Increased Cocoa Bean Exports under Trade Liberalization: A Gravity Model Approach

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Abstract
Gravity models were developed to estimate the potential bilateral exports of cocoa under trade liberalization by the sixteen major cocoa producing countries to the US using panel data from 1989 to 2003. The results indicate that differences between resource endowment, relative size of economies, and the sum of bilateral GDP of U.S. and exporting countries are the major determinants. Thus, as trade is liberalized, farmers share of the world price of cocoa increases and this raises exports.

Background
World cocoa exports from producing countries to the United States (U.S.) nearly doubled from 1989 to 2003. Causes for this increase can to some extent be attributed to changes in production practices and biotechnology, and increases in and changes in consumer demand. For instance, the introduction of a full-sun, high-yielding variety of cocoa to Indonesia and improved infrastructure there has led it to become a fixture in the top 5 cocoa bean exporters list (Franzen and Mulder 2007). In addition, consumer demand for chocolate increased along with exports at this time, despite demand inelasticity (Gilbert and Varangis 2003). One reason for this is a plethora of studies published showing the positive health effects from the consumption of dark chocolate (rich in antioxidant flavanols). These benefits include lower rates of heart disease, lower blood pressure, reduced rates of atherosclerosis, reduced risk of colon cancer, slower aging and reduced rates of diabetes (Carnésecchi and Schneidera, et al, 2001; Engler and Engler 2004; Fisher and Hughes, et al, 2004, and so on).

But market liberalization has been the major driving force. Market liberalization resulted in fewer taxes on producers and reductions in marketing costs (Gilbert and Varangis 2003). Commodity market liberalization in the Less Economically Developed
Countries (LEDCC) since the early 1980s resulted from changes in export commodity markets, shocks associated with price declines, and changing views on the role of government. Government-run national markets have been opened up to foreign competition, and pricing in each country converged more than in pre-liberalization years. Liberalization is done by eliminating government marketing agencies and administered prices, reducing taxes on cocoa, and privatizing government-owned assets (Gilbert and Varangis 2003). These countries became members within its first 13 months when the General Agreement and Tariffs and Trade (GATT) became the World Trade Organization after the Uruguay Round of negotiations. This paper therefore, applies gravity equations to bilateral trade factors to estimate the cocoa trade potential between U.S. and sixteen major exporting countries from 1989 to 2003.

The Generalized Gravity Framework

Originally inspired by Newton’s gravity equation in physics, the gravity model has become common knowledge in regional science for describing and analyzing spatial flows. Anderson (1979) was the first to draw linkages to economic theory and was pioneered in the analysis of international trade by Tinbergen (1962); Pöyhön (1963); and Linneman (1966). The generalized framework Anderson developed incorporates the Armington assumption that goods produced by different countries are inherently imperfect substitutes by virtue of their provenance. This framework assumes Cobb-Douglas expenditure system. Under the assumption of monopolistic competition, each country is assumed to specialize in different products and to have identical homothetic preferences. Zero balance of trade is also assumed to hold in each period. Then the equilibrium trade flow from country $i$ to $j$ ($X_{ij}^*$) at any time period $t$ can be expressed as:
\[ X_{ij}^* = \theta Y_j \]

(1) or

\[ \theta_i = \frac{X_{ij}}{Y_j} \]

where \( \theta_i \) denotes the fraction of income spent on country \( i \)'s products (the fraction is identical across importers) and \( Y_j \) denotes real GDP in importing country \( j \). Since production in country \( i \) must be equal to the sum of exports and domestic consumption of goods, country \( i \)'s GDP is expressed as follows:

\[ Y_i = \sum X_{ij}^* = \sum \theta_j Y_j = \theta_i \left( \sum Y_j \right) \]

(2) or

\[ \theta_i = \frac{Y_i}{\left( \sum Y_j \right)} = \frac{Y_i}{Y_w} \]

Where \( \sum Y_j = Y_w \) is world real GDP, which is constant across country pairs. Equating equation (1) and (2) and rearranging yields:

\[ X_{ij}^* = \frac{Y_i Y_j}{\left( \sum Y_j \right)} \left( \frac{Y_j}{Y_w} \right) \]

(3)

Therefore, this simple gravity equation relies only upon the adding-up constraints of a Cobb-Douglas expenditure system with identical homothetic preferences and the specialization of each country in one good. The basic empirical gravity equation is obtained by taking a natural logarithm of both sides of (3) as follows:

\[ \ln X_{ij}^* = \alpha + \beta \ln Y_i + \gamma \ln Y_j + \Phi \ln T_{ij} \]

(4)

where \( \alpha = (-\ln Y_w) \), and \( T_{ij} \) is a vector of time-invariant variables such as distance and border effects. Because, in reality, countries do not have identical and homothetic taste,
the coefficients should not be unity, but are not significantly different from unity in
aggregate level trade (Anderson 1979).

**Model Specification of Gravity Models**

More recently, the application of gravity models has enjoyed a big revival. However, this has not so much been driven by its more rigorous theoretical foundation
(Anderson, 1979; Bergstrand, 1985, 1989, and 1990; Helpman and Krugman, 1985; and
Helpman, 1987; and so on) but the opportunity to project bilateral trade relations
(Hamilton and Winters, 1992; Baldwin, 1994). According to the traditional concept of
the gravity equation, bilateral trade can be explained by GDP and GDP per capita figures
and both trade impediment (distance) and preference factors (common border, common
language, etc.). The economic framework in most cases was cross-section analysis
(Wang and Winters, 1991; Hamilton and Winters, 1992; Brulhart and Kelly, 1999; and
Nilsson, 2000; and so on). Only a few authors made use of (random effects) panel
econometric methods (Baldwin, 1994; Gros and Gonciarz, 1996; Mátyás, 1997; and
econometric specification without dealing with the issue of trading potentials.

According to the endowment-based new trade model with Dixit and Stiglitz
(1977) preferences, bilateral trade is an increasing sum of factor income $G$, relative size
$S$, and the difference in relative factor endowments $R$. Additionally, bilateral trade is
affected by more traditional measures of transportation cost which is represented by
distance $D_{ij}$. $AL_{ij}$ quantifies exporter-to-importer land/labor ratios and lastly, the real
bilateral exchange rate $E_{ijt}$. $AL_{jit}$ was included in the model to capture the land resource
base. Like all primary products, cocoa uses land more intensively than labor.
Accordingly, bilateral trade can be estimated by:

(5) \[ Y_{ijt} = \beta_0 + \beta_1G_{it} + \beta_2S_{ijt} + \beta_3R_{ijt} + \beta_4AL_{ijt} + \beta_5E_{ijt} + \varepsilon_{ijt} \]

where all variables are in real figures and expressed in natural logs, and the error term can be written as

(6) \[ \varepsilon_{ijt} = u_{ij} + w_{ijt} \]

with \( u_{ij} \) as the (one-way fixed or random) unobserved bilateral effect and \( w_{ijt} \) as the remaining residual error. Using the Helpman (1987) model, the Heckscher-Ohlin bilateral trade determinants can be formulated in the following way:

(7) \[ G_{it} = \log \left( GDP_{it} + GDP_{jt} \right) \]

(8) \[ s_{ijt} = \frac{GDP_{jt}}{GDP_{it}} \]

(9) \[ R_{ijt} = \left| \ln \left( \frac{GDP_{it}}{N_a} \right) - \ln \left( \frac{GDP_{jt}}{N_j} \right) \right| \]

(10) \[ AL_{ijt} = \frac{\text{Land}_{it}}{\text{Labor}_{jt}} \]

where, N denotes a country’s population and GDP per capita is commonly used as a proxy for a country’s capital-labor ratio.

For the panel econometric projection of potential bilateral trade, researchers have concentrated on random effects model (REM), which requires that \( u_{ij} \sim (0, \sigma_u^2) \), \( w_{ijt} \sim (0, \sigma_v^2) \), and the \( u_{ij} \) are independent of the \( w_{ijt} \). Moreover, the \( X_{ijt} \) (i.e. the explanatory variables) have to be independent of the \( u_{ij} \) and \( w_{ijt} \) for all cross-sections \((ij)\) and time periods \((t)\). Whereas the fixed effects model (FEM) is always consistent in the absence of
endogeneity or errors in variables, the REM is only consistent if the above-mentioned orthogonality conditions are fulfilled. Then, the REM has the advantage of more efficiency as compared to the FEM. If these conditions do not hold, only the FEM is consistent since it wipes out all the time-invariant effects ($u_{ij}$). The decision between FEM and REM can be based on the Hausman (1978) test.

**Data and Estimation Procedures**

The gravity model is applied using panel data for the period 1989 to 2003 for the export of cocoa beans to the U.S. from 16 (11 Latin American, 3 West African, and 2 Asian) cocoa exporting countries. In this analysis, several variations across individual country are analyzed in the one-way FEM, the one-way REM, and two-way FEM as well as Pooled O.L.S. to see whether individual country’s effects are as fixed or randomly distributed across cross-sectional units. The dependent variable, real value of cocoa exports to U.S. was regressed on factor income $G_{ijt}$, relative $S_{ijt}$, the difference in relative factor endowments $R_{ijt}$, distance $D_{ij}$, land-labor ratio $AL_{ijt}$ and the real bilateral exchange rate $E_{ijt}$. Other observable determinants impeding or inducing bilateral trade include 1) common borders ($CB_{ij}$), a dummy variable which equals 1 when $i$ and $j$ share a contiguous border and 0 otherwise; 2) language similarity ($LS_{ij}$), a dummy variable which equals 1 whenever nine percent or more of the population in both countries share a common language and 0 otherwise; 3) colonial heritage ($CH_{ij}$), a dummy variable which equals 1 if two countries have established colonial ties since 1945 and 0 otherwise.

Since the individual country’s effects were included, there was a need to decide whether these effects should be treated as fixed or random. The Hausman test was conducted to examine the model that was most efficient. The other observable
determinants impeding or inducing bilateral trade were dropped out in the final models together with distance as they are all time-invariant variables. Already, the number of the cross-sectional units exceeds that of the time series therefore, the introduction of such variables significantly reduces the predicting power of the model.

Data on cocoa exports are from U.S. International Trade Center Interactive Tariff and Trade DataWeb (http://dataweb.usitc.gov/). Exchange rate of each country’s currency to the U.S. dollar was obtained from the USDA Economic Research International Data Sets (http://www.ers.usda.gov/data/macroeconomics/). The distances, measured in nautical miles were obtained using the World News Network’s World Ports Distances Calculator. Real GDP and population data for each country were obtained from IMF World Economic Outlook Database for April 2007 (http://www.imf.org/external/pubs/ft/weo/2007/01/data/index.aspx). Information about arable land and labor came from the United Nations, Food and Agricultural Organization’s FAOSTAT ResourceSTAT and ProdSTAT databases (http://faostat.fao.org/site/348/default.aspx).

The descriptive statistics of the variables in the model are presented in Table 1 while Table 2 presents the estimation results for the two-way fixed effect panel estimator. According to the test statistics we cannot ignore the cyclic and cross-sectional effects as the F-test for the two-way FEM is significant at (P < 0.0001) with R^2 of 0.85. Thus, the probability that there are no effects in the model is 0.

Also, the intercepts of all the first fourteen years (i.e. 1989 to 2002) are all positive and significant relative to 2003. This informs us that export trend is positive and significant as depicted in Figure 1.
The coefficients of sum of factor income and resource factor endowment differences are all positive and statistically significant at \((p < 0.0001)\) and \((p < 0.0088)\). Thus, the larger the per capita GDP difference between U.S. and a cocoa exporting country, the larger the exports. The income of exporting countries represents the country’s production capacity, and the income of importing countries represents the country’s purchasing power, both of which are positively related to trade flows. A higher level of income in the exporting country indicates a high level of production of which increases the availability of products for export, while a high level of income in the importing country suggests higher imports. The elasticity of 7.6\% implies a 1\% change in the sum of bilateral trade GDP will change exports by 7.6\% or $2.5\text{million}.

Our empirical result -- with positive coefficients for relative factor endowment differences lends to support the H-O explanation of trade. Heckscher-Ohlin (H-O) theory leads one to expect that cocoa trade would be positively related to the exporter-to-importer per capita GDP differences. Cocoa production is relatively land-intensive but the harvesting and through shipping to the ports are highly labor intensive. The elasticity of 0.562 implies a 1 percent change in the level of resource endowment differences will raise imports by about 0.56 percent or $0.201 million.

The relative size of the economies is also statistically significant with a consistent sign. The negative sign of the coefficient implies that the smaller the size of a cocoa exporting economy relative to that of U.S., the larger the volume of exports to the latter. The elasticity of 2.007 informs us that 1 percent decrease in the GDP ratio increases exports of cocoa beans to the U.S. by about 2 percent or $0.67 million.
Exchange rates and the exporter-importer land-to-labor ratios variables are however, not significant. These are not surprising results especially with respect to exchange rates, these countries are developing and most developing countries practice managed exchange rates. With regard to land-labor ratios, cocoa production, though very land-intensive, labor expenses from harvesting, drying, bagging, and hauling to the nearest purchasing agency are extremely labor-intensive. Therefore, the resource endowment differences variable, which is measured as differences in per capita income or GDP-to employment ratio, dwarfs this variable.

Conclusions

Economic theory informs us that at the individual country level, border relaxation reduces domestic prices that help local consumers and increases the profit for low-cost exporters through increased sales in the foreign market. At the global level, free trade causes demand and supply to expand, both of which improve price signals and improves world welfare.

Theory also teaches us that there are many other socio-economic and political-institutional determinants of cross-border trade, including market size, resource endowments, geographical proximity, tastes and preferences, cultural ties, and financial linkages. This paper used the two-way fixed effect panel estimation to determine the influence of the various factors driving the volume of U.S. imports from major cocoa exporting countries.

One noteworthy finding is that the relative factor endowment differences matters. The per capita difference between the importer and exporter was positive and statistically significant. By contrast, the exchange rate relative to the U.S. dollar does not matter. But
as producers’ share of world price of cocoa through trade liberalization grows, production increase and the volume of export rises. Another important finding was that as the GDP of the U.S. grows relative to that of a cocoa exporting country the volume of exports into former increases.
References


<table>
<thead>
<tr>
<th>Variable</th>
<th>Units</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of Exports</td>
<td>Actual $</td>
<td>33522927</td>
<td>59761580</td>
<td>0</td>
<td>344179130</td>
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<tr>
<td>Population of U.S.</td>
<td>Millions</td>
<td>269.485</td>
<td>13.73994</td>
<td>247.286</td>
<td>291.194</td>
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<tr>
<td>Bilateral Trade GDP</td>
<td>Billion $</td>
<td>8.978</td>
<td>0.222097</td>
<td>8.610</td>
<td>9.359</td>
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<tr>
<td>Differences in Endowment</td>
<td>Ratio</td>
<td>28.585</td>
<td>5.143</td>
<td>18.541</td>
<td>37.534</td>
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<tr>
<td>Land-Labor</td>
<td>Ratio</td>
<td>51.498</td>
<td>35.422</td>
<td>13.041</td>
<td>147.847</td>
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<tr>
<td>Exchange Rate</td>
<td>Ratio</td>
<td>2.951</td>
<td>7.056</td>
<td>-9.681</td>
<td>18.941</td>
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Table 2: Results of the Two-Way Fixed Effect Panel Estimation Procedure

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Standard Error</th>
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<td>Intercept</td>
<td>-7.3301***</td>
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<tr>
<td>Exchange Rate</td>
<td>-0.0974</td>
<td>0.2141</td>
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<tr>
<td>Bilateral Trade GDP</td>
<td>7.6988***</td>
<td>1.9423</td>
</tr>
<tr>
<td>Differences in Endowment</td>
<td>0.5623***</td>
<td>0.2123</td>
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<tr>
<td>Size of the Economy</td>
<td>-2.0079***</td>
<td>0.6576</td>
</tr>
<tr>
<td>Land – Laborer Ratio</td>
<td>-0.0654</td>
<td>0.0581</td>
</tr>
<tr>
<td>Brazil</td>
<td>18.18804***</td>
<td>5.9885</td>
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<tr>
<td>Costa Rica</td>
<td>-7.39335***</td>
<td>1.5676</td>
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<tr>
<td>Cote d’Ivoire</td>
<td>1.64011</td>
<td>1.2156</td>
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<tr>
<td>Dominican Republic</td>
<td>-1.25447</td>
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<td>Ecuador</td>
<td>-0.50496</td>
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<td>Ghana</td>
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<td>Haiti</td>
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<td>Indonesia</td>
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<td>Jamaica</td>
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<td>St. Lucia</td>
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<td>Trinidad and Tobago</td>
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<td>$R^2$</td>
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$F(29, 186)$ Test for No Fixed Effects: 25.69, P < 0.0001

*** Indicates significance at 1% confidence level
** Indicates significance at 5% confidence level
Figure 1: Aggregated Cocoa Bean Exports to the U.S. from Selected Countries (1989-2003)