0067 percentage points. However, this estimate is not statistically significant when the other factors in the model are controlled for.[105] This result runs counter to the generally

[105] When the labor variable is excluded from the estimation, both trade restrictiveness measures indicate a positive and significant relationship to per capita economic growth. The difference restrictiveness

Table 5: Regressions for per capita Growth 1970 - 2006: Trade Restrictiveness 1

Dependent variable: Average Annual Growth Rate of per Capita Real GDP 1970-2006

	I	II	III	IV	V	VI
Constant	0.306	0.301	0.355	-1.10	-1.18	-1.40
	(0.34)	(0.345)	(0.344)	(1.38)	(1.38)	(1.37)
GDP 1970	-0.06**	-0.06**	-0.06*	-0.07*	-0.07*	-0.06*
	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)
School 1970	0.278**	---	---	0.166	---	---
	(0.081)			(0.118)		
School 1965	---	0.301**	---	---	0.156	---
		(0.089)			(0.123)	
School 1960	---	---	0.289**	---	---	0.113
			(0.092)			(0.123)
Labor	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
INV	0.031**	0.032**	0.033**	---	---	---
	(0.012)	(0.012)	(0.012)			
K per worker	--	---	---	0.292	0.309*	0.348*
				(0.184)	(0.183)	(0.18)
Trade Restrictiveness 1	0.0067	0.0065	0.0064	0.0073	0.0072	0.007
	(0.005)	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)
Sample Size	112	112	112	81	81	81
Adjusted R-squared	0.249	0.247	0.236	0.226	0.222	0.214
Root MSE	1.50	1.51	1.52	1.43	1.43	1.44

* and ** denote significance at the 10% and 5% level, respectively. Standard errors are in parentheses. GDP 1970 coefficient is multiplied by 1000. Labor coefficient is multiplied by 1,000,000. Restrictiveness = -(Actual Trade – Predicted Trade)

accepted view that greater trade openness and less restrictive trade policies enhance economic growth. Yet, a casual review of the data shows that the countries that rank as the least restrictive also tend to have fairly low average per capita growth rates. The ten countries with the lowest restrictiveness value have an average annual growth rate of 1.39% which is below the average taken over the entire sample (1.76%). In the reduced sample estimation the relationship between more restrictive trade policies and growth continues to be positive (point estimate around 0.007); yet the results are statistically

measure has a point estimate of 0.011 (t-stat = 1.95). The percent deviation restrictiveness measure has a point estimate of 0.003 (t-stat = 2.14).

insignificant, implying that over a long span of time initial trade restrictiveness is not as an important determinant of growth as the literature on growth suggests.

Table 6: Regressions for per capita Growth 1970 – 2006: Trade Restrictiveness 2

Dependent variable: Average Annual Growth Rate of per Capita Real GDP 1970-2006	I	II	III	IV	V	VI
Constant	0.35	0.347	0.403	-1.12	-1.20	-1.41
	(0.344)	(0.349)	(0.348)	(1.37)	(1.37)	(1.37)
GDP 1970	-0.06**	-0.06**	-0.06*	-0.07**	-0.07*	-0.06*
	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)
School 1970	0.277**	---	---	0.17	---	---
	(0.081)			(0.118)		
School 1965	---	0.301**	---	---	0.16	---
		(0.09)			(0.123)	
School 1960	---	---	0.292**	---	---	0.119
			(0.091)			(0.123)
Labor	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**
	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)
INV	0.03**	0.032**	0.033**	---	---	---
	(0.012)	(0.012)	(0.012)			
K per worker	---	---	---	0.299*	0.315*	0.353*
				(0.183)	(0.182)	(0.179)
Trade Restrictiveness 2	0.0022	0.0022	0.0023	0.0023	0.0023	0.0023
	(0.0016)	(0.157)	(0.159)	(0.181)	(0.182)	(0.183)
Sample Size	112	112	112	81	81	81
Adjusted R-squared	0.253	0.251	0.242	0.231	0.227	0.22
Root MSE	1.50	1.51	1.52	1.42	1.43	1.44

* and ** denote significance at the 10% and 5% level, respectively. Standard errors are in parentheses. GDP 1970 coefficient is multiplied by 1000. Labor coefficient is multiplied by 1,000,000. Restrictiveness = -(Actual Trade – Predicted Trade)/Predicted Trade.

The results reported in Table 6, when the percent deviation of predicted trade from actual trade is employed as the restrictiveness measure, maintain that there is a positive, though statistically insignificant, relationship between a higher trade restrictiveness measure and long-run growth. The coefficients imply that a one percentage point increase in the restrictiveness measure corresponds to a 0.0022 to 0.0023 percentage point increase in the long-run per capita growth rate in both the full-sample model and the reduced-sample model. Despite the evidence that indicates a positive relationship between the trade restrictiveness measure and economic growth, this by no means implies that trade restrictions are good for growth. What the results indicate is that while being less restrictive to trade may enhance growth in many countries, integrating into the world economy is by no means such a potent force for growth that countries can substitute less restrictive trade policies for a comprehensive development strategy that incorporates increases in investments in both physical and human capital.

b. Average Annual Growth: 1970-1985

Due to the lack of a consistent, significant relationship between trade openness (trade shares) and trade restrictiveness (policy measure) with long-run economic growth, the time period is shortened to the years 1970 to 1985 to test whether the trade measures have an impact on per capita economic growth over a shorter span of time. Tables 7 – 10 report the results of the regressions using the various trade measures employed in this study. These estimations focus only on the full sample regressions as these provide the most consistent estimates of the variable coefficients.

For the regressions in Table 7, trade openness is measured by the actual trade-to-GDP ratio. The results, as in the previous estimations, show that there is a negative relationship between initial per capita real GDP and the per capita growth rate. A $1000 increase in per capita real GDP is associated with between a 0.03 and 0.04 percentage point reduction in the per capita growth rate; however, the relationship is statistically insignificant. This suggests that the property of conditional convergence is a long-run phenomenon and not a characteristic established for shorter time spans.

Nonetheless, the regression results do continue to confirm that there is a strong positive relationship between the initial measures of human capital (except for column 3), physical capital, and labor. The expansive literature on growth theory has consistently shown that these three variables are important determinants of economic growth and the regressions undertaken in this study confirm those findings. The regressions show that a one year increase in the average years of schooling increases the per capita growth rate by between 0.2 and 0.22 percentage points, a 1,000,000

Table 7: Regressions for per capita Growth 1970 – 1985: Actual Trade Shares

Dependent variable: Average Annual Growth Rate of per Capita Real GDP 1970-1985			
	I	II	III
Constant	-0.016	-0.004	0.042
	(0.538)	(0.547)	(0.546)
GDP 1970	-0.04	-0.04	-0.03
	(0.04)	(0.04)	(0.04)
School 1970	0.219*	---	---
	(0.117)		
School 1965	---	0.224*	---
		(0.127)	
School 1960	---	---	0.205
			(0.131)
Labor	0.06*	0.006*	0.007*
	(0.004)	(0.004)	(0.004)
INV	0.048**	0.049**	0.05**
	(0.0173)	(0.017)	(0.017)
Actual Trade	0.0008	0.0011	0.0013
	(0.007)	(0.007)	(0.007)
Sample Size	112	112	112
Adjusted R-squared	0.119	0.113	0.108
Root MSE	2.16	2.17	2.18

* and ** denote significance at the 10% and 5% level, respectively. Standard errors are in parentheses. GDP 1970 coefficient is multiplied by 1000. Labor coefficient is multiplied by 1,000,000.

person increase in the labor measure increases per capita growth by 0.006 (0.007) percentage points, and a one percentage point increase in the investment-to-GDP ratio increases growth by about 0.05 percentage points. The relationship between the actual trade shares and the 1970-1985 growth rate is positive yet statistically insignificant and demonstrates that a one percentage point increase in the actual trade share will raise the per capita economic growth rate between 0.0008 and 0.0013 percentage points.

Table 8: Regressions for per capita Growth 1970 – 1985: Predicted Trade Shares

Dependent variable: Average Annual Growth Rate of per Capita Real GDP 1970-1985			
	I	II	III
Constant	-0.501	-0.493	-0.461
	(0.543)	(0.552)	(0.552)
GDP 1970	-0.06	-0.06	-0.05
	(0.04)	(0.04)	(0.04)
School 1970	0.226*	---	---
	(0.115)		
School 1965	---	0.236*	---
		(0.13)	
School 1960	---	---	0.225*
			(0.13)
Labor	0.008**	0.008**	0.008**
	(0.004)	(0.004)	(0.004)
INV	0.041**	0.042**	0.043**
	(0.017)	(0.017)	(0.017)
Predicted Trade	0.023*	0.023*	0.023*
	(0.012)	(0.012)	(0.012)
Sample Size	112	112	112
Adjusted R-squared	0.147	0.142	0.138
Root MSE	2.13	2.14	2.14

* and ** denote significance at the 10% and 5% level, respectively. Standard errors are in parentheses. GDP 1970 coefficient is multiplied by 1000. Labor coefficient is multiplied by 1,000,000.

When the predicted trade shares replace the actual trade shares as the measure of openness in Table 8, the results do not change notably. The effects of the initial level of real GDP per capita on the growth rate are negative (between 0.05 and 0.06 percentage points for a $1000 increase in Real GDP per capita) yet remain statistically insignificant since conditional convergence is a property of long-run rather than short-run growth. Moreover, the strong positive relationships between initial human capital[106], physical capital[107], and labor[108] continue to be confirmed by the model. The main difference is that the trade shares constructed from the gravity model predict a strong, positive relationship between trade and economic growth. According to the results, a one percentage point increase in the predicted trade shares will raise per capita economic growth by 0.023 percentage points in each of the three regressions.

In Tables 9 and 10, trade openness is measured with each of the restrictiveness measures constructed in this study. For the regressions is Table 9, as in the previous two estimations of the 1970 - 1985 time period, no evidence is found in supports of conditional convergence in the short run. Both initial human capital and initial physical capital continue to be strong positive determinants of the economic growth rate; increases in initial human capital increase the per capita growth rate by 0.21 - 0.23 percentage points and increases in the initial investment ratio increase the per capita growth rate by 0.051 - 0.054 percentage points.

In each of the regressions for the reduced time period, as previously seen in the full time period sample, there exists a positive relationship between the trade restrictiveness measure and economic growth (0.008 percentage points for each one percentage point increase in the restrictiveness measure) but the relationship continues to be insignificant. The positive relationship is not surprising when it is seen that the top ten countries based on trade restrictiveness (most restrictive) had an average annual growth rate of 1.78% while the bottom ten countries based on trade restrictiveness

[106] Between 0.23 and 0.24 percentage points for each one year increase in the average years of schooling.
[107] Between 0.041 and 0.043 percentage points for each one percentage point increase in the Investment ratio.
[108] 0.008 percentage points for every 1,000,000 person increase in the labor force measure.

(least restrictive) had an average growth rate of 1.36 percent. What is surprising is that all of the estimations using the difference between the actual trade shares and predicted trade shares as the restrictiveness measure are statistically insignificant determinants of economic growth. We can conclude from this that the initial restrictiveness

Table 9: Regressions for per capita Growth 1970 – 1985: Trade Restrictiveness 1

Dependent variable: Average Annual Growth Rate of per Capita Real GDP 1970-1985			
	I	II	III
Constant	0.128	0.145	0.199
	(0.485)	(0.494)	(0.491)
GDP 1970	-0.05	-0.04	-0.04
	(0.04)	(0.04)	(0.04)
School 1970	0.227*	---	---
	(0.116)		
School 1965	---	0.231*	---
		(0.127)	
School 1960	---	---	0.212*
			(0.131)
Labor	0.005	0.005	0.005
	(0.004)	(0.004)	(0.004)
INV	0.051**	0.053**	0.054**
	(0.017)	(0.017)	(0.017)
Trade Restrictiveness 1	0.008	0.008	0.008
	(0.008)	(0.008)	(0.008)
Sample Size	112	112	112
Adjusted R-squared	0.128	0.121	0.116
Root MSE	2.15	2.16	2.17

* and ** denote significance at the 10% and 5% level, respectively. Standard errors are in parentheses. GDP 1970 coefficient is multiplied by 1000. Labor coefficient is multiplied by 1,000,000. Restrictiveness = -(Actual trade share – Predicted trade share)

(or un-restrictiveness) of a country's trade policy does not play a significant role in determining economic growth and that other factors, like human and physical capital, exert a more important influence on economic growth.

The final restrictiveness measure is employed in the regressions reported in Table 10. As noted with the previous estimations, the initial levels of human capital and physical capital are the most important determinants of economic growth. Again, the measure of restrictiveness displays a positive, yet insignificant effect on economic growth. A one percentage point increase in the restrictiveness measure causes a 0.0033 percentage point increase in the average annual growth rate. The ten least

Table 10: Regressions for per capita Growth 1970 – 1985: Trade Restrictiveness 2

Dependent variable: Average Annual Growth Rate of per Capita Real GDP 1970-1985			
	I	II	III
Constant	0.217	0.234	0.288
	(0.49)	(0.50)	(0.494)
GDP 1970	-0.05	-0.05	-0.04
	(0.04)	(0.04)	(0.04)
School 1970	0.226*	---	---
	(0.116)		
School 1965	---	0.233*	---
		(0.13)	
School 1960	---	---	0.217*
			(0.13)
Labor	0.005	0.005	0.005
	(0.004)	(0.004)	(0.004)
INV	0.051**	0.053**	0.054**
	(0.017)	(0.017)	(0.017)
Trade Restrictiveness 2	0.0033	0.0033	0.0033
	(0.223)	(0.225)	(0.226)
Sample Size	112	112	112
Adjusted R-squared	0.136	0.131	0.126
Root MSE	2.14	2.15	2.16

* and ** denote significance at the 10% and 5% level, respectively. Standard errors are in parentheses. GDP 1970 coefficient is multiplied by 1000. Labor coefficient is multiplied by 1,000,000. Restrictiveness = -(Actual trade – Predicted trade)/Predicted trade

restrictive countries had an annual average growth rate between 1970 and 1985 of 1.19% while the ten most restrictive countries experienced an average annual growth rate of 2.19 percent. These results continue to show that the initial starting value for trade restrictions does not play a significant role in determining the economic growth rate and that less restrictive trade policy, on average, reduced economic growth rates.

Concluding Remarks

The present study investigates the relationship between trade openness and economic growth in a cross-section of countries once other growth-causing factors are controlled. Specifically, this study attempts to establish if the level of trade openness in 1970 (the starting year) has any significant effect on the average annual growth rate of per capita real GDP from 1970 - 2006. The framework of this study follows the methods developed by Barro (1991), Easterly and Levine (1997), and Sachs (1997). The average annual growth rate is regressed on the initial, 1970 level of real GDP per capita, the 1970 (and 5 year lagged) levels of human capital, the 1970 investment-to-GDP ratio (as a proxy for capital formation), the 1970 adult population (as a proxy for the labor force and scale effects), and the measures of trade openness and trade restrictiveness.

The measure of trade policy restrictiveness constructed for this study follows the methods of Leamer (1988) in which trade restrictiveness is measured as the difference between the actual level of trade and the level of trade predicted in a model without trade barriers. The construction of the restrictiveness measure requires that trade barriers (which have proven difficult to measure objectively and accurately) are uncorrelated with the variables in the model of predicted trade and that trade barriers are the only important omitted variable in the predicted trade model. This study employs a gravity model of trade to construct the predicted trade shares. In the gravity model, the level of bilateral trade between two countries depends on the distance between them, their size (area and population), their latitudes, tropical exposure, and past historical and cultural connections. The gravity model predicts a level of trade based on these characteristics in the absence of any trade barriers or trade policies.

Two trade restrictiveness measures for 1970 are constructed: 1) trade restrictiveness is measured as the difference between a country's actual trade-to-GDP ratio and the trade shares predicted by the gravity model and 2) trade restrictiveness is measured as the percentage deviation of the predicted trade shares from the actual trade shares. For each of these measures, a higher value indicates that a country has adopted more restrictive trade policies and is less open to trade. These two trade restrictiveness measures should be highly correlated with trade barriers and trade policy since the level of predicted trade removes the amount of trade that is determined by a country's geography as well as their cultural and historical connections to their trading partners. The remaining, residual, trade must then be the amount of trade determined by trade policies.

This study tests the relationship between trade openness and trade restrictiveness and average per capita economic growth using four measures of openness: 1) the actual trade shares (exports + imports divided by GDP), 2) the predicted trade shares from the gravity model, 3) the difference between actual and predicted trade, and 4) the percentage deviation of predicted trade from actual trade. While the main focus of this study is to test the relationships between the restrictiveness measures and per capita economic growth, this paper also tests for evidence of conditional convergence. That is, once other factors are controlled for, do poorer countries tend to grow faster than the more developed countries over time? Conditional convergence can be established if there is a significant, negative relationship between the initial level of real GDP per capita and the average annual growth rate in the country. Furthermore, this paper attempts to confirm that human capital, physical capital, and labor are all important determinants of long-run growth as has been documented in the literature on economic growth.

The model estimation was broken into two separate time frames. First, the full time frame (1970 - 2006) was estimated to determine what effects each of the variables have on long-run economic growth. Then, as an additional test, a smaller time frame (1970 - 1985) was tested to see if the variables in the model had any significant impact on economic growth in a smaller time sample. The results of the full time frame estimations generally confirm the conditional convergence hypothesis[109]; the results show a significant, negative effect of initial real GDP per capita on long-run economic growth with the effect ranging from a reduction in the growth rate of between 0.05 to 0.08 percentage points for a $1000 increase in Real GDP per capita. Moreover, the results confirm that initial human capital, labor, and physical capital are all important determinants of long-run economic growth.

The most interesting results, though, occur when the various measures of trade are included in the model. The actual trade shares show a positive, yet statistically insignificant effect on long-run economic growth. The predicted trade shares indicate that there is a significantly positive relationship between economic growth and higher trade share values. This further confirms the findings of Frankel and Romer (1999) that the predicted trade shares from the gravity model consistently indicate a stronger relationship with economic growth than the actual trade shares. Both of the restrictiveness measures, on the other hand, indicate that there is a positive, yet insignificant relationship between more restrictive trade policies and economic growth. These results run counter to much of the accepted theory of the effects of trade on

[109] This finding is not present in the reduced time sample estimate, indicating that conditional convergence is a long-run growth characteristic.

growth except for the studies that have shown that the relationship between openness and growth is tenuous at best but for the most part non-existent.[110]

However, just because the results yield a positive relationship between the trade measures and long run growth, this does not imply that trade restrictions are beneficial or required for a country to grow. What the results indicate is that while freer trade policies and higher trade levels can have positive impacts on growth in many instances, opening to trade is not an instantaneous growth generator and that the effects of more liberal trade policies may take many years to be fully realized. What is more, for the most part, other factors (human and physical capital, labor) have been more important determinants of long-run economic growth than trade levels or trade policies. This failure to find the significant, positive relationship between trade policies and economic growth as held by the literature is more a failing in the measurement of trade policy and trade restrictions, than it is a failure of theory to provide adequate answers to the main causes of growth.

As an extension of this study, it may be useful to break the time periods into decades (1970s, 1980s, etc.) and examine if the level of openness and the policy measures at the beginning of each decade had a significant effect on growth over the ensuing ten years. Moreover, an attempt can be made to test the relationship between trade openness and economic growth for the different geographic (or income) groups of countries. Has trade had a larger impact on growth in East Asia versus Latin America or Sub-Saharan Africa? Is trade openness and less restrictive trade policy a more important determinant of growth for the developed nations, the emerging economies, or

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[110] Krugman (1994), Rodriguez and Rodrik (2001)

the developing world? Is there a difference when these individual country groups are estimated?

When using the trade restrictiveness measure developed in this paper a concern is that the measure may be endogenous to per capita growth since the restrictiveness measure is attempting to capture trade that is determined by trade policy. Because the trade restrictiveness measure may be endogenous to growth an attempt should be made to test for and control for the endogeneity to generate unbiased estimations. Finally, there will always be questions and problems with the validity of any cross-sectional studies of economic growth, so an effort should be made to develop the trade restrictiveness measures in a time series framework to estimate the dynamic effects that changes in trade policy have on economic growth as the economies of the world continually evolve.

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APPENDIX A

Variable Definitions and Sources

Bilateral Trade. The volume of trade between two countries measured as the total exports from country i to country j plus the total exports from country j to country i. Source: Correlates of War Project Trade Data Set Codebook, Version 2.0.

Trade Share. The total volume of trade (exports plus imports) divided by GDP. Source: World Development Indicators Data Set.

Distance. The distance between two countries measured in square kilometers. Various measures of distance are used. Source: CEPII Bilateral Data Set.

Area. The land area of a country measured in square kilometers. Source: Center for International Development Geographic Data Set.

Population. Total 1985 population. Source: Penn World Tables 7.0.

Landlocked. A dummy variable that equals 1 if a country is landlocked.

Common Border. A dummy variable that equals 1 if two countries share a common border. Source: CEPII Bilateral Data Set.

Real GDP per capita. Real GDP measured at constant 2005 prices divided by 1985 total population. Source: ERS International Macroeconomic Data Set.

Latitude. A country's average(center) latitude. Source: Center for International Development Geographic Data Set.

Tropical Exposure. The percentage of a country's population that resides in the tropical zone. Source: Center for International Development Geographic Data Set.

Island. A dummy variable that equals 1 if a country is an island.

Common Colonizer. A dummy variable that equals 1 if two countries in a trading pair were previously colonized by the same mother country. Source: CEPII Bilateral Data Set.

Colony. A dummy variable that equals 1 if one country ever colonized another country in a trading pair. Source: CEPII Bilateral Data Set.

Language. A dummy variable that equals 1 if two countries in a trading pair share a common official or major language. Source: CEPII Bilateral Data Set.

Cultural Similarity. A dummy variable that equals 1 if two countries in a trading pair share a common dominant religion.

APPENDIX B

Variable Definitions and Sources

Real GDP. Annual Real GDP from 1970 – 2006 measured at constant 2005 prices. GDP for each country was reported in current U.S. dollars. Real GDP was obtained by deflating the current value by the U.S. GDP deflator price level (base year = 2005). Source: OECD country statistical profiles.

Real Capital Stock. Physical capital stock from 1970 – 2006 measured at constant 2005 prices. The physical capital stock = (Investment-to-GDP ratio)*GDP. The physical capital stock was deflated with the U.S. GDP deflator price level (base year = 2005) to obtain the real value. Source: OECD country statistical profiles.

Human Capital Stock. Human capital is measured as the total average years of schooling (primary, secondary, and tertiary) for the population 25 years and older from 1970 – 2006. Source: A new data set of educational attainment in the world, 1950-2010. Barro and Lee (2010).

Labor force. Total labor force of the economy from 1970 – 2006. Source: OECD country statistical profiles.

Real Exports. Total exports of goods are measured at current U.S. prices from 1970 - 2006 and deflated by the GDP deflator price level to obtain the real value. Source: OECD country statistical profiles.

Real Imports. Total imports of goods are measured at current U.S. prices from 1970 – 2006 and deflated by the GDP deflator price level to obtain the real value. Source: OECD country statistical profiles.

APPENDIX C

Variable Definitions and Sources

Average Annual Growth Rate of Real GDP per capita. Average per capita growth rates from 1970 – 2006 and from 1970 – 1985 measured at U.S. constant 2005 prices. Source: ERS International Macroeconomic Data Set.

Real GDP 1970. The value of Real GDP in 1970 measured at U.S. constant 2005 prices. Source: ERS International Macroeconomic Data Set.

Human Capital Stock. Human capital is measured as the total average years of schooling (primary, secondary, and tertiary) for the population 25 years and older in 1960, 1965, and 1970. Source: A new data set of educational attainment in the world, 1950-2010. Barro and Lee (2010).

Investment-to-GDP ratio 1970. A measure of physical capital equal to the level of investments in 1970 divided by Real GDP per capita in 1970 measured at U.S. constant 2005 prices. Source: Penn World Tables 7.0.

Capital per worker 1970. An alternative measure of physical capital. Equal to the capital stock divided by the working-age population. Source: Easterly and Levine (2001).

Labor 1970. The labor force of each country for 1970 is proxied by the total population 15 years of age and older. Source: A new data set of educational attainment in the world, 1950-2010. Barro and Lee (2010).

Actual Trade Shares 1970. The total volume of trade (exports plus imports) divided by GDP. Source: World Development Indicators Data Set.

Trade Restrictiveness. A measure of the level of trade determined by a country's trade policies. Two measures of restrictiveness are constructed: 1) Trade Restrictiveness equals the inverse of the actual trade shares minus the trade shares predicted from a gravity model of trade; 2) Trade Restrictiveness equals the inverse of the actual trade shares minus the trade shares predicted from a gravity model of trade all divided by the predicted trade shares.

Distance. The distance between the most populous cities of two countries measured in square kilometers. Source: CEPII Bilateral Data Set.

Area. The land area of a country measured in square kilometers. Source: Center for International Development Geographic Data Set.

Population. Total 1970 population. Source: Penn World Tables 7.0.

Landlocked. A dummy variable that equals 1 if a country is landlocked.

Common Border. A dummy variable that equals 1 if two countries share a common border. Source: CEPII Bilateral Data Set.

Latitude. A country's average (center) latitude. Source: Center for International Development Geographic Data Set.

Tropical Exposure. The percentage of a country's land area in the tropical zone. Source: Center for International Development Geographic Data Set.

Island. A dummy variable that equals 1 if a country is an island.

Common Colonizer. A dummy variable that equals 1 if two countries in a trading pair were previously colonized by the same mother country. Source: CEPII Bilateral Data Set.

Colony. A dummy variable that equals 1 if one country ever colonized another country in a trading pair. Source: CEPII Bilateral Data Set.

Language. A dummy variable that equals 1 if two countries in a trading pair share a common official or major language. Source: CEPII Bilateral Data Set.

Cultural Similarity. A dummy variable that equals 1 if two countries in a trading pair share a common dominant religion.