IMPORT DEMAND, FOOD SAFETY, AND PRICE TRANSMISSION: A STUDY OF THE INTERNATIONAL COCOA SECTOR

By

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To God and my family

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TABLE OF CONTENTS

LIST OF TABLES

Table page

LIST OF FIGURES

Abstract of Dissertation Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Doctor of Philosophy

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Cocoa plays an important role in the economic development of major cocoa producing and exporting countries and in the livelihoods of smallholder cocoa farmers; hence it is important to investigate the current issues related to the cocoa sector and come up with remedies to these issues. Our first objective is to determine the best pricing strategies that will increase cocoa exporters' revenues from the marketing of cocoa products. Therefore, we investigate the United States (U.S.) import demand for cocoa products using four demand models: the Rotterdam; AIDS; CBS; and NBR. Expenditure elasticities indicate that as U.S. total expenditure on cocoa beans increases, the U.S. quantity demanded for cocoa beans increases by 1.35% for Ecuador, 1.18% for Cote d'Ivoire, and 0.91% for Indonesia. Also, expenditure elasticities are inelastic for Canada (.62) and Germany (.61). The Slutsky and Cournot own-prices of cocoa beans are elastic and significant for Cote d'Ivoire and the rest of the world, while those of chocolate are elastic for Germany. In the second essay, we investigate the impacts of the maximum residue limit of two pesticides, benalaxyl and pyrethrins, on cocoa exports between importing countries and producing countries of

cocoa beans, and we examine the effects of colonial ties and free-trade agreements between them. Pyrethrins and benalaxyl pesticides are used for the treatment of cocoa in storage and for the treatment of black pod disease present in cocoa, respectively. We find that the regulated maximum residue level (MRL) of benalaxyl has a positive effect on the traded volume of cocoa beans, while the regulated MRL of pyrethrin has a negative effect. In the third essay, we examine the impacts of policy reforms on the transmission of world prices of cocoa beans to domestic prices in major cocoa producing countries as well as the impacts of the imposition of a value added tax (VAT) in the cocoa sector on Indonesia's cocoa exports. Results indicate that world prices are better transmitted to domestic prices after the reforms, meaning that the policy reforms are effective in better integrating the domestic cocoa market with the world market. Also, the imposition of a VAT did not have a significant effect on Indonesia's cocoa exports.

CHAPTER 1
INTRODUCTION

Importance of Cocoa Crops

Cocoa tree was given the name “Theobroma cocoa” in the Greek language by a Swedish botanist in the 18th century. Cocoa trees come from “neotropical rainforests” located in the Amazon basin and Guyana Plateau. They are as high as 25 meters (m) in height and look similar to cauliflorous plants. The fruit of cocoa trees, called pod, encloses 30 to 60 seeds inside them. Once the seeds are fermented and dried, they turn into beans that are processed to obtain different forms of cocoa products. About 400 to 2500 plants of cocoa per hectare are planted, which grow under shade and yield on average 200 to 800 kilograms (kg) of beans (Wood and Lass, 1985).

Cocoa bean plays a crucial role in the economic development of major cocoa producing and exporting countries (e.g. Cote d’Ivoire, Ghana, Nigeria, Cameroon, and Indonesia). In fact, cocoa is the largest agricultural export crop in some African countries, particularly in Cote d’Ivoire and Ghana. Exports of cocoa generate an important source of revenue for these countries. For instance, over the period 2000 through 2009, Cote d’Ivoire and Ghana, the two major exporters of cocoa, generated earnings from cocoa exports accounting for 31% and 30% of total exports value, respectively (FAO, 2012). Cocoa was the second export commodity, after gold, to generate high revenues (US$ 2.2 billion) to the Ghanaian nation in 2010(ICCO, 2012). Similarly, cocoa has been the leading export-earning commodity in Cote d’Ivoire (except in 2005 where earnings from crude oil and petroleum surpassed those of cocoa), generating revenues of US$ 3.7 billion and US$ 3.8 billion in 2009 and 2010, respectively (ICCO, 2012).

Furthermore, cocoa is a good source of rural employment in that it is essential to the livelihoods of 40-50 million people worldwide, including over 5 million smallholder cocoa farmers who grow this valuable crop (World Cocoa Foundation, 2012). The other 35-45 million people are small traders, wholesalers, exporters, and processors of cocoa. African countries account for 77% of World production from 2006/07 to 2010/11, with Cote d'Ivoire, Ghana, Cameroon and Nigeria making the top four producing countries in Africa. Next, Asia and Oceania represent 16% of world production with Indonesia, Malaysia and Papua New Guinea being the largest producers. Finally, the Americas make up 7% with Brazil and Ecuador being the largest exporters (World Cocoa Foundation, 2012).

Cocoa Value Chain

The marketing channel of cocoa beans occurs in several ways. One way is that developing country cocoa farmers sell their cocoa beans to small traders and these traders sell the beans to wholesalers who in turn sell them to exporters (Figure 1-1; the dashed line in Figure 1-1 indicates less important links). This marketing channel applies to many African producing countries of cocoa. A second way is that farmers sell the beans directly, or via farmers' cooperatives, to exporters (ICCO, 2013; Gilbert, 2006). Additionally, in some case, farmers sell their beans directly to multinational converters, but sell less to domestic converters (because there are few domestic converters). Multinational converters or local companies (e.g., Barry Callebaut, Archer Daniels Midland (ADM), Cargill, Nestlé), which are controlled by converters, account for the biggest exporters in several cocoa-producing countries. Once exported to Europe and North America, which are the major cocoa importers and the biggest multinational converters, cocoa beans are processed (also known as converted or grinded) into two major products, cocoa butter and cocoa powder. Cocoa butter is mainly destined for chocolate preparation, and it is predominantly shipped to large and small chocolate manufacturers. Cocoa powder is mainly used in the confectionary industry. However, these two products can be blended together to obtain chocolate, incorporating other inputs such as milk and sugar. Chocolate is sold at supermarkets and specialist retail outlets.

Objectives of the Study

This dissertation includes three empirical essays on import demand, food safety, and price transmission relative to the cocoa sector. In the first essay, our objective is to investigate the United States (U.S.) import demand for cocoa products. In fact, we estimate U.S. income and price elasticities of import demand for cocoa beans and chocolate by country of origin. Results of this study are helpful to cocoa bean and chocolate producers in making strategic pricing decisions that will increase revenues from the marketing of cocoa products.

In the second essay, our objective consists of analyzing the impacts of food safety standards, particularly the impacts of the maximum residue levels of (MRLs) of benalaxyl and pyrethrins on the exports of cocoa beans between developed importing countries and developing producing countries of cocoa beans. Pyrethrin is a type of pesticide used for the treatment of cocoa in storage, and benalaxyl is a type of fungicide used for the treatment of black pod disease present in cocoa. Also, we examine the effects of trading partners' GDPs, population, distance, colonial ties and free-trade agreements between trading partners on the export of cocoa beans. The findings of this essay are useful in providing information to analyze food safety concerns relative to trade of cocoa beans and in adding to the discussion of the remedies to these concerns.

In the third essay, we have two objectives. Our first objective is to examine empirically whether the policy reforms have been effective in getting cocoa producer's prices close to world prices. We then discuss the implication of effectiveness or non-effectiveness of these market reforms, particularly in terms of inputs into policy making. Our second objective is to examine the effects of the imposition of a value added tax (VAT) on Indonesia's cocoa exports on the transmission of world prices to producers' prices in Indonesia. The latter objective is important in that results could be useful to infer some policy measures for the Indonesia government, but also could be expanded to other major cocoa producing countries (e.g., West African countries), where export taxes have been imposed for decades.

Because of the importance of cocoa in the livelihoods of many people (40-50 million people), particularly in the livelihoods of smallholder cocoa farmers, in the economic development of cocoa producing and exporting countries, and because tremendous trades in cocoa have developed over the years, it is essential to discuss these objectives, which respond to three important concerns that arise in the cocoa market. We hope to infer some policy measures and possibly provide strategies to improve this market and implicitly improve cocoa producers' and exporters' welfare.

The first concern applies to cocoa producers who, alike any producer, look for ways to maximize their profits. The second concern involves cocoa producers and cocoa exporters, who face obstacles (e.g., financial obstacles) in meeting food safety standards imposed by developed countries importers of cocoa beans, which could affect cocoa exports. The third concern is that cocoa farmers have demonstrated unhappiness, over the past decades, about the prices of cocoa they received from buyers. In fact, cocoa beans' prices were at low levels in the late 1980s and early 1990s. To improve these prices, different policy reforms were gradually developed over the years. Hence, we are interested about analyzing whether or not these policies were effective.

The paper is organized as follow. Chapter 2 discusses the U.S. import demand for cocoa products. Chapter 3 covers the impacts of pesticide residue limits on cocoa exports. Chapter 4 analyzes the transmission of world prices to domestic prices, and Chapter 5 concludes the paper.

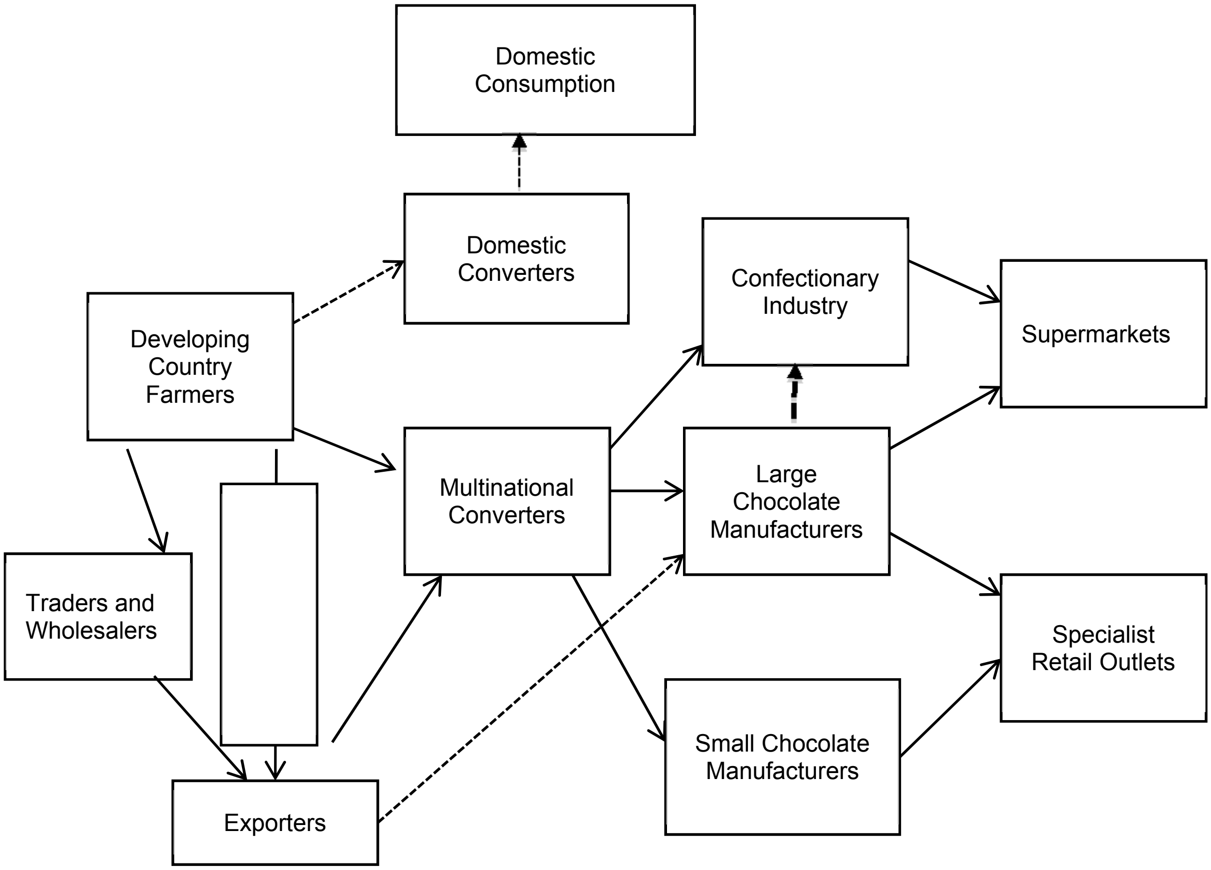

Figure 1-1. Cocoa supply chain (Source: Gilbert, 2001)

CHAPTER 2
U.S. IMPORTS DEMAND FOR COCOA PRODUCTS BY COUNTRY OF ORIGIN

Introduction to the Chapter

The latest data (from 2005/06 to 2010/11) on net imports of cocoa indicate that European nations account for 58% of net imports of cocoa, followed by the Americas with 27%, and Asia and Africa denoting 14% and 2%, respectively (ICCO, 2012). Also, the International Cocoa Organization (ICCO) reports in 2010/2011 that Europe represents the world largest consuming continent with 48% of total world consumption of cocoa, followed by the Americas (33%), Asia (15%), and Africa (3%). However, the United States is the leading cocoa importing country worldwide with 21% of global net imports, followed by Germany at 13%, Belgium at 7%, France and Russia at 6% (Figure 2-1). Figure 2-3 reports that the four major exporters of cocoa beans to the United States from 1999 to 2011 are Cote d'Ivoire (1st), Indonesia (2nd), Ecuador (3rd) and Ghana (USDA, 2012). During the same period (1999-2011), U.S. imports chocolate predominantly from Canada, Mexico, Belgium-Lux and Germany ranking 1st, 2nd, 3rd and 4th, respectively (Figure 2-4). In 2011, U.S. total imports of cocoa and cocoa products are valued at $940.9 million and $870.5 million from Canada and Cote d'Ivoire as 1st and 2nd exporters, respectively.

West Africa accounts for 73% of world cocoa beans production with Cote d'Ivoire, Ghana, Cameroon and Nigeria making the top four producing countries in Africa. Asia represents 14% of world production with Indonesia, Malaysia and Papua New Guinea. Finally, South America with Brazil and Ecuador produces 13% of cocoa beans worldwide (World Cocoa Foundation, 2012).

According to Food and Agriculture Organization (FAO) statistics, over the past 33 years (1980-2011) Cote d'Ivoire has been the world leading cocoa producing country with a production growth of 2.24%. During the period 1980-1993, world cocoa beans production was dominated by Brazil, Ghana and Nigeria as 2nd, 3rd and 4th producers of that crop (Figure 2-2). Also, from 1999 to 2010, Indonesia cocoa beans production noticeably overtakes other countries' production making it the second producer worldwide. Ghana, Nigeria and Brazil rank 3rd, 4th and 5th, respectively, during the same period. In 2011, Cote d'Ivoire (CI) dominates the world cocoa beans production with a share of 36%, followed by Ghana (24%), Indonesia (10%), Nigeria (6%), Cameroon (5%), Brazil (5%) and Ecuador (3%).

Many models such as the original linear expenditure and the translog models have been suggested to estimate import demand elasticities, but two significant and widespread demand systems, the Rotterdam model (Theil, 1965; Barten, 1993) and the Almost Ideal Demand System (AIDS) (Deaton and Muellbauer, 1980), have been mostly applied for demand analysis. Richard Stone (1954) was the first economist to derive a system of demand equations from consumer theory, and then additional specifications and functional forms followed later. The two popular models (AIDS and Rotterdam) have a lot of similarities but some differences as well. For instance, marginal expenditure shares and Slutsky terms remain constant in the Rotterdam model, whereas they are functions of budget shares in the AIDS model (Lee, Brown and Seale, 1994). The AIDS model, the Rotterdam model, the hybrid of the AIDS (the Central Bureau of Statistics (CBS), Keller and Van Driel, 1985) and the hybrid of the Rotterdam (the National Bureau of Research (NBR), Neves, 1987) are all nonnested models.

However, Barten (1993) proposes a general model that nests the four systems, and with pair-wise and higher-order tests, one can evaluate which of them best fit the data.

The objective of this paper is to investigate the U.S. import demand for cocoa beans. To do so, we estimate U.S. price and income elasticities of import demand for two commodities, chocolate and cocoa beans by country of origin and we use four functional approaches (AIDS, Rotterdam, CBS, and NBR), following Lee, Brown, and Seale (1994). The import demand analysis covers the period 1986 to 2010 for cocoa beans and the period 1992 to 2010 for chocolate due to data availability. We consider four important exporting markets to the U.S: Cote d'Ivoire, Indonesia, Ecuador and the rest of the world (ROW) to estimate import demand for cocoa beans. For the estimation of chocolate imports, we take into account Canada, Mexico, Germany and the ROW as major partners to the United States. Additionally, we apply the general model (Barten, 1993) and use likelihood-ratio tests to choose which of the four models best fits the cocoa products import data.

This study contributes to the paucity of the literature on import demand for cocoa products by providing latest elasticity estimates, which outcomes can be utilized by cocoa bean and chocolate producers in making strategic pricing decisions that will increase revenues from the marketing of cocoa products. In fact, elasticity estimates from the previous studies on import demand for cocoa products are outdated. Also, it is important to study the elasticities of U.S. import demand for cocoa products (i.e. chocolate, cocoa beans and cocoa powder) because the U.S. consumes and imports a large proportion of traded cocoa products.

This paper is organized as follows. First, we review literature relevant to the import demand. Next, we discuss respectively the methodology and the data source. Finally, we analyze the results and conclude the paper.

Literature Review

Empirical researches have evaluated elasticities of import demand. For instance, Seale, Zhang and Traboulsi (2013), Lee, Brown and Seale (1994), Faroque (2008), and Seale Jr., Sparks, and Buxton (1992) evaluate elasticities of import demand for different goods such as fresh vegetables and fruits. Of the previous studies on demand elasticities, only two studies have estimated import demand for cocoa products, and these studies are out of date. Indeed, Behrman (1965) analyzes the United States, the United Kingdom, the Federal Republic of Germany, Netherlands, and France (major consuming countries of cocoa) elasticities of import demand for cocoa beans from the five top producing countries of cocoa (Ghana, Nigeria, Brazil, Cote d'Ivoire, and Cameroon) over the period 1950 through 1961. He uses the per capita demand for adjusted grindings (AG_t) function (which in theory is a general demand function) to estimate the demand for per capita consumption of cocoa products in each individual country. He derives elasticity estimates of the demand for cocoa from the demand for grindings function. Results show that for Germany and France, cocoa is an income inelastic superior good, whereas for Netherlands, UK, and U.S., cocoa is an inferior good. The own-price elasticities indicate inelastic price responses for all the countries. The cross-price elasticities imply that sugar is a substitute for cocoa in Netherlands and UK, but a complement in the United States. Husted and Kollintzas (1984) use a two-stage estimation method to analyze the U.S. imports of bauxite, cocoa, coffee, and petroleum from 1956 to 1980. They applied the distributed lag structure method to model the import demand equations and used the Autoregressive-Moving-Average (ARMA) models developed by Box and Tiao (1975) to estimate the commodities import price. They found significant estimates of the structural parameters of the model for all the commodities with evidence that import demand respond gradually to changes in expected parametric estimates (i.e., price).

Model Specification

This study utilizes four demand systems to analyze U.S. import demand elasticities for cocoa beans and chocolate. We start by discussing the AIDS, followed by the Rotterdam, CBS, and NBR models plus the general model.

AIDS Model

Many researches have estimated demand elasticities using the AIDS. Nzaku, Houston, and Fonsah (2010) examine the U.S. consumer demand for 10 fresh tropical fruits and vegetables imports over the period 1989 to 2008 using the AIDS and include seasonal trigonometric variables, trend and a policy dummy variable (NAFTA variable) in the budget shares of the AIDS. They found that most fresh fruit and vegetable's import shares are significantly and positively responsive to the change in real income or expenditure. Also, of the 10 produces, six have budget shares that respond significantly to the change in the prices. Likewise, Seale, Marchant, and Basso (2002) apply the AIDS to evaluate U.S. import demand for red wine along with U.S. demand for domestic red wines. Findings show that the U.S. consumes more domestic red wines than imported ones. Also, conditional expenditure elasticities of foreign red wines are all inelastic while they are elastic for domestically produced red wines.

The AIDS model was developed by Deaton and Muellbauer (1980). The theory of this demand system involves a specific class of preferences that permit accurate aggregation over purchasers, reflecting market demands where these purchasers rationally make decisions. These preferences (called PIGLOG) are denoted by the cost and expenditure function and give knowledge about the least spending needed by the consumer in order to obtain a certain utility level at a set price. The cost function is *c (u, p)* where *u* is the utility level and *p* is the price.

The PIGLOG class is written as:

$$logc(u,p) = (1-u)\log\{\alpha(p)\} + ulog\{(b(p)\} \quad (2\text{-}1)$$

where *a(p)* and *b(p)* are the costs of subsistence (0) and bliss(1).

By using the functional forms of and we can write the AIDS cost function as:

$$\log c(u,p) = \alpha_0 + \sum_i \alpha_i \log p_i + \frac{1}{2}\sum_i\sum_j \gamma_{ij}^* \log p_i \log p_j + \mu\beta_0 \prod_j p_j^{\beta_j} \quad (2\text{-}2)$$

where

α_i β_i Υ_{ij}^* are parameters and

$$\sum_i \alpha_i = 1, \sum_j \gamma_{ij}^* = \sum_i \gamma_{ij}^* = \sum_j \beta_j = 0$$

The demand functions can be derived from Equation (2-2) and following Ronald Shephard (1953, 1970) the derivation of the cost function with respect to prices equal the quantities demanded:

$$\partial c(u,p)/\partial p_i = q_i \quad (2\text{-}3)$$

We obtain the budget share by multiplying both sides of (2-3) by $p_i / c(u,p)$:

$$\frac{\partial \log c(u,p)}{\partial \log p_i} = \frac{p_i q_i}{c(u,p)} = w_i \quad (2\text{-}4)$$

The logarithmic differentiation of Equation (2-2) leads to the budget shares as a function of prices and utility:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \mu \beta_0 \Pi p_j^{\beta_j} \tag{2-5}$$

with $\gamma_{ij} = \frac{1}{2}(\gamma_{ij}^* + \gamma_{ji}^*)$. (2-6)

By reversing the equality between total expenditure, m and the cost function, c(u,p), to derive the indirect utility function, u(p,m), and using Equations (2-4) and (2-6), we obtain the AIDS demand function in budget share form:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log(m / P) \tag{2-7}$$

where P is a price index denoted by

$$\log P = \alpha_0 + \sum_i \alpha_i \log p_i + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \log p_i \log p_j . \tag{2-8}$$

The restrictions on the parameters of Equations (2-2) and (2-6) extrapolate to restrictions on (2-7). In order for the budget shares to add up to unity ($\sum w_i = 1$), the adding-up conditions have to hold:

$$\sum_{i=1}^{n} \alpha_i = 1 \quad \sum_{i=1}^{n} \gamma_{ij} = 0 \quad \sum_{i=1}^{n} \gamma_{ij} = 0 . \tag{2-9}$$

Also, the demand functions have to be homogenous of degree zero in prices and satisfy Slutsky symmetry, respectively:

$$\sum_j \gamma_{ij} = 0 \ ; \ \gamma_{ij} = \gamma_{ji} . \tag{2-10}$$

In the time-series context, the AIDS and the Rotterdam model of Theil (1965, 1976) and Barten (1993) are closely related. Taking the first-difference form of Equation (2-7) can show the relationship between the AIDS and the Rotterdam model. The first-difference form of the Equation (2-7) is given as

$$dw_i = \beta_i d\log(\frac{m}{P}) + \sum_j \gamma_{ij} d\log p_j . \tag{2-11}$$

Deaton and Muellbauer (1980) found that using the Divisia price index is an excellent approximation to $d\log P$. Therefore, $d\log P$ in Equation (2-11) is replaced by the Divisia price index, $\sum w_i d\log p_i$, to obtain

$$dw_i = \beta_i (d\log m - \sum w_i d\log p_i) + \sum_j \gamma_{ij} d\log p_j . \tag{2-12}$$

The similarity between the AIDS and the Rotterdam model can be observed later on by looking at the right-hand side of Equation (2-12), which is identical to the right-hand side of the Rotterdam model (Equation 2-19). The Rotterdam model is derived in the next section.

According to Barten (1993), starting with the logarithmic differential of the budget equation, $\sum_i p_i q_i = m$, gives the real income equation

$$d\log m = \sum_i w_i d\log p_i + \sum_i w_i d\log q_i \ . \tag{2-13}$$

Equivalently,

$$\sum_i w_i d\log q_i = d\log m - \sum_i w_i d\log p_i \ . \tag{2-14}$$

We insert Equation (2-14) into Equation (2-13) to obtain a new form of the AIDS as

$$dw_i = \beta_i d\log Q + \sum_j \gamma_{ij} d\log p_j \tag{2-15a}$$

or

$$w_i d\log q_i = (\beta_i + w_i) d\log Q + \sum_j \gamma_{ij} - w_i(\delta_{ij} - w_j) d\log p_j \tag{2-15b}$$

where $d\log Q = \sum w_i d\log q_i$ is the divisia volume index and represents real income.

Rotterdam Model

Some studies have estimated import demand and consumer demand using the Rotterdam system. For instance, Seale, Sparks and Buxton (1992) evaluate geographically demand estimates of U.S. fresh apples imported by four important importers of U.S. apples: Canada, Hong Kong, Singapore, and the United Kingdom by using a Rotterdam model. They found that all accounted apple suppliers to Canada, Hong Kong, Singapore, and the U.K. would increase apple exports if total expenditures for fresh apple imports in these markets increase. They also found that U.S. apples are more price elastic than apples from the four other apple suppliers (South Africa, Australia, France, and New Zealand). However, apples from other suppliers (i.e. South Africa to Canada, Australia to Singapore) were more expenditure elastic than apples from the U.S. to the four apple importers (Canada, Hong Kong, Singapore, U.K). Faroque (2008) uses both a Rotterdam and an AIDS (almost ideal demand system) to study Canadian consumption of alcoholic drinks such as beer, wine and spirits from

1950 through 2003. His findings indicate that statistically the Rotterdam system fits the data better than the AIDS model.

The Rotterdam model was initially developed by Theil (1965). He started the model with the budget share formula,

$$w_i = p_i q_i / m, \tag{2-16}$$

where w_i is the budget share of commodity *i*, p_i is the price of commodity *i*, q_i is the quantity of commodity *i* , and *m* is the income or total expenditure.

The logarithmic function of Equation (2-16) is:

$$\log w_i = \log p_i + \log q_i - \log m \,. \tag{2-17}$$

After transformation, he continues with the relation below,

$$d\log q_i = \eta_i (d\log m - \sum_i w_i d\log p_i) + \sum_j \varepsilon_{ij} d\log p_j \tag{2-18}$$

Multiplying both sides by w_i, we obtain the Rotterdam model as

$$w_i d\log q_i = \theta_i (d\log m - \sum_i w_i d\log p_i) + \sum_j \pi_{ij} d\log p_j \tag{2-19}$$

where $\theta_i = w_i \eta_i$ and $\pi_{ij} = w_i \varepsilon_{ij}$ are now treated as constants.

Let us set two equations as follow,

$$\sum_i w_i d\log q_i = d\log m - \sum_j w_i d\log p_i \quad \text{and} \tag{2-20}$$

$$d\log Q = \sum_i w_i d\log q_i ; \;\; d\log P = \sum_i w_i d\log p_i \tag{2-21}$$

where the left-hand side variable is a change in the quantity index corresponding to the change in real income on the right-hand side.

We use Equations (2-20) and (2-21) to rewrite the Rotterdam model in Equation (2-19) as

$$w_i d\log q_i = \theta_i d\log Q + \sum_j \pi_{ij} d\log p_j \,. \quad (2\text{-}22)$$

The Rotterdam model follows the adding up, homogeneity, and symmetry properties below:

Adding-up property,

$$\sum \theta_i = 1 \,, \; \sum \pi_{ij} = 0 \,; \quad (2\text{-}23)$$

Homogeneity property,

$$\sum \pi_{ij} = 0 \text{; and} \quad (2\text{-}24)$$

Symmetry property,

$$\pi_{ij} = \pi_{ji} \quad (2\text{-}25)$$

CBS Model

To obtain the CBS system, let's consider, first, the Rotterdam model in Equation (2-22), which is one system of the class of four models considered by Barten (1993). Second, we use the AIDS model in Equation (2-15a). Looking at both Equations (2-22) and (2-15a), we notice that the right-hand sides of these equations are similar while the left-hand sides are different, but closely related. Therefore, we can write

$$dw_i = w_i d\log q_i + w_i d\log p_i - w_i d\log m \quad (2\text{-}26)$$

where $w_i dlogq_i$ is the quantity element of the change in budget share w_i; and $w_i dlogp_i$ and $-w_i dlogm$ are due to the (exogenous) changes in the price and total income, respectively.

By using Equation (2-26), we can show the relationship between the coefficients of Equations (2-22) and (2-15a). We replace $w_i d\log q_i$ in Equation (2-26) by the right-hand side of Equation (2-22); and replace $d\log m$ by Equation (2-13) to have

$$dw_i = \theta_i d\log Q + \sum_j \pi_{ij} d\log p_j + w_i d\log p_i - w_i d\log P - w_i d\log Q \text{ and} \quad (2\text{-}27)$$

$$dw_i = (\theta_i - w_i) d\log Q + \sum_j \pi_{ij} d\log p_j + w_i d\log p_i - w_i \sum_i w_i d\log p_i. \quad (2\text{-}28)$$

We use the kronecker delta equal to unity if i=j and zero otherwise to rewrite Equation (2-28) as

$$dw_i = (\theta_i - w_i) d\log Q + \sum_j (\pi_{ij} + w_i \delta_{ij} - w_i w_j) d\log p_j. \quad (2\text{-}29)$$

Comparing Equation (2-15a) with Equation (2-29) shows equivalence for

$$\beta_i = \theta_i - w_i \text{ and} \quad (2\text{-}30)$$

$$\gamma_{ij} = \pi_{ij} + w_i \delta_{ij} - w_i w_j. \quad (2\text{-}31)$$

Keller and van Driel (1985) of the Dutch Central Bureau of Statistics invented a hybrid of the AIDS and Rotterdam models by replacing θ_i in the Equation (2-22) by $\beta_i + w_i$ and moving to the left-hand side. The CBS model is as follow:

$$w_i(d\log q_i - d\log Q) = \beta_i d\log Q + \sum_j \pi_{ij} d\log p_j. \quad (2\text{-}32)$$

The CBS model has the AIDS income coefficient and the Rotterdam price coefficients. Also, the CBS satisfies the same adding-up condition as the AIDS system, the same homogeneity condition as the Rotterdam, and the same symmetry condition as both the AIDS and Rotterdam.

NBR Model

The NBR model is also a hybrid, which is developed by Neves (1987). The NBR system is obtained by replacing β_i in the AIDS system by $\theta_i - w_i$ to obtain

$$dw_i + w_i d\log Q = \theta_i d\log Q + \sum_j \gamma_{ij} d\log p_j \quad (2\text{-}33a)$$

or

$$w_i d\log q_i = \theta_i d\log Q + \sum_j \gamma_{ij} - w_i(\delta_{ij} - w_j) d\log p_j \qquad \text{(2-33b)}$$

The NBR model has the Rotterdam income coefficient and the AIDS price coefficients. It satisfies the same adding-up condition as the Rotterdam system, the same homogeneity condition as the AIDS.

General Model

Few studies have applied the general model to examine which of the four differential models, the Rotterdam, the AIDS, the hybrid of the Rotterdam (NBR), and the hybrid of the AIDS (CBS), best fits the data in estimating demand systems. In fact, Lee, Brown, and Seale (1994) use these four non-nested demand systems plus the general model to study the effects of price and income on consumer demand for 12 commodity groups in Taiwan from 1970 to 1989. They found that the AIDS best fits the Taiwanese expenditure data out of the four demand systems.

The four functional models accounted for in our study are not nested, but a general form can be developed to nest all four models (Barten, 1993). Appendix B shows a more detailed derivation of the general model, thus we will provide in this section a shorter version of the derivation of general model. Let's start with this equation,

$$y_{Rt} = X_t\gamma + \delta_1(y_{Rt} - y_{Ct}) + \delta_2(y_{Rt} - y_{Nt}) + \upsilon_t\,, \qquad \text{(2-34)}$$

where

$$y_{Rt} - y_{Nt} = w_i d\log q_i - \{w_i(d\log p_i + d\log q_i - d\log P - d\log Q)\} - w_i d\log Q\,, \qquad \text{(2-35a)}$$

$$y_{Rt} - y_{Nt} = w_i(d\log P - d\log p_i) \text{, and} \qquad (2\text{-}35b)$$

$$X\gamma = \theta_i d\log Q + \sum_j \pi_{ij} d\log p_j . \qquad (2\text{-}36)$$

.

We use Equations (2-35b) and (2-36) and the Kronecker delta $\delta_{ij} = 1$ if i=j to rewrite the general model as:

$$w_i d\log q_i = (d_i + \delta_1 w_i) d\log Q + \sum_j \left[e_{ij} - \delta_2 w_i (\delta_{ij} - w_j) \right] d\log p_j + \upsilon_t \qquad (2\text{-}37)$$

where

$$d_i = \delta_1 \beta_i + (1 - \delta_1)\theta_i \text{ and} \qquad (2\text{-}38)$$

$$e_{ij} = \delta_2 \gamma_{ij} + (1 - \delta_2)\pi_{ij} . \qquad (2\text{-}39)$$

There are four parameter sets to be estimated in the general model; and δ_2. Equation (2-37) becomes the Rotterdam model when $\delta_2 = 0$ and $\delta_1 = 0$, the CBS model when $\delta_1 = 1$ and $\delta_2 = 0$, the AIDS when $\delta_1 = 1$ and $\delta_2 = 1$, and the NBR when $\delta_1 = 0$ and $\delta_2 = 1$.

The general model follows the adding up, homogeneity, and symmetry properties below:

Adding-up property,

and; (2-40)

Homogeneity property,

and; (2-41)

Symmetry property,

(2-42)

To determine which of the four demand systems best fits the data, we perform likelihood-ratio tests on the four demand systems.

- For the Rotterdam model, we test the null hypothesis H_0, $\delta_2 = 0$ and $\delta_1 = 0$, against the alternative hypothesis H_a, and
- For the AIDS model, we test the null hypothesis H_0, $\delta_1 = 1$ and $\delta_2 = 1$, against the alternative hypothesis H_a, and
- For the CBS model, we test the null hypothesis H_0, $\delta_1 = 1$ and $\delta_2 = 0$, against the alternative hypothesis H_a, and
- For the NBR model, we test the null hypothesis H_0, $\delta_1 = 0$ and $\delta_2 = 1$, against the alternative hypothesis H_a, and

The likelihood-ratio test (LRT) is given as (Lee, Brown, and Seale, 1994):

$$LRT = -2[\log L(\theta^*) - \log L(\theta)] \quad (2\text{-}43)$$

where θ^* is the vector of the parameter estimates of each of the demand systems (i.e., AIDS, Rotterdam, CBS, NBR); θ is the vector of the parameter estimates of the general model; and log L (.) is the log value of the likelihood function. The likelihood-ratio test follows a $\chi^2(q)$ distribution with two degrees of freedom. The degrees of freedom are the difference between the number of parameters in the general model and those in any of the four models.

Elasticities

According to Lee, Brown, and Seale (1994), income and price elasticities for the four models can be derived as follows.

Income elasticities

For the Rotterdam and NBR:

$$\eta_i = \theta_i / w_i . \quad (2\text{-}44)$$

For the AIDS and the CBS:

$$\eta_i = (\beta_i / w_i) + 1 . \quad (2\text{-}45)$$

Additionally the income elasticity for the general model is

$$\eta_i = (d_i / w_i) + \delta_1. \tag{2-46}$$

Slutsky price elasticities

The Slutsky price elasticity measures the percent change in the quantity demanded of a good for a 1% change in the price when real expenditure is kept constant.

For the Rotterdam and CBS models:

$$\varepsilon_{ij} = \pi_{ij} / w_i. \tag{2-47}$$

For the AIDS and NBR:

$$\varepsilon_{ij} = (\gamma_{ij} / w_i) - \delta_{ij} + w_j. \tag{2-48}$$

The Slutsky price elasticity for the general model is

$$\varepsilon_{ij} = (e_{ij} / w_i) + (\delta_2(\delta_{ij} + w_j)) \tag{2-49}$$

where $\delta_{ij} = 1$ if $i = j$ and $\delta_{ij} = 0$ if $i \neq j$.

Cournot price elasticities

The Cournot price elasticity measures the percent change in the quantity demanded of a good for a 1% change in the price when nominal income is held constant. It measures both a substitution effect and an income effect of the price change.

For the Rotterdam model:

$$\varepsilon_{ij} = (\pi_{ij} / w_i) - \theta_i (w_j / w_i). \tag{2-50}$$

For the CBS model:

$$\varepsilon_{ij} = (\pi_{ij} / w_i) - [(\beta_i + w_i) w_j / w_i] \quad . \tag{2-51}$$

For the AIDS model:

$$\varepsilon_{ij} = (\gamma_{ij} / w_i) - \delta_{ij} + w_j - [(\beta_i + w_i) w_j / w_i]. \quad (2\text{-}52)$$

For the NBR model:

$$\varepsilon_{ij} = (\gamma_{ij} / w_i) - \delta_{ij} + w_j - \theta_i (w_j / w_i). \quad (2\text{-}53)$$

The Cournot price elasticity for the general model is

$$\varepsilon_{ij} = (e_{ij} / w_i) + (\delta_2 (\delta_{ij} + w_j)) - [(d_i + \delta_1 w_i) w_j / w_i] \quad (2\text{-}54)$$

where $\delta_{ij} = 1$ if $i = j$ and $\delta_{ij} = 0$ if $i \neq j$.

Data

The dataset used in this study is U.S. import expenditure data on cocoa products collected from the FAO (Food and Agricultural Organization) Statistics. It consists of annual observations of U.S. import values and import quantities related to three cocoa products: cocoa beans; chocolate; and cocoa butter. The prices of those commodities are determined by dividing the import values by the import quantities. The time period ranges from 1986 to 2011 for cocoa beans data. We consider Cote d'Ivoire, Indonesia, and Ecuador as major exporting countries of cocoa beans to the U.S. and the rest of the world (ROW), which includes 73 countries. With regards to the chocolate product, we account for Canada, Mexico, Germany, and ROW. Due to missing data on chocolate for Germany from the period 1986 to 1991, our dataset starts from the period 1992 through 2010.

Results and Analysis

Results for Cocoa Beans

Test results of homogeneity indicate the presence of homogeneity for the four models (i.e., AIDS, CBS, NBR, and Rotterdam). However, we reject homogeneity for the general model at the 5% significance level. Similarly, test results of symmetry indicate the presence of symmetry for the four models and the general model.

Table 2-1 illustrates the log-likelihood values and test statistics for each model. Numbers in column 2 are log-likelihood values, and numbers in column 3 are log-likelihood-ratio-test statistics for each model. The ratio tests show that the general model fails to reject only the Rotterdam model. This means that the Rotterdam model fits the data better than do the AIDS, CBS, and NBR models. Therefore, we present results of the marginal shares, and Slutsky price coefficients as well as income and price elasticities for the Rotterdam model.

Barten (1993) argues that the general model is more flexible than the Rotterdam, AIDS, and their hybrids in that it combines all four models and features two additional parameters. Additionally, Brown, Lee, and Seale, Jr. (1994) emphasize Barten's argument by stating that the general model is interesting for empirical work because of its flexibility. Hence, we report the results in forms of table from the general model in addition to the Rotterdam model, but only interpret the results from the general model. In fact, results from both models present similarities in terms of the significance and signs of the elasticity estimates. Expenditure elasticities are significant and positive for all countries (i.e., Cote d'Ivoire, Indonesia, Ecuador, and ROW) in both models. Similarly, both models present negative Slutsky own-price elasticities for all countries, but only that of Cote d'Ivoire is statistically significant. Also, all significant cross-price elasticities are positive, in particular for Indonesia/Cote d'Ivoire and ROW/Cote d'Ivoire. The major differences in the results of these two models are that the Cournot own-price elasticities from the general model are significant for Cote d'Ivoire and the ROW while from the Rotterdam model, they are significant only for Cote d'Ivoire.

Table 2-4 reports the expenditure coefficients d_i from the general model, which are insignificant for all countries. With regards to the Slutsky own-price coefficients, they are negative and significant at the 1% and 5% level for all countries. The expenditure elasticities are greater than one and significant at the 1% level for Cote d'Ivoire and Ecuador at the sample mean, implying they are elastic (Table 2-5). This indicates that the quantity demanded of cocoa beans from these countries increases by more than 1% as total U.S. import expenditure on this crop increases by 1%. Also, Indonesia's expenditure is unitary elastic, meaning the quantity demanded of cocoa beans from Indonesia increases proportionally to the increase in total U.S. import expenditure on cocoa beans. However, the expenditure elasticities for the ROW are less than one, implying they are inelastic. This indicates that the quantity demanded of cocoa beans from the ROW are less sensitive to total U.S. import expenditure, and it increases by less than 1% as total U.S. import expenditure on cocoa beans increases by 1%. As U.S. total expenditure on cocoa beans increases by 1%, the U.S. imports of cocoa beans predominantly from Ecuador increases by 1.38%, from Cote d'Ivoire by 1.17%, from Indonesia by 1.01%, and from the ROW by 0.65%.

Additionally, results from the general model in Table 2-5 indicate that the absolute value of the Slutsky own-price elasticity is significant at the 1% level and greater than one for only Cote d'Ivoire, implying an elastic demand. This means that the percent change of quantity demanded of cocoa beans from this country is more sensitive to changes in own price than that of the other countries. As the price of cocoa beans from Cote d'Ivoire increases by 1%, the quantity demanded of cocoa beans from this country decreases by 1.22%. Note that the absolute value of the Cournot own-price elasticities, that take into account both substitution and income effects of an own-price change, are greater than one and significant at the 1% and 5% level for Cote d'Ivoire (1.72%) and the ROW (1.09%), respectively.

Furthermore, the Slutsky cross-price elasticities from the general model are positive and significant for Indonesia/Cote d'Ivoire, for the ROW/ Cote d'Ivoire, for Cote d'Ivoire/Indonesia, and for Cote d'Ivoire/ ROW, with cross-price elasticities of 1.16,1.06, 0.56, and 0.73, respectively. This indicates that as the price of cocoa beans from Cote d'Ivoire increases by 1%, the U.S. will increase its quantity demanded of cocoa beans from Indonesia by 1.16% and the U.S. will increase its quantity demanded of cocoa beans from the ROW by 1.06%. Likewise, as the price of cocoa beans from Indonesia increases by 1%, the U.S. will increase its quantity demanded of cocoa beans from Cote d'Ivoire by 0.56% while as the price of cocoa beans from the ROW increases by 1%, the U.S. will increase its quantity demanded of cocoa beans from Cote d'Ivoire by 0.73%. Hence, Indonesia and Cote d'Ivoire and the ROW and Cote d'Ivoire are substitute countries. However, the Slutsky cross-price elasticities are negative and significant for ROW/ Indonesia (-0.76). This indicates that as the price of cocoa beans from Indonesia increases by 1%, the U.S. will decrease its quantity demanded of cocoa beans from the ROW by 0.76%; thus, the ROW and Indonesia are complementary countries.

Results for Chocolate

With regards to chocolate, test results of homogeneity and symmetry indicate the presence of homogeneity and symmetry for the Rotterdam, AIDS, CBS, NBR and the general model. The likelihood-ratio tests indicate that the general model rejects the AIDS and NBR model, but not the Rotterdam and the CBS, meaning that only the Rotterdam and CBS fit the data at the 5% significance level compared to the general model (Table 2-6). However, the Rotterdam fits the data better than the CBS because its log-likelihood value is closer to that of the general model than the CBS log-likelihood value is. Also, the Rotterdam and the general model present some similarities in that their Slutsky own-price elasticities are significant and negative for the same countries (Mexico and Germany). Likewise, all three models, CBS, Rotterdam, and the general model, have significant and positive expenditure elasticities for the same countries (Canada and ROW). Again, we report in the forms of table parameter estimates and asymptotic standard errors from the Rotterdam, CBS, and general model, but only interpret the results from the general model because of the flexibility in its parameters. Table 2-11 indicates that the expenditure parameters of the general model are insignificant for all countries. Also, all Slutsky own-price coefficients are negative, and that of Germany is significant at the 5% level. Expenditure elasticities are significantly positive at the 1% level and less than one for Canada, but greater than one for the ROW, calculated at the sample mean (Table 2-12). This indicates that as U.S. total expenditure on chocolate increases by 1%, quantity demanded of chocolate from Canada increases by 0.61%, while quantity demanded of chocolate from the ROW increases by 1.57%. Additionally, the absolute values of the Slutsky compensated own-price elasticities of chocolate are less than one and are significant at the 10% level for Mexico but greater than one and significant at the 5% for Germany. This implies that as the price of chocolate from Mexico increases by 1%, the quantity demanded of chocolate from Mexico decreases by 0.68% whereas as the price of chocolate from Germany increases by 1% the quantity demanded of chocolate from Germany decreases by 1.04%. Thus, the quantity demanded of chocolate from Germany is more responsive to the price change than that from Mexico. Finally, the absolute values of the Cournot own-price elasticities are significant and less than one for Canada at the 5% level and greater than one for Germany at the 10% level. This indicates that the quantity demanded of chocolate from Canada decreases by less than 1% for a 1% increase in the price of chocolate from Canada while the quantity demanded of chocolate from Germany increases by more than 1% for a 1% increase in the price of chocolate from Germany. All the Slutsky cross-price elasticities for chocolate from the general model are insignificant.

Summary of the Chapter

This paper fits four differential demand systems (i.e., AIDS, Rotterdam, CBS, and NBR) to data for cocoa bean and chocolate imports into the U.S. and estimates expenditures and price elasticities for these products by place of origin, during the periods 1986 through 2010 (cocoa beans), and 1992 through 2010 (chocolate). A fifth model, the general model, is used to test which of the four demand systems best fits the data. Results indicate that the Rotterdam model best fits the cocoa bean data, whereas the Rotterdam and CBS models best fit the chocolate data. We report and interpret results from the general model only for both cocoa products because it is a more flexible model than the other demand models (Barten, 1993; Lee, Brown, and Seale, 1994).

The Cournot and Slutsky own-price elasticities indicate that quantity demand of cocoa beans is elastic for Cote d'Ivoire and the ROW. This means that the quantity demanded of cocoa beans from Cote d'Ivoire and the ROW is responsive to the price change of cocoa beans, but cocoa quantity demanded from Cote d'Ivoire is more elastic than that from the ROW. Exporters of cocoa beans in both countries (Cote d'Ivoire and ROW) will increase their revenues by reducing cocoa prices, but Cote d'Ivoire's exporters could reduce their prices more than the ROW's exporters. Demand of cocoa beans from Indonesia is unitary elastic, implying that the quantity demanded changes proportionally to the change in price. In this case, the change in price will not affect exporters' total revenues; revenues will stay constant no matter the change in price.

Similarly, chocolate industries in Germany can increase their revenues by reducing the price of chocolate because the Slutsky own-price and Cournot price of chocolate are elastic for Germany. Additionally, conditional expenditures are elastic for Ecuador (1.38), Cote d'Ivoire (1.17), and Indonesia (1.01). This indicates that as U.S. total expenditure on cocoa beans increases by 1%, the U.S. is more likely to import more cocoa beans primarily from Ecuador, and then from Cote d'Ivoire and Indonesia. Also, expenditures at the sample mean are inelastic for Canada, indicating that the U.S. quantity demanded of chocolate from Canada increases by less than 1% (by exactly 0.61) as U.S. total expenditure on chocolate increases by 1%.

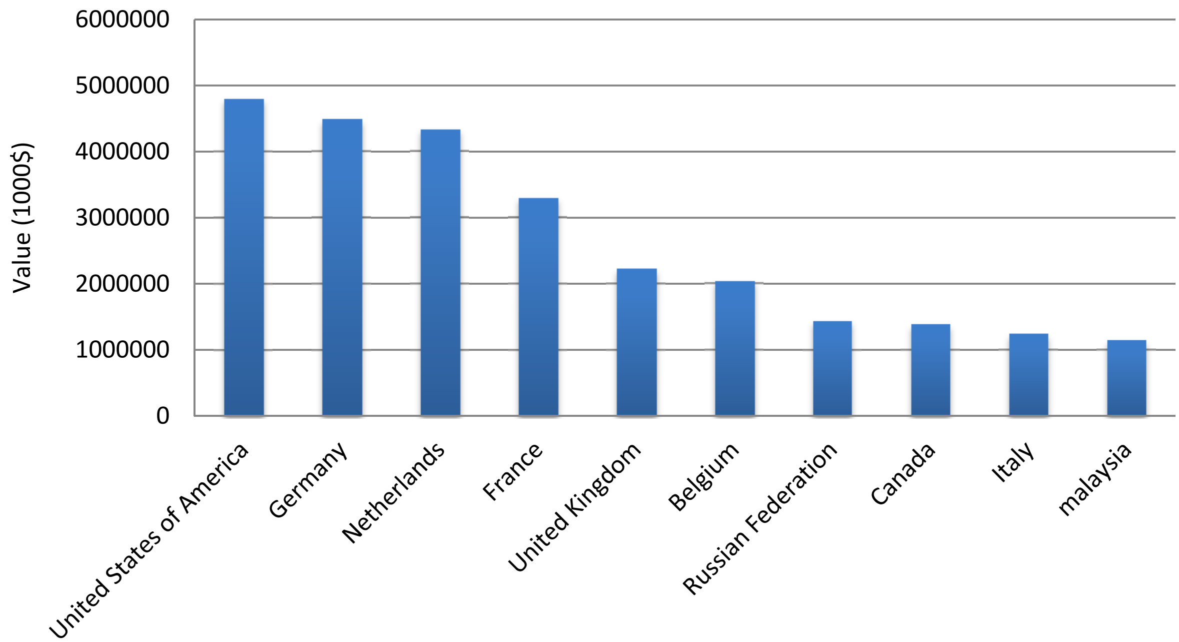

Figure 2-1. Top imports of cocoa products in 2011

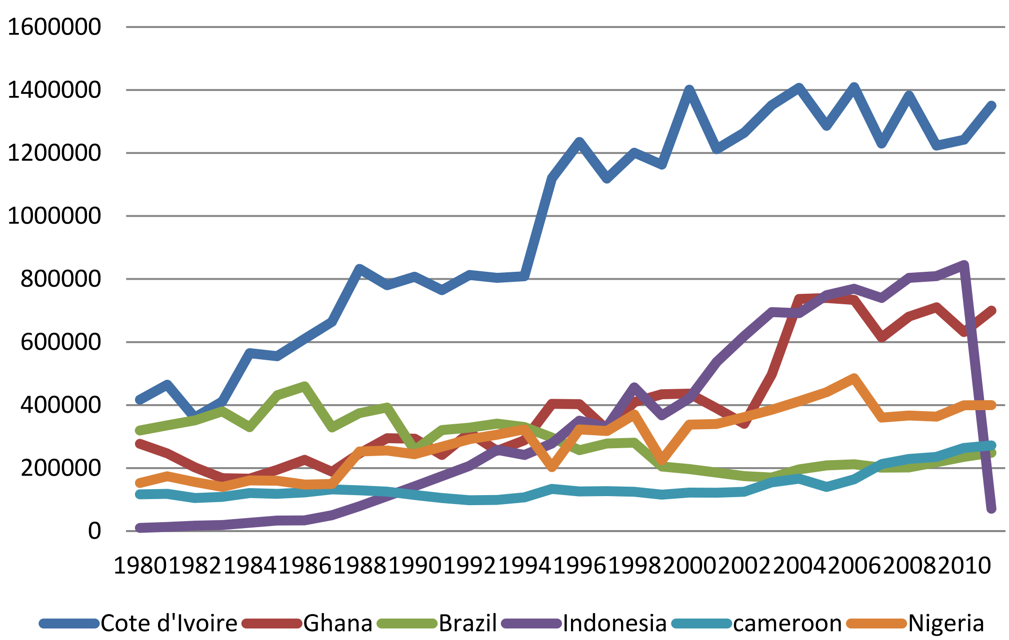

Figure 2-2. Cocoa beans production (metric tons) from major cocoa beans producers

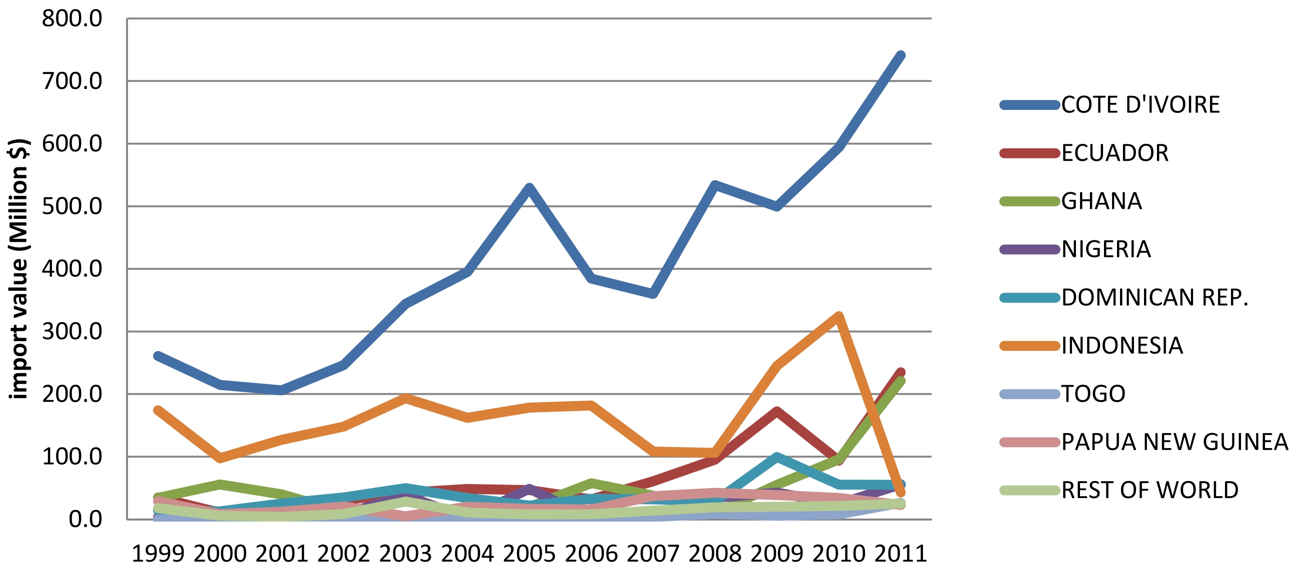

Figure 2-3. U.S. import demand values (in $US) of cocoa beans by country of origin

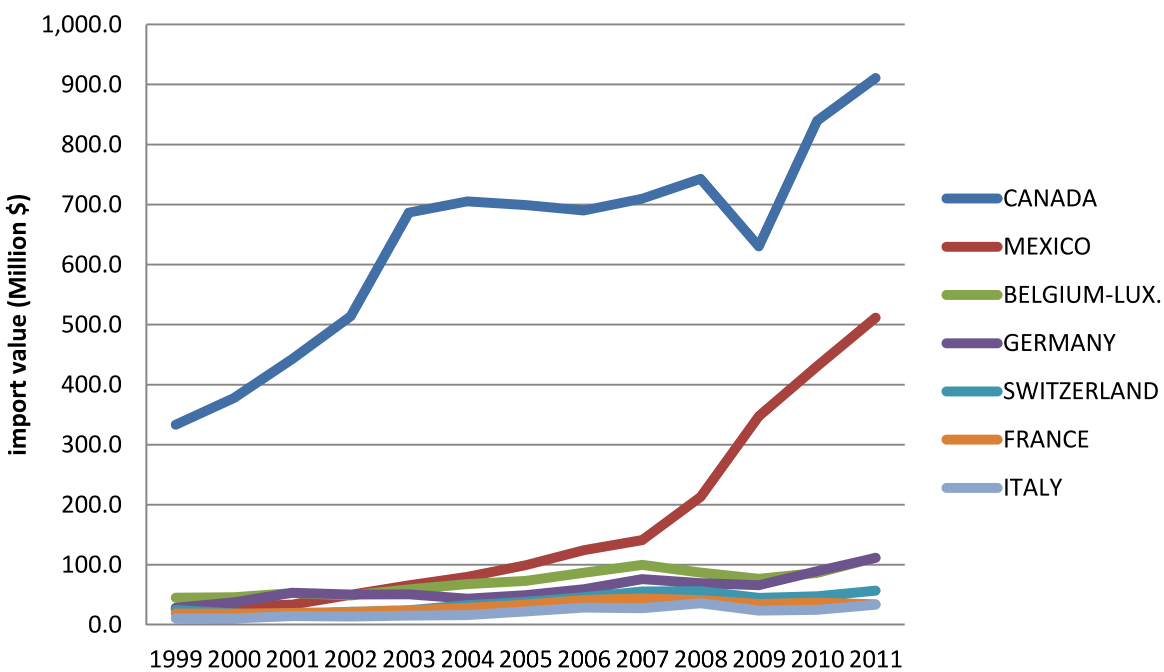

Figure 2-4. U.S. import demand values of chocolate by country of origin

Table 2-1. Test results of U.S. cocoa bean imports for the Rotterdam, CBS, AIDS, NBR, and general model

Model	Log likelihoods values	$-2\left[L\left(\theta^{*}\right)-L\left(\theta\right)\right]^{a}$
General model	114.446	
Rotterdam	112.523	3.846*
CBS	111.299	6.294
AIDS	109.935	9.022
NBR	111.244	6.404

[a] The critical value for $\chi^2_{(2)}$ =5.99 at α=0.05.

θ^* is the vector of parameter estimates of either the Rotterdam, the AIDS, or their variants.
θ is the vector of parameter estimates of the general model.
* means significant at the 5% level.

Table 2-2. Expenditure and Slutsky price coefficients from the Rotterdam model for U.S. cocoa bean imports

	Slutsky coefficients				Marginal shares
Country	Cote d'Ivoire	Indonesia	Ecuador	ROW[a]	
Cote d'Ivoire	-0.537*** (0.159)[b]	0.273** (0.115)	-0.005 (0.078)	0.264** (0.123)	0.489*** (0.719)
Indonesia		-0.129 (0.152)	0.045 (0.077)	-0.188 (0.121)	0.195** (0.067)
Ecuador			-0.105 (0.813)	0.061 (0.099)	0.127** (0.043)
ROW[a]				-0.137 (0.177)	0.188** (0.065)

*** Significance at 1%, ** significance at 5%, *significance at 10%.
a ROW represents rest of the world.
b Asymptotic standards errors are reported in parentheses.

Table 2-3. Conditional expenditure, Slutsky price and Cournot own-price elasticities from the Rotterdam model for U.S. cocoa bean imports, at sample mean.

	Compensated price elasticities				Expenditure	Cournot own-price elasticities
Country	Cote d'Ivoire	Indonesia	Ecuador	ROW[a]		
Cote d'Ivoire	-1.27***	0.65**	-0.00	0.63**	1.16***	-1.76***
	(0.38)[b]	(0.27)	(0.19)	(0.29)	(0.17)	(0.38)
Indonesia	1.35**	-0.64	0.22	-0.93	0.97***	-0.84
	(0.57)	(0.75)	(0.38)	(0.60)	(0.33)	(0.77)
Ecuador	-0.01	0.54	-1.30	0.73	1.54***	-1.40
	(0.95)	(0.93)	(0.98)	(1.20)	(0.51)	(0.98)
ROW[a]	0.90**	-0.64	0.21	-0.47	0.64***	-0.66
	(0.42)	(0.41)	(0.34)	(0.61)	(0.22)	(0.61)

*** Significance at 1%, ** significance at 5%, *significance at 10%.
a ROW represents rest of the world.
b Asymptotic standards errors are reported in parentheses.

Table 2-4. Expenditure and price coefficients from the general model for U.S. cocoa bean imports.

	Price coefficients e_{ij}				Expenditure coefficients d_i
Country	Cote d'Ivoire	Indonesia	Ecuador	ROW[a]	
Cote d'Ivoire	-1.306***	0.511***	0.085	0.710***	0.380
	(0.374)[b]	(0.156)	(0.082)	(0.235)	(0.242)
Indonesia		-0.549**	0.070	-0.032	0.150
		(0.244)	(0.073)	(0.145)	(0.114)
Ecuador			-0.331***	0.176	0.093
			(0.126)	(0.113)	(0.066)
ROW[a]				-0.854**	0.111
				(0.371)	(0.172)

*** Significance at 1%, ** significance at 5%, *significance at 10%.
a ROW represents rest of the world.
b Asymptotic standards errors are reported in parentheses.

Table 2-5. Conditional expenditure, Compensated and Cournot own-price elasticities from the general model for U.S. cocoa bean imports, calculated at sample mean.

Country	Compensated price elasticities				Expenditure	Cournot own-price elasticities
	Cote d'Ivoire	Indonesia	Ecuador	ROW[a]		
Cote d'Ivoire	-1.22***	0.56**	-0.07	0.73**	1.17***	-1.72***
	(0.38)[b]	(0.28)	(0.18)	(0.30)	(0.17)	(0.38)
Indonesia	1.16**	-0.14	0.08	-0.64	1.01***	-0.57
	(0.59)	(0.83)	(0.36)	(0.85)	(0.36)	(0.83)
Ecuador	-0.34	0.19	-1.02	1.17	1.38***	-1.42
	(0.91)	(0.88)	(0.88)	(1.20)	(0.48)	(0.92)
ROW[a]	1.06***	-0.76*	0.33	-0.63	0.65***	-1.09*
	(0.43)	(0.44)	(0.34)	(0.61)	(0.23)	(0.62)

*** Significance at 1%, ** significance at 5%, *significance at 10%.
a ROW represents rest of the world.
b Asymptotic standards errors are reported in parentheses.

Table 2-6. Test results for the Rotterdam model, CBS, AIDS, NBR, and general model for U.S. chocolate imports

Model	Log likelihoods values	$-2\left[L(\theta^*)-L(\theta)\right]^a$
General model	138.859	
Rotterdam	138.498	0.722*
CBS	137.662	2.394*
AIDS	134.724	8.270
NBR	136.337	5.044

[a]The critical value for $\chi^2_{(2)}$ =5.99 at α=0.05.

θ^* is the vector of parameter estimates of either the Rotterdam, the AIDS, or their variants.
θ is the vector of parameter estimates of the general model.
* means significant at the 5% level.

Table 2-7. Expenditure and Slutsky coefficients of the estimated Rotterdam model for U.S. chocolate imports.

Country	Slutsky coefficients				Marginal shares
	Canada	Mexico	Germany	ROW[a]	
Canada	-0.157	0.058	0.021	0.078	0.283***
	(0.119)[b]	(0.040)	(0.027)	(0.119)	(0.072)
Mexico		-0.049*	-0.001	-0.007	0.011
		(0.026)	(0.011)	(0.044)	(0.041)
Germany			-0.047**	0.027	0.023
			(0.024)	(0.032)	(0.017)
ROW[a]				-0.098	0.683***
				(0.140)	(0.085)

*** Significance at 1%, ** significance at 5%, *significance at 10%.
a ROW represents rest of the world.
b Asymptotic standards errors are reported in parentheses.

Table 2-8. Conditional expenditure, Slutsky price and Cournot own-price elasticities from Rotterdam model for U.S. chocolate imports, calculated at sample mean.

Country	Compensated Slutsky price elasticities				Expenditure	Cournot own-price elasticities
	Canada	Mexico	Germany	ROW		
Canada	-0.35	0.13	0.05	0.17	0.62***	-0.63**
	(0.26)	(0.09)	(0.06)	(0.26)	(0.16)	(0.28)
Mexico	0.80	-0.68*	-0.01	-0.10	0.16	-0.69**
	(0.56)	(0.37)	(0.15)	(0.61)	(0.57)	(0.36)
Germany	0.47	-0.02	-1.05**	0.60	0.51	-1.08**
	(0.60)	(0.24)	(0.52)	(0.72)	(0.37)	(0.53)
ROW[a]	0.18	-0.02	0.06	-0.23	0.65***	-0.91***
	(0.28)	(0.10)	(0.08)	(0.33)	(0.10)	(0.33)

*** Significance at 1%, ** significance at 5%, *significance at 10%a ROW represents rest of the world
b Asymptotic standards errors are reported in parentheses

Table 2-9. Expenditure and price coefficients of the estimated CBS model for U.S. chocolate imports.

Country	Price coefficients π_{ij} Canada	Mexico	Germany	ROW[a]	Expenditure coefficients β_i
Canada	-0.155	0.054	0.023	0.078	-0.177**
	(0.125)[b]	(0.042)	(0.026)	(0.123)	(0.075)
Mexico		-0.039	-0.001	-0.014	-0.041
		(0.028)	(0.010)	(0.046)	(0.044)
Germany			-0.049**	0.028	-0.017
			(0.023)	(0.030)	(0.016)
ROW[a]				-0.092	1.234***
				(0.141)	(0.087)

***Significance at 1%, ** significance at 5%, *significance at 10%
a ROW represents rest of the world
b Asymptotic standards errors are reported in parentheses

Table 2-10. Conditional expenditure, compensated and Cournot own-price elasticities from CBS model for U.S. chocolate imports, calculated at sample mean.

Country	Compensated price elasticities Canada	Mexico	Germany	ROW[a]	Expenditure	Cournot own-price elasticities
Canada	-0.34	0.12	0.05	0.17	0.61***	-0.16
	(0.28)[b]	(0.09)	(0.06)	(0.27)	(0.17)	(0.29)
Mexico	0.75	-0.55	-0.01	-0.19	0.43	-0.51
	(0.59)	(0.39)	(0.14)	(0.63)	(0.60)	(0.38)
Germany	0.50	-0.02	-1.09**	0.61	0.63*	-1.08**
	(0.57)	(0.22)	(0.50)	(0.67)	(0.35)	(0.50)
ROW[a]	0.18	-0.32	0.06	-0.21	1.55***	-1.45***
	(0.29)	(0.11)	(0.07)	(0.33)	(0.20)	(0.33)

***Significance at 1%, ** significance at 5%, *significance at 10%
a ROW represents rest of the world
b Asymptotic standards errors are reported in parentheses

Table 2-11. Expenditure and price coefficients of the estimated general model for U.S. chocolate imports

	Price coefficients e_{ij}				Expenditure coefficients d_i
Country	Canada	Mexico	Germany	ROW[a]	
Canada	-0.322	0.082*	0.036	0.204	0.066
	(0.201)[b]	(0.048)	(0.029)	(0.170)	(0.450)
Mexico		-0.095*	0.002	0.011	-0.008
		(0.055)	(0.011)	(0.049)	(0.064)
Germany			-0.077**	0.039	0.005
			(0.035)	(0.032)	(0.041)
ROW[a]				-0.254	0.472
				(0.205)	(0.441)

***Significance at 1%, ** significance at 5%, *significance at 10%
a ROW represents rest of the world
b Asymptotic standards errors are reported in parentheses

Table 2-12. Conditional expenditure, compensated price and Cournot own-price elasticities from general model for U.S. chocolate imports, calculated at sample mean.

	Compensated price elasticities				Expenditure	Cournot own-price elasticities
Country	Canada	Mexico	Germany	ROW[a]		
Canada	-0.38	0.13	0.05	0.16	0.61***	-0.61**
	(0.26)[b]	(0.09)	(0.06)	(0.26)	(0.16)	(0.28)
Mexico	0.83	-0.68*	-0.01	-0.65	0.35	-0.78
	(0.55)	(0.38)	(0.14)	(0.58)	(0.65)	(0.60)
Germany	0.48	-0.01	-1.04**	0.57	0.57	-1.13*
	(0.57)	(0.22)	(0.51)	(0.69)	(0.38)	(0.68)
ROW[a]	0.17	-0.02	0.06	-0.20	1.57***	-0.47
	(0.28)	(0.11)	(0.07)	(0.33)	(0.21)	(0.34)

***Significance at 1%, ** significance at 5%, *significance at 10%
a ROW represents rest of the world
b Asymptotic standards errors are reported in parentheses

CHAPTER 3
FOOD SAFETY MEASURE AND COCOA EXPORTS: THE CASE OF PESTICIDE REGULATIONS

Introduction to the Chapter

Farmers have strong concerns about pests and diseases that attack their crops during production and storage as they cause crop losses, thus the use of agro-chemicals on cocoa is thought important to help decrease these losses and to reduce food shortage for consumers. Conversely, cocoa importing countries have raised important concerns about the health risks associated with the use of these chemicals in the production of cocoa beans. These food safety concerns relate to “pesticides residues, harmful substances such as Ochratoxin ‘A’ (OTA), Polycyclic Aromatic Hydrocarbons (PAH), Free Fatty Acids (FFA), and heavy metals such as lead and cadmium”, that are sometimes present in cocoa beans (ICCO, 2013). To remedy food safety concerns, the World Trade Organization (WTO), under the Uruguay Round Agreement on Agriculture (URAA), has implemented Sanitary and Phytosanitary (SPS) measures, consisting of health standards to protect human or animal health from food-borne risks; human health from animal- or plant-carried diseases; and animals and plants from pests or diseases. These standards can be imposed in many forms such as “*requiring products to come from a disease-free area, inspection of products, specific treatment or processing of products, setting of allowable maximum levels of pesticide residues or permitted use of only certain additives in food”* (WTO, 2013). As a result of food safety concerns related to the use of chemicals in the production of cocoa beans, the committee on pesticide residue of the Food and Agricultural Organization/ World Trade Organization (FAO/WHO), the Codex Alimentarius Commission (CAC), has implemented international pesticide regulations and is responsible for setting the maximum residue level (MRLs) of pesticide legally allowed in cocoa beans. Likewise, importing countries consumers of cocoa products (i.e. the U.S., EU, and Japan) have imposed their own pesticide regulations, which should be met by imported cocoa. The SPS agreement permits these individual countries to set their own standards, but if national standards are higher than international standards, they are required to be scientifically justified and to demonstrate that they are necessary to protect human, animal or plant life or health (WTO, 2013). Both the approximation on the expected pesticide residues in crops when the pesticide is applied conformingly to good agricultural practice (GAP) and the acceptable daily intake (ADI) for pesticide are used to determine the MRLs of pesticides (European Commission, 2013).

Food safety standards are viewed by consumers as a signal of product safety, therefore, if properly adhered, they can positively affect trade (Disdier et al., 2008). However, if not properly adhered, they can negatively affect trade. In other words if imported cocoa beans meet the required MRLs of pesticides, importing countries will be more willing to import cocoa beans whereas if imported cocoa beans do not meet the MRLs of pesticides, importing countries will be less willing to import cocoa beans or might not import at all. Hence, the impacts of food safety regulations on trade are ambiguous. In fact, developing countries in general encounter obstacles in trading in agricultural and food products due to food safety regulations imposed to them (Henson and Loader, 1999). They face financial and political constraints to participating in the SPS agreement and in meeting food safety measures (Henson and Loader, 1999).

This study aims to quantify the effects of selected pesticides standards (or MRLs of pesticides) on the trade flows of cocoa between developed countries –seven EU countries, U.S., Canada, and Japan – and five African, two Asian, and three Latin American countries during the period 2003 to 2012. We consider two pesticides, pyrethrins and benalaxyl, which are used, respectively, to treat cocoa beans in storage and to treat black pod diseases present in the cocoa. This paper also examines the effects of colonial ties and free-trade agreements between trading partners on the export of cocoa beans. Our aim is to infer policy implications from our findings.

Among the few studies (e.g., Otsuki et al., 2001; Moenius, 2004; Disdier et al., 2008; Wei et al., 2012; Yunus, 2009; Yue et al., 2010) on the impacts of food safety standards that have applied statistical or empirical analysis, none have examined the impacts of pesticide standards on cocoa exports. Thus, we contribute to this sparse empirical literature of the impacts of food safety standards by examining the impacts of a specific food safety standard, MRLs of pesticides allowed in cocoa, on cocoa exports.

This paper is organized as follows. We discuss, next, the trades in cocoa beans, background information relative to the types of pesticides use in the cocoa production, the literature review, the econometric specification, the data, and the analysis of the results. Finally, we provide a summary.

Trades in Cocoa Beans and Effects of Pesticide Regulations on Trades Flows in Cocoa Beans

According to the World Cocoa Foundation (2012), African countries are the dominant cocoa exporters supplying about 77% of net world exports of cocoa beans from 2006/07 to 2010/11. The top four producing and exporting countries are Cote d'Ivoire, Ghana, Nigeria, and Cameroon. Next, Asia and Oceania represent 16% of world production with Indonesia, Malaysia, and New Papua Guinea being the largest producers and exporters. Finally, the Americas make up 7% of world production with

Brazil and Ecuador as the largest producers and exporters. Total world exports of cocoa beans include exports of cocoa products converted to beans equivalent.

International trade of cocoa beans over the years has become important. The International Cocoa Organization (ICCO, 2013) reports that in 2010/2011, Africa and European Union (EU) trade represents 54% of world total trade of cocoa, Africa and North America trade represents 13%, and Africa and Asia trade represents 12% (Table 3-1). Also, Asian countries trade considerable amounts of cocoa among themselves, accounting for 10% of world total trade of cocoa, but little is traded with North America countries (1%) and EU countries (0.2%). Finally, Latin American and EU trade represents 3.1% of world total trade of cocoa, intra Latin American trade represents 2.7%, Latin American and North America trade represents 1.2%, and Latin American and Asia trade represents 0.3%.

Figure 3-1 represents the trend in cocoa exports from the top three exporting countries—Cote d'Ivoire, Ghana, and Indonesia— to the major trading partners considered for this study—seven EU countries, the U.S., Canada and Japan—from 2003 through 2012. In fact, during that same period (2003-2012), there has been an increase of 6% in the trade of cocoa from Cote d'Ivoire to the major importers. Similarly, there has been a growth of 24% in the trade of cocoa from Ghana to the major importers, and a growth of 2% from Indonesia to the major importers. The year 2009 experienced the highest increase in cocoa exports with a growth of 66% in cocoa exports from Cote d'Ivoire to the major importers, a growth of 187% in cocoa exports from Ghana to the major importers, and a growth of 113% in cocoa exports from Indonesia to the major importers.

Effects of Pesticide Regulations on Cocoa Trades

Figure 3-2 describes how pesticide standards or MRLs of pesticides allowed in cocoa affect cocoa exports both negatively and positively. Initially, in the absence of pesticide regulations, the price equilibrium, P_1, and the equilibrium quantity of coca beans, Q_1, are determined at the intersection of the supply curve S_1 and the demand curve D_1. Then, the imposition of pesticide regulations (i.e., MRLs of pesticide allowed in cocoa) on imported cocoa induces additional costs to producers in the production of cocoa, which leads to a decrease in the supply of cocoa shifting the supply curve left and upward, from S_1 to S_2. Thus, while the price of cocoa increases from P_1 to P_2, the quantities supplied of cocoa beans or cocoa exports decrease from Q_1 to Q_2. In this case, pesticide standards impact cocoa exports negatively. However, if the MRLs of pesticide are properly adhered, cocoa importing countries perceive cocoa as safe to import, thus they increase their demand for cocoa beans shifting the demand curve to the right from D_1 to D_2. In the case shown in Figure 3-2, the increase in the demand outweighs the decrease in supply of cocoa causing cocoa prices and cocoa exports to increase with a new price equilibrium, P_3, and a new quantity equilibrium, Q_3. However, it is also possible that the net effect of pesticide regulations can have an overall negative effect on cocoa exports.

Types of Pesticide Use in Cocoa Production

There are numerous types of pesticides used in the production and storage of cocoa beans. These pesticides are applied to treat black pod diseases, insects, weeds, stump and cocoa in storage. Pesticide use in cocoa can be categorized into three groups. The first group includes the strategic/recorded active substances for use in cocoa. The second group includes those pesticides that should be used with great caution, but which levels of residues are temporary, subject to change. The third group includes experimental control compounds for possible future inclusion (ICCO, 2013). Among all these groups of pesticides, we consider pesticides coming from the first group because they are already in use. Expert studies on pesticides maintain that pesticides used to treat cocoa beans in storage present the highest health risks, followed by insecticides applied on the farm, fungicides and herbicides (ICCO, 2013). For our study, we choose one commonly used pesticide—pyrethrin— from the lists of active ingredients (pesticides) used for the treatment of cocoa in storage, and we choose another, benalaxyl, among the list of fungicides used to treat black pod diseases (Table 3-2). We choose these pesticides because high residue levels of these pesticides have been discovered on imported cocoa beans to the EU and Japan (ICCO, 2013). The hazards or risks of pesticides have been classified into four aspects: pesticides that have acute risks to farmers and other spray operators in the short-run; pesticides that have a negative impact on the environment as they contaminate the air and the water; pesticide with residues remaining on food are risky for human health; and there is a longer term negative effects on human health (ICCO, 2013).

Clinical experiments were conducted on a group of mammals (e.g., rats, minces, dogs, and rabbits) to observe the effects of benalaxyl on them. They found that benalaxyl was quickly and extensively absorbed and dispersed by all organs and tissues, with the highest proportion of radioactivity residual in the intestine, in the liver and in the kidneys (small portion). However, its acute toxicity is low by the oral, dermal and inhalation way. Furthermore, benalaxyl does not irritate the eye or the skin, and there was no evidence for skin sensitization (EFSA, 2013).

Pyrethrins can enter the body by the oral route, when individuals consume foods contaminated by these pesticides, by breathing air that is contaminated by these pesticides, or through a dermal exposure. These pesticides have negative effects on humans. In fact, they affect the functioning of nerves and the brain. If a person’s skin gets in contact with a large amount of them, he or she may get “feelings of numbness, itching, burning, stinging, and tingling” that might last several hours. Also, if a great amount of pyrethrins enter a person’s body, he or she could get feelings of dizziness, headache, and nausea that could last for several hours (ATSDR, 2003).

Literature Review

Several studies exist on food safety standards and other non-tariff barriers, but very few have applied empirical analysis. In fact, data on food safety standards and non-tariff are scarce (Otsuki et al. 2001). Of the few, several researchers have applied a gravity model to examine the empirical effects of food safety standards on the trade flows. For instance, Otsuki et al. (2001) use a gravity model to investigate the effect of aflatoxin standards regulated by Europe on the trade flows of groundnuts between African countries and 14 EU countries, and Switzerland. They focused on two types of groundnut products: edible groundnuts and groundnuts for oilseeds. They found that tightening aflatoxin standards had a significant impact on the trade flows of edible groundnuts, but had no effect on the exports of groundnuts for oilseed. Indeed, a 10% reduction of the maximum allowable level of aflatoxin (tighter allowable level of aflatoxin) decreases exports of groundnuts by 11%. They also analyzed the effect of the standards over time and they found that the standards’ effect on the exports of edible groundnuts and oil seeds increased over time.

Disdier et al. (2008) examined the impacts of Sanitary and Phytosanitary (SPS) and Tariff Barrier to Trade (TBT) measures imposed by importing countries on bilateral trade flows between OECD countries. Their findings indicate that SPS and TBT standards negatively affect trade in agricultural commodities. Yunus (2009) applied an augmented gravity model to analyze the effect of the 1997 shrimp import ban imposed by EU and the effect of the hazard analysis and critical control points (HACCP) compliance on the volume of trade in shrimp from Bangladesh. Results indicated that the EU ban decreased Bangladesh shrimp exports, leading to losses of US$ 25 million worth of shrimp in the short run and a loss of US$ 5 million in the long run. However, the HACCP compliance was beneficial for Bangladesh's shrimp exports in that revenues that accrued from shrimp exports in the short run were enough to cover the total costs of the HACCP compliance with further surplus of US$ 18 million. In the long run, HACCP compliance boosted Bangladesh shrimp exports to the US$ by 35 million. Additionally, Wei et al. (2012) analyzed the effect of the MRLs of pesticides (e.g., endosulfan, fenvalerate and flucythrinate) and coverage requirements of regulated pesticides on China's tea exports over the 1996 through 2009. Their findings indicated that a 1% tighter MRLs of pesticides decreased tea export from China by 22%.

Gravity Model

The gravity model is one of the most successful and commonly utilized econometric models for the analysis of international trade (Moenius, 1999; Mahe, 1997). The concept of the gravity model started with Tinbergen (1962) and Pöyhönen (1963a, b). From their work, a vast literature to analyze the structure of international trade was developed. Analogically to the Newtonian theory, which implies that planets are mutually attracted in proportion to their sizes and proximity, in the gravity theory, the trade flows between two countries are proportional to the gross national products of the countries and inversely proportional to the distance between them. The empirics of the model were elaborated by Pulliainen (1963), Linnemann (1966), and Aitken (1973) through their analysis of the impact of regional trade agreements on trade flows.

Anderson (1979) was the first economist among many others (Helpman and Krugman, 1985; Bergstrand, 1985, 1989; Helpman, 1987; Deardorff, 1998; Evenett and Keller, 1998) to develop theoretical foundations of the gravity model. He provides a theoretical explanation of the model using the properties of expenditure systems, which involve the hypothesis of identical homothetic preferences across regions, implying that as income increases consumption increases proportionally. In the pure expenditure system model developed by Anderson (1979), the simplest gravity-type model is derived from a rearrangement of a Cobb-Douglas expenditure system. It is assumed in this expenditure system that each country is specialized in the production and export of one good, and no tariffs or transport costs exist.

Additionally, Anderson and van Wincoop (2003) contribute in the theory of the gravity model, discussing the importance of including multilateral resistance terms (MRT) or fixed effects in the gravity model. They state that empirical gravity literature either does not include any form of multilateral resistance or includes a theoretic "remoteness" variable related to distance to all bilateral partners. So the lack of a theoretical foundation for empirical gravity equations leads to two problems: first, biasness in the estimation results due to omitted variables; and, second, the inability to conduct comparative statics exercises. Anderson and van Wincoop develop a gravity model, which states that bilateral trade flows between two regions depend on their output, their bilateral distance, and whether they are separated by a border.

Chenery (1960) argues that income per capita, measured by GDP per capita, represents an exogenous demand side factor, and population (country size) is a supply-side factor. Further, he adds that, in cross-section data, trade flows are well explained by income and population. The exporting countries' GDPs indicate their ability to produce and supply goods and services, while the importers' GDPs show the capacity for importing countries to import and purchase goods and services. Trade flows should increase with GDP and decrease with population (Tinbergen, 1962; Pöyhönen, 1963a, b; Pulliainen, 1963; Linnemann, 1966). However, populated countries tend to rely on economies of scale to produce their goods, thus could trade more than countries with fewer markets. Therefore, the effects of population on trade can be sometimes uncertain (Brada and Mendez, 1983).

Past research (Soloaga and Winters, 2001; Frankel and Wei, 1993; Eichengreen and Irwin, 1998; and Sandberg and Seale, 2011) has shown the importance of including in the gravity model factors such as colonial ties, common language, and regional trade agreements. Sandberg and Seale (2011) show that all three factors increase trade. Distance is added to account for transaction cost (transportation costs) and is expected to have a negative effect on traded volumes (Tinbergen, 1962; Poyhonen, 1963a, b). We use a "partial" gravity model for our analysis. "Partial" because there is only a one-way trade between exporting and importing countries, and not bilateral trade. Otsuki et al. (2001) and Yue et al. (2010) have used this method as well for their analysis on the effects of food safety standards.

Our model specification is as follows:

$$\ln(X_{jit}) = \beta_{0j} + \beta_1 \ln(GDP_{jt}) + \beta_2 \ln(GDP_{it}) + \beta_3 \ln(pop_{jt}) + \beta_4 \ln(pop_{it}) + \beta_5 \ln(dist_{ji}) + \beta_6 \ln(ben_i) + \beta_7 \ln(pyr_i) + \beta_8 col_{ji} + \beta_9 FTA_{ji} + \beta_{10} africa + \beta_{11} southamerica + \varepsilon_{jit} \quad (3\text{-}1)$$

where X_{jit} represents the export value of traded cocoa from exporting countries j to importing countries i in year t. GDP_{jt} and GDP_{it} denote the GDP per capita for exporters and importers, respectively. Sandberg et al. (2011) demonstrates that GDP per capita is a better indicator than absolute GDP for measuring the effect of income on trade. POP_{jt} and POP_{it} are the population sizes of exporting and importing countries. The distance between trading partners is included as $dist_{ij}$. The variables ben_i and pyr_i denote the MRLs of benalaxyl and pyrtherins pesticides imposed by importing countries. Data on MRLs of pesticides set by EU are available only from 2008 to 2012 and are invariant for that period. With regards to the MRLs set by Japan, the U.S. and Canada, data are available only for the year 2011. Hence, following Otsuki et al. (2001), we assume that the allowable levels of pesticides (MRLs) are invariant for the period considered for our study, even though it might not be the case. MRLs variables are included to capture the impact of food safety standards on the traded cocoa. Col_{ji} and FTA_{ji} are dummy variables, which take the value 1 if the trading countries have colonial ties and a free trade agreement, respectively, and the value 0 otherwise. The variables *Africa* and *Southamerica* are dummies used to estimate continent effects. These fixed effects are included to account for any unobserved variations such as production technology and regulatory systems in the continents (Africa, South America, and Asia) over time. *Asia* is the omitted variable to avoid falling into the dummy-variable trap. β_{0j} represents the intercept of Asia, β_{10} and β_{11} are the dummy variable coefficients, denoting by how much the intercepts of Africa and South America differ from the intercept of Asia. ε_{ji} is an error term and is assumed to be normally and independently distributed. The model is in linear logarithms on exporters' GDPs, importers' GDPs, exporters' population, importers' population, distance, MRLs for benalaxyl, and MRLs for pyrethrins. Therefore, the estimated parameters are interpreted as elasticities. However, the parameters of the binary variables (i.e., colonial ties, free trade agreement, Africa and South America) must be converted into marginal effects for interpretation. The marginal effects of the binary variables are calculated by taking the exponential of the parameter estimate of each binary variable, e^{β_m}, where *m* represents a binary variable in the gravity model, and β_m is the parameter estimate of each binary variable (Sandberg, 2010). These marginal effects are interpreted relatively to the baseline trade behavior that is also the benchmark behavior. The baseline trade behavior denotes the case where all binary variables are equal to zero; that is when there is no colonial tie between trading countries, no free trade agreement between trading countries, and no continent effect.

Data Explanation and Source

This study uses data from several sources. Data on volume traded of cocoa are from the UNCOMTRADE website. GDP and population data are obtained from the World Development Indicators (WDI) database of the World Bank. The distance between exporting and importing countries is from the Institute for Research on the International Economy (CEPII, 2013). Pesticides database on MRLs is obtained from the international cocoa organization website (ICCO). We consider 10 major developed country importers of cocoa beans: seven EU countries (i.e., Netherlands, Germany, Belgium, France, Italy, U.K., and Spain), the U.S., Canada, and Japan. With regards to developing countries, we account for five African countries –Cote d'Ivoire (CI), Ghana, Nigeria, Cameroon, and Togo; three South American countries –Peru, Ecuador, Dominican Republic; and two Asian countries –Indonesia and Malaysia. These countries make the top exporting, developing countries of cocoa beans.

Empirical Results

Similar to other studies (Wang & Winters, 1992; Hamilton & Winters, 1992; Brulhart & Kelly, 1999; and Nilsson, 2000; Sandberg and Seale, 2011), we apply an annual cross-section analysis. Using ordinary least squares (OLS), we estimate ten annual cross section datasets across time from 2003 to 2012. Each annual cross section dataset has 100 observations. A usual problem that arises with cross-section analysis is the presence of heteroskedasticity (Sandberg and Seale, 2011). Consequently, we run the White's (1980) test to identify the presence of heteroskedasticity. Results of the White's test, although not reported, indicate that we reject the null hypothesis, the presence of homoscedasticity, meaning that the variances are heteroskedastic. To correct for this problem, we apply the robust standard errors or White-Huber standard errors, which adjust the weight of each error term (Huber, 1967; White, 1980). Results of the regression model on cross-section data across time are reported and discussed in Appendix C.

Additionally, we pool all ten cross-section data to analyze the overall effects of pesticide standards and other trade factors on cocoa bean exports. If pooling the data is appropriate, econometric results are improved and will lead to more accurate estimates than will a cross-section data analysis across time. To determine if pooling the data is appropriate, we perform an F-test.

F-test for pooled data: In this section we use an F-test to evaluate whether we should pool the data or not. This F-test consists of testing whether parameter estimates are statistically the same across time. If they are, we can then pool the data (Sandberg and Seale, 2011; Regmi et al., 2001).

Our hypotheses are as follow:

- The null hypothesis H_0 is that parameter estimates are the same across time.
- The alternative hypothesis H_a is that parameter estimates are different across time.

We compute the F-test using the formula

$$F_{df_1,df_2} = \frac{(SSE_p - \sum_t SSE_t)/df_1}{\sum_t SSE_t / df_2} \qquad (3\text{-}2)$$

where SSE_p is the sum of squared errors obtained from the pooled data regression. SSE_t is the sum of squared errors for each year, which are summed for all 10 years. Df_1 is the numerator degrees of freedom that are equal to the difference of the total number of unrestricted parameters from the 10 cross section regressions and the total number of restricted parameters from the pooled regression. Df_2 is the difference of the total number of observations in the pooled data and the total number of unrestricted parameters from the 10 cross-section regressions.

If the computed F-test statistics is greater than the F-critical value obtained from the F-distribution table, we reject the null hypothesis, implying that the parameter estimates are different across time, so we do not pool the data. If the F-test is less than the F-critical value, we fail to reject the null hypothesis, implying that the parameter estimates are statistically the same across time and that it is appropriate to pool the data. We obtain an F-test statistic equal to 1.242 whereas the F-critical value at the 5%

significance level is 1.256. Because the F-test statistics is less than the F-critical value, we fail to reject the null hypothesis; hence the parameter estimates are statistically the same across time, and pooling the data is appropriate.

Table 3-3 reports the results from the pooled data regression. The findings indicate that exporting and importing countries' GDPs per capita have positive effects on cocoa exports as expected, with elasticity estimates of 0.42 and 7.05, respectively. This means that a 1% increase in exporting countries' GDPs per capita increases cocoa exports by 0.42% while a 1% increase in importing countries' GDPs per capita increases cocoa exports by 7.05%. However, only importers' GDPs per capita are significant at the 5% level. Likewise, population coefficients for both trading partners are positive. The elasticity estimate of exporters' population is equal to the difference of exporters' GDPs-parameter estimate and exporters' population-parameter estimate (. This elasticity estimate is 0.96. The elasticity estimate of importers' population is equal to the difference of importers' GDPs-parameter estimate and importers' population-parameter estimate (. This elasticity estimate is -6.98. This means that as exporters' population increases by 1%, cocoa exports increase by 0.96% while for a 1% increase in importers' population, cocoa exports decrease by 6.98%. MRLs for benalaxyl have positive and significant effects on cocoa exports at the 5% level, with an elasticity estimate of 13.47. For a 1% decrease in MRL (tighter MRL), cocoa bean exports will increase by 13.7%. This means that, in terms of Figure 3-2, the benefits of compliance, which shifts the demand curve for cocoa up and to the right, outweighs the costs of compliance, the shift in the supply curve upward to the left. The net effect is positive. However, the coefficient of MRLs for pyrethrins is negative negative and significant indicating that its net effect on cocoa exports is negative, and a 1% decrease in MRL for pyrethrin would decrease cocoa exports from the studied countries by 3.37%. This means that, in terms of Figure 3-2, the costs of compliance outweigh the benefits of compliance. Numerous reasons can explain this negative outcome. Among them, one reason could be that adhering properly to the MRLs for pyrethrins might induce high costs (e.g. more capital invested in infrastructure and more labor) for cocoa producers than adhering to MRLs for benalaxyl does. Hence, these costs would induce producers to decrease their supply of cocoa beans more than they would in the case of benalaxyl. Importing countries still increase their demand for cocoa imports, but this time the decrease in the supply for cocoa outweighs the increase in the demand for cocoa, causing a negative effect of MRLs for pyrethrins on cocoa exports. Another reason could be that exporting countries tend to comply better with the allowable level of benalaxyl than that of pyrethrins. In fact, it can be that cocoa bean sacks are stacked on one another during their storage and some sacks might have been over treated with the pyrethrins pesticide. Therefore, at the inspection border, it can be that all cocoa sacks are rejected for importing because a few don't meet the MRLs standards.

Distance is negatively and statistically significant at the 1% level as expected with a coefficient equal to -4.10. This indicates that a 1% greater distance between trading countries of cocoa decreases cocoa trade by 4.1%. Similar to Sandberg, Seale, and Taylor (2006), regional trade agreement and colonial ties have positive impacts on trade with coefficients of 0.72 and 0.69, but these estimates are not significantly different from zero. The marginal effects of regional trade agreement and colonial ties are equal to $e^{0.72}$ and $e^{0.69}$, which give 2.05 and 1.99, respectively. This indicates that in the presence of colonial ties between cocoa exporting countries and cocoa importing countries, trade in cocoa is 1.99 times the baseline trade volume of cocoa beans. In another word, exporting countries with colonial ties trade 1.99 times more cocoa beans than those with no colonial ties. Additionally, in the presence of regional trade agreements between cocoa exporting countries and cocoa importing countries, trade in cocoa is 2.05 times the baseline trade volume of cocoa beans. In another word, exporting countries with a regional trade agreement trade 2.05 times more cocoa beans than those with no regional trade agreement.

Also, Africa and South America dummy variables are positive and significant at the 1% level, with coefficients of 4.17 and 6.45, respectively. This means that if all variables in the model were zero, African countries and South American countries would export more cocoa beans than Asian countries. The marginal effects of Africa and South America are equal to $e^{4.17}$ and $e^{6.45}$, which give 64.72 and 632.7, respectively. This indicates that African countries trade 64.72 times more cocoa beans than Asian countries (benchmark continent) and South American countries trade 632.7 times more cocoa beans than Asian countries.

Summary of the Chapter

This study examines the effects of pesticides standards also known as MRLs of pesticides on the trade flows of cocoa between seven EU countries, the U.S., Canada, and Japan, importers of cocoa beans, and five African, two Asian, and three Latin American countries, exporters of cocoa beans, during the period 2003 to 2012. We estimate the effects of two pesticides, pyrethrins and benalaxyl, which are used for the treatment of cocoa storage and for the treatment of black pod disease present in cocoa, respectively. This paper additionally examines the effects of GDP per capita, population, distance, colonial ties and free trade agreement between trading partners on cocoa exports. We use a partial gravity model—which means one-way trade between exporting and importing countries and not bilateral trade—on 10 years of annual cross section data to analyze the effects across years and on the data pooled. The F-test result indicates statistical evidence for pooling the data for our analysis.

Our findings from the pooled data analysis indicate that while the allowable levels of pesticide used to control pests and fungus, benalaxyl, is actually beneficial to trade, those used to control pest during cocoa storage, pyrethrins, decrease cocoa trade. In fact, MRLs of benalaxyl statistically increase the trade in cocoa, with an elasticity estimate of 13.47. This indicates that the benefits of compliance to MRL on benalaxyl outweigh the costs of compliance. This compliance provokes two things: it leads to higher costs in the production of cocoa, forcing producers to decrease their supply of cocoa beans, but at the same time it incites importing countries to increase their demand for cocoa beans because they perceive cocoa safe to import. This increase in the demand for cocoa outweighs the decrease in the supply of cocoa in the case of benalaxyl compliance. MRLs for pyrethrins, as opposed to MRLs for benalaxyl, decrease cocoa exports, with an elasticity estimate of -3.37. Two main reasons could explain this result: either pyrethrins have been overused on cocoa in storage, thus imported cocoa don't properly adhere to the standards so importing countries decrease their cocoa imports; or costs induced from complying with MRLs for pyrethrins are so high (higher than costs induced by MRLs for benalaxyl) that producers decrease considerably their supply of cocoa beans. So, although producers are able to comply with the standard, which pushes up the demand for cocoa beans, this increase in the demand does not outweigh the decrease in supply due the cost of MRL compliance for pyrethrins. Hence, cocoa exports decrease overall. Other reasons could be:

- Inefficiency by the cocoa market board in providing specific information on pesticides and other SPS concerns to all stakeholders in the supply chain, and this hinders cocoa producers to comply with the standards.
- The lack of adequate infrastructure to monitor and to enforce pesticide standards and the shortage of highly skilled personnel, and these hinder cocoa producers to comply with the standards.

To remedy the negative effects of MRLs for pyrethrins on cocoa exports, we suggest an increase of skilled personnel for the treatment of cocoa beans, but of course this requires additional finances from the cocoa board. Next, cocoa producers could use some financial aid from either the government or outsiders (i.e., importing countries). Also, having access to adequate infrastructure will help producers properly meet pesticide standards. For example, in Gambia, the Agriculture and Pest Management Unit (APMU) offers support to producers and traders in dealing with export markets (Henson and Loader, 1999).

Furthermore, similar to Sandberg, Seale, and Taylor (2006), Sandberg and Seale (2011), and Disdier et al. (2008), we found that exporter' s and importer' s GDPs per capita and exporter's population have positive effects on cocoa exports, whereas distance has a negative effect. However, importer's population has a negative effect on cocoa trade. Also, the marginal effect of regional trade agreement is 2.05 and that of colonial ties is 1.99. This indicates that in the presence of a regional trade agreement, cocoa exporting countries trade 2.05 times more cocoa beans than when there is no regional trade agreement between trading countries. Likewise, in the presence of colonial tie, cocoa exporting countries trade 1.99 times more cocoa beans than when there is no colonial tie between trading countries.

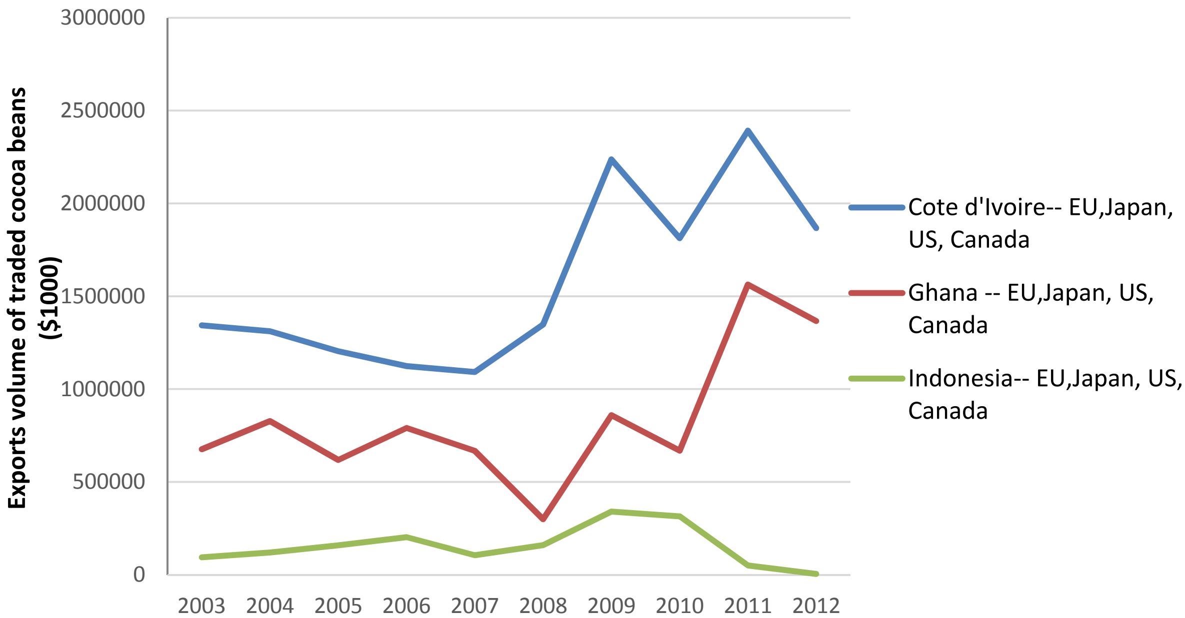

Figure 3-1. Trade flows in cocoa beans between the top three exporting countries of cocoa and their major partners

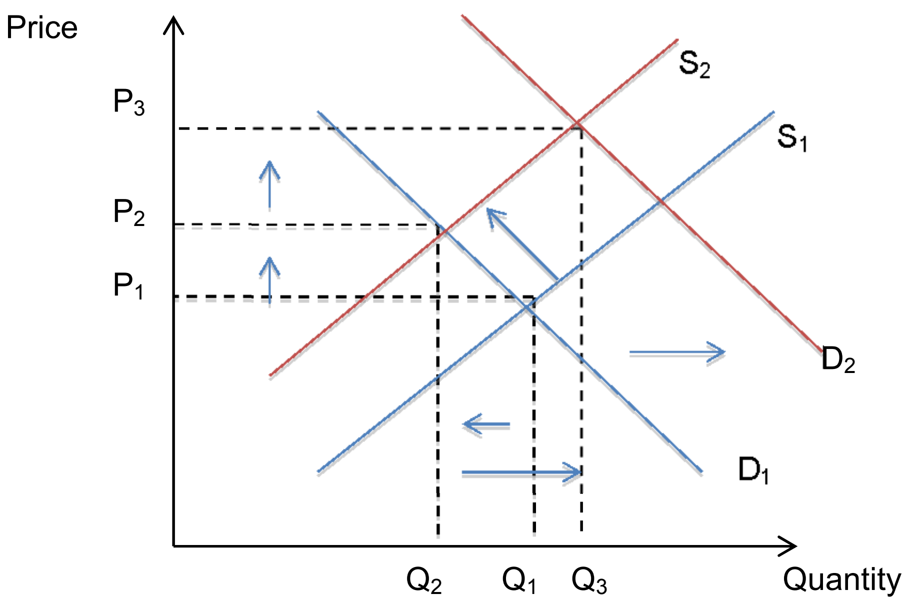

Figure 3-2. Supply and demand curve showing the negative and positive effects of MRLs of pesticide on cocoa exports

Table 3-1. Exports of cocoa beans by region[a]

	Regions	Exports of Cocoa Beans (% of world total)		
Origin	Destination	2002/03	2006/07	2010/11
Africa	EU	56.9	52.2	54
Africa	Other Europe	3	0.1	0.2
Africa	Africa	0.7	0.3	0.3
Africa	North America	9.4	10.4	13
Africa	Latin America	0.7	0.6	0.9
Africa	Asia	6.4	11	12.4
Latin America	EU	2.1	3.8	3.1
Latin America	Other Europe	0	0	0.1
Latin America	Latin America-Africa	0	0	0
Latin America	North America	2.4	1.9	2.7
Latin America	Latin America	0.3	0.3	1.2
Latin America	Asia	0.5	0.6	0.3
Asia	EU	0.6	0.6	0.2
Asia	Other Europe	0	0	0
Asia	Africa	0	0	0
Asia	North America	3.4	3	1
Asia	Latin America	1.8	3.1	0.4
Asia	Asia	11.6	12	10.2
World	World	100	100	100

Source: ICCO report, 2012.
[a]means regional exports as percentage of world exports of cocoa beans. Totals may differ from sum of constituents due to rounding.

Table 3-2. The choice of pesticide

Treatment	EU status	EU MRL	Japan MRL
(i) Black pod diseases			
Active ingredients			
Benalaxyl	Y	0.1	0.01
		Cu ions:	
Copper hydroxide	Y	50.0	
Copper oxide	Y	—	
Copper oxychloride	Y	—	
Fosetyl aluminium	Y	2	0.05
Dimethomorph (DMM)	Y	0.05	0.01
Mandipropamid	P	0.02	0.01
Metalaxyl (unresolved)	Y	0.1	0.2
Metalaxyl-M (mefenoxam)	Y	0.1	0.2
(ii) Insects			
Active ingredients			
As sprays (mostly against Miridae)			
Acetamiprid	Y	0.1	0.01
Beta-cyfluthrin	Y	0.1	0.1
Bifenthrin	Y	0.1	0.1
Clothianidin	—	0.05	0.02
Cypermethrin-all isomers:	Y	0.1	—
Cypermethrin (isomer)	Y	0.1	0.03
Deltamethrin	Y	0.05	0.05
Lambda-cyhalothrin	Y	0.05	0.01
Imidacloprid	—	0.05	0.05
Novaluron	P	0.01	0.02
Teflubenzuron	Y	0.05	0.02
Thiacloprid	Y	0.05	0.02
Thiamethoxam	—	0.05	0.02
(iii) Weeds and stump treatments			
Active ingredients			
Riclopyr	Y	0.1	0.03
Glyphosate salts	Y	0.1	0.2
(iv) Stored produce			
Active ingredients			
Aluminium phosphide	Y	0.05	0.01 (as hydrogen phosphide)
Magnesium phosphide	Y	0.05	—
Pyrethrins (pyrethrum) for fogging	Y	0.5	0.01
Pyrethroids (treating sackes,etc.)	—	—	—

Source: ICCO, 2013
 indicates no MRL is given in Japan; Dash (—) indicates not applicable
Y indicates Yes; P indicates Pending

Table 3-3. Results of the logarithmic regression model for pooled data

Lexp	Coefficient	Robust Standard Error
Lgdpe	0.420	0.473
Lgdpi	7.048***	1.273
Lpope	1.380***	0.256
Lpopi	0.069	0.285
Lben	13.474**	6.768
Lpyr	-3.374***	1.364
Ldist	-4.101***	0.626
FTA	0.723	0.718
Colony	0.688	0.659
Africa	4.169***	0.997
South America	6.445***	0.689
Constant	-59.723***	15.802

Table notes:
Lexp represents logarithm of export volume
Lgdpe represents logarithm of exporters' GDP
Lgdpi represents logarithm of importers' GDP
Lpope represents logarithm of exporters' population
Lpopi represents logarithm of importers' population
Lben represents logarithm of benalaxyl pesticide
Lpyr represents logarithm of pyrethrin pesticide
Ldist represents logarithm of distance
FTA represents free trade agreement
Asterisks denote levels of significance: * for 10% ** for 5% *** for 1%

CHAPTER 4
COCOA MARKETS EFFICIENCY IN MAJOR COCOA PRODUCING COUNTRIES: A COINTEGRATION APPROACH

Introduction to the Chapter

The last 40 decades have experienced ups and downs in world cocoa prices. The period 1977-2005 has exhibited mainly downward movements in world prices whereas the period 2006 to 2010 has experienced steady increases in these prices (Figure 4-1). However, movements in cocoa producer or farm-gate prices in developing countries do not always follow those of world prices over the period 1977 through 2010 (Figure 4-2). In fact, governments in developing countries have developed policies consisting of direct tax on exports and subsidy mechanisms, and quantitative restrictions, which tend to isolate producer prices from world price movements. Competitive sectors in world markets have been taxed while less competitive sectors have been subsidized, leading to a reallocation of resources from successful to less successful sectors. These policies have been widely criticized for their inefficiency, causing several developing countries to adopt reforms under structural adjustment programs during the mid-1980s and early 1990s (Baffes and Gardner, 2003).

Before the 1980s, much of West Africa's cocoa was produced and marketed under state-controlled systems, meaning that the government was the regulator of the cocoa chain. Considerable changes in export commodity markets and other shocks lead to a drop in the price of cocoa and other raw commodities in the world market. In the mid-1980s and 1990s, with the support of the World Bank and the International Monetary Fund, most West African cocoa producers began to reform their cocoa marketing and pricing systems. Among the four major producing countries in West Africa (i.e., Cote d'Ivoire, Ghana, Nigeria, and Cameroon) plus Togo, Ghana was the slowest adopter, undertaking a partial liberalization only in 1999-2000, after years of modest changes. Cote d'Ivoire also adopted reform gradually, but fully liberalized its market after August 1999. Nigeria, Cameroon and Togo undertook instead drastic reforms and came quickly to full liberalization. The reform consisted of eliminating government marketing actions and statutory controls in output and input markets, replacing prices set by the government with prices determined by the market, diminishing taxes on cocoa exports, and privatizing marketing (Akiyama et al., 2001). Furthermore, the reform aims to improve producers' prices and get these prices close to international prices. As opposed to market reforms of cocoa beans in West African countries, Indonesia's marketing and pricing systems were always free of government interventions until April 1, 1995, when there was the imposition of a value added tax (VAT) on the marketing of cocoa (Akiyama and Nishio, 1996). In fact, there have been no marketing boards, export quotas or special trade licensing requirements affecting agricultural commodities in Indonesia. Likewise, after the market reforms in West Africa, producer prices started to increase both in absolute values and as a percentage of the free on board (f.o.b.) price. For instance in Cameroon, Nigeria, and Togo, producer prices rose from about 45%, 20%, and 60 % of the f.o.b. price, respectively, prior to the reforms to over 70 %, 80%, and 80% subsequently (Akiyama et al., 2001). This indicates that market reforms have positively affected producer prices. While statistics on prices have showed a rise or amelioration in producer prices, no empirical study has yet analyzed whether the movements in producer prices in major African producing countries of cocoa beans have gotten closer to those of world prices after the reforms.

This study investigates two main questions: first, have policy reforms undertaken by West African cocoa producing countries to a closer relationship between world cocoa prices and producer prices? Second, has the 1995 imposition of a VAT on Indonesia's cocoa exports pushed producer prices in Indonesia away from world cocoa prices? Consequently, first, we examine the transmission of world prices to domestic prices before and after policy reforms over the period 1975 through 2010. Our assumption is if there is a better or higher transmission of prices after reforms than before reforms, policy reforms have been effective. The countries considered for this study are Nigeria, Cameroon, Cote d'Ivoire (CI), and Ghana. We focus on these countries because they are the top four West African producing countries of cocoa beans worldwide, producing together 71% of world cocoa beans supply, and they have all adopted some degree of market policy reforms in the mid-1980s and early 1990s.

Second, we investigate the effects of the imposition of a VAT on Indonesia's cocoa exports on the transmission of world cocoa prices to producer prices in Indonesia before and after the imposed tax during the same time period (1975-2010). This second objective is important in that results could be useful to infer some policy measures for the Indonesia government, but also could be expanded to other major cocoa producing countries (e.g., West African countries), where export taxes or VAT have been imposed for decades. In fact, these results could be used to draw interesting policy implications for West African countries as well.

Few studies (Baffes and Gardner, 2003; Beck, 1994; Dawe, 2008; Mundlak and Larson, 1992; Morisset, 1998; Mofya-Mukuka and Abdulai, 2013) have investigated the transmission of world commodity prices to domestic or producer prices, and most of these studies are outdated. The closest work to this current study is that of Baffes and Gardner (2003) who investigated the effects of policy reforms on the transmission of world price signals to producer prices for ten commodities including cocoa beans and in eight countries including only one cocoa producing country: Ghana. This current study contributes to the sparse literature on price transmission by focusing mainly on the cocoa crop and on its major producing countries. Also, the time period for this study (1975-2010) allows us to provide an update of the effects of policy reforms on the transmission of world prices to producer prices. Additionally, no study has investigated before the effects of export taxes (or VAT) on the transmission of world prices to producer prices.

This paper is organized as follows. We discuss next the market reforms, followed by discussions of international prices of cocoa beans, of the literature review, of concepts of time-series data. We continue with discussions of the cointegration method, of the data source, and of results. Finally, we provide a summary.

Market Reforms

Marketing boards and stabilization funds came under pressure in the 1990s from major donors of financial assistance. Although critics of the reforms claim that the pressure was ideologically motivated, other factors need to be taken into account.

- Cocoa prices were at low levels in the late 1980s and early 1990s and stabilization agencies failed to maintain higher producer prices due to budgetary issues and corruption (Gilbert, 2007).
- There was no transparency in the operations of marketing boards and stabilization funds.
- The administrative pricing systems imposed high marketing costs (Gilbert, 2007).
- High operational costs and low world cocoa prices impacted on farmer’s income.

The cocoa marketing and pricing systems are differentiated into three categories: free marketing systems, marketing board systems, and price stabilization funds. A free marketing system is a system where the price regulations are left to the market mechanism, but it is not totally a noninterventionist system because the government can interfere in the market regulation at any time if deemed necessary. However, the government is more likely to intervene in the “quality control, taxation, and typical monitoring and supervision” (Gilbert, 2007). The countries that have adopted the free marketing system include Brazil, Cameroon (since 1994-1995), Cote d’Ivoire (since 1999), Indonesia, Malaysia, and Nigeria (since 1986). The marketing board system is the opposite of the free marketing system. A parastatal agency has control over the internal and external crop marketing from the purchasing of the crop to its exports. Ghana follows this system, and Nigeria did as well until 1986. The stabilization fund is similar to the marketing board system in the sense that internal prices are set by the government. Cameroon had this system until 1994-95 as well as Cote d’Ivoire until August 1999 (Akiyama, 2001, p. 40).

Many agricultural policy reforms were not adopted straightforward but instead were gradually established over many years. Some countries have initiated reform actions aimed to render parastatal agencies more efficient in their governance of the cocoa marketing, and more transparent vis a vis their setting of cocoa prices for farmers. We define, for our study, the structural break as the latest reform undertaken by the included countries. Cameroon started reforming its cocoa market in the early 1990s, and adopted its latest reform, the free market system, in 1994-1995. Cote d’Ivoire begun a partial liberalization of its cocoa marketing in 1995, which came into full liberalization in 1999-2000. Ghana adopted modest reforms in 1992-1993, until it finally established a partial reform in 1999-2000, where the government still controls the external marketing of cocoa. Nigeria adopted a drastic and full liberalization of its cocoa marketing in 1986 (Akiyama, 2001, p. 52-66).

The cocoa market in Indonesia has always followed a free marketing system and exports of cocoa beans have always been free of taxes until 1995. In fact, in April 1, 1995, Indonesia government imposed a value added tax (VAT) on the exports of cocoa beans in Indonesia (Akiyama and Nishio, 1996). We provide next background information on how international prices or world prices of cocoa beans are recorded and factors that influence these prices.

International Price of Cocoa Beans

The International Cocoa Organization is responsible for recording cocoa bean international prices. Created in 1973, the International Cocoa Organization (ICCO) is a global organization located in London, and its members include cocoa producing and cocoa consuming nations. The first International Cocoa Agreement negotiation occurred in Geneva at the creation of the organization, during a United Nations International Cocoa Conference. Seven other agreements have followed.

Cocoa international prices are recorded on a daily basis and calculated by taking "the average of the quotations of the nearest three active futures trading months on the New York Stock Exchange (NYSE) liffe futures and options and the Intercontinental Exchange (ICE) futures at the time of London closing "(ICCO, 2012). Three major factors affect the international prices of cocoa beans: trends in the supply and demand of cocoa beans; political and social conditions in the major producing countries; and weather conditions. The growth rate in supply and demand for cocoa is measured by the grinding of cocoa beans and has fluctuated over the last 35 years. Econometric analyses have proven that about 85% of price fluctuations are due to the difference in the stocks-to-grindings ratio (ICCO, 2012). Therefore, cocoa bean prices diminish as the stocks-to-grindings ratio rises. Furthermore, due to the ongoing political and social crisis in 2002 in Cote d'Ivoire (the leading cocoa producing country), there were concerns about the flow of cocoa beans being disrupted, leading to a hike in international prices.

Literature Review

Many studies have utilized cointegration techniques. Among the few recent contributions, Baffes and Gardner (2003) investigated the transmission of world price movements to domestic prices for eight countries and ten commodities using a cointegration method. They also analyzed the effects of policy reforms undertaken by these countries on the movements between world prices and domestic prices. They found evidence that policy reforms adopted in the included countries have diminished distortions between commodity prices in these countries and world prices. However, in most of the country-commodity cases, they did not find a significant effect of reforms on either short-run transmission or long-term adjustment of domestic to world prices. They also found that, at the time of the reform, the short-run transmission of world prices to domestic prices increased considerably in six cases out of the 11 cases.

Furthermore, Mofya-Mukuka and Abdulai (2013) analyzed the effects of policy reforms on the transmission of world coffee prices to domestic prices in Zambia and Tanzania, using monthly observations of Arabica coffee producer prices from January 1986 to September 2008. Their model consisted of a momentum-based threshold cointegration and threshold ECM. They found that producer prices in Zambia were more responsive to the decreases than the increases in world prices after policy reforms while before reforms producer prices were almost stable because decreases and increases in world prices were not passed on rapidly to producer prices. Their findings for Tanzania indicated that, overall, producer prices responded faster to increases than to decreases in world prices. Before policy reforms, these prices responded faster to decreases than to increases in world prices whereas after reforms they responded faster to increases than to decreases in world prices.

Additionally, Mundlak and Larson (1992) investigated the correlation between domestic and world prices of agricultural commodities. They examined whether the fluctuations in world prices are transmitted to domestic prices, and, if so, how much of these fluctuations contribute to the fluctuations in domestic prices. They solved these questions by applying a regression model, which draws on the law of one price where the domestic price of commodities is expressed as a product of the world price, the nominal exchange rate, and the tax policy. Their results indicated that most of the variations in world prices were transmitted to domestic prices and these variations constituted the dominant component in the variations of domestic prices.

Morriset (1998) used data from six countries and seven commodities to look at the gap between international and domestic prices in commodity markets during 1975-94. He found that the downtrend in world commodity prices were not transmitted or were transmitted imperfectly to domestic consumer prices. However, the upward movements in world prices were perfectly transmitted to domestic consumer prices.

Beck (1994) applied two tests of market efficiency in five US commodity future markets using cointegration techniques. The first test aimed to determine whether the spot and futures price series are cointegrated. The second test aimed to investigate the possibility that spot prices rely on past spot prices in addition to current futures prices. The results showed that all seven markets are sometimes inefficient but no market rejected efficiency all the time. Their results also indicated that the ECM is the most general specification form.

The Concepts of Time-Series Data

For decades, econometricians have used conventional statistical methods to analyze stationary random series (Kirchgässner et al., 2012). They omitted the possibility that time-series data could be integrated, until Granger and Newbold (1974) came up with a different way of analyzing economic time series. They argued that the methods used in the past could cause a spurious regression problem. Granger (1981) was the first economist to develop the theory of time-series data and cointegration methods. Many other studies on cointegration and error correction models followed later (Engle and Granger, 1987; Granger, 1983; Johansen, 1988; Kirchgässner et al., 2012).

A time series, “an individual economic variable”, happens to drift considerably from another time series. In this case, economists will suggest some forces that can maintain these series closer to each other (Engle and Granger, 1987). Also, economic theory suggests the use of “equilibrium”, a fixed point, toward which the economy is constantly pushed back by economic forces whenever it drifts away. Time-series data are stationary if their mean, variance, and autocovariance remain constant independently of the time periods at which they are measured, implying that a stationary time series is time invariant. On the contrary, nonstationary time series data have variant means and variances that depend on the time period (Charemza and Deadman, 1992, p. 118; Gujarati, 2003, p. 798). Stationary time series will have the tendency to go back to their means and their variances, with a steady magnitude (Cuthbertson et al., 1995). One might ask: why is it crucial for time series to be stationary? According to Gujarati (2003, p. 798), a stationary time series allows us to examine its reaction over several periods, while if a series is nonstationary, we can observe its reaction only for the actual time periods.

Method

We begin our analysis by testing the unit root of each included African country's time series of price data before and after policy reforms and during the entire period of the study (1975-2010). We perform the same unit root test on Indonesia's time series of price data before and after the imposition of a VAT and during the entire period of the study. Hence, we use the augmented Dickey-Fuller (ADF) test and the Philips-Perron (1998) (PP) test (as unit root tests) to evaluate whether or not the time series of price data are stationary (Dickey and Fuller, 1979; Engle and Granger, 1987). The difference between the ADF and the PP test is that, unlike the ADF test, the PP test uses nonparametric statistical methods instead of lagged difference to account for the presence of serial correlation in the error term, if any (Gujarati, 2003, p. 818). If the time series of price data are nonstationary, taking their first differences, which is the difference between the actual price at time t and their lagged value at time t-1, will often make them stationary. However, if the data are integrated at a higher level, say of degree two, I (2), we would have to take second differences to get a stationary series.

Next, we test for cointegration between world prices and producer prices or farm-gate prices before and after policy reforms and during the entire period of the study. Two variables are said to be cointegrated if there exists a long run, or equilibrium relationship between them (Gujarati, 2003, p. 822). Following Baffes and Gardner

(2003); Isard (1977); Richardson (1978); and Mundlak and Larson (1992), the most straightforward test of price cointegration uses the following ordinary least square (OLS) regression (expressed in logarithms):

$$p_{it}^{d} = \beta_1 + \beta_2 p_t^{w} + \mu_t \qquad (4\text{-}1)$$

where p_{it}^{d} represents the annual domestic price (in US$) of the cocoa commodity for each country i at time t; and p_t^{w} the annual world price of cocoa at time t; and μ_t is the error term. β_2 is the long-run price transmission effect or the long-run relationship between domestic prices and world prices, and β_1 is the constant.

We regress log of p_{it}^{d} on log of p_i^{w} as expressed in Equation (4-1), and we perform the ADF and PP tests on the residuals obtained from Equation (4-1) to test for cointegration in the prices. It can happen that the time series are nonstationary but still cointegrated; in this case the OLS regression denotes a cointegrating regression of the long-run relationship of the two sets of prices. However, in case the time series are nonstationary and not cointegrated, the OLS regression leads to a spurious regression (Seale et al., 2013). In fact, the regression of two nonstationary time series variables can lead to autocorrelation (with a very high R^2) even though there is no relationship between the two variables (Engle and Granger, 1987). Depending on the outcomes from the OLS regression, we can estimate two models. On one hand, if we fail to reject the cointegration test, we apply the error correction model (ECM) used, first, by Sargan (1984) and later popularized by Engle and Granger (1987). On the other hand, if the cointegration test is rejected, we use the first differenced price time series and fit them to our OLS regression in Equation 4-1 (Maddala and Kim, 1998, p.24; Seale et al., 2013).

The ECM is as follows (expressed in logarithms):

$$\Delta p_{it}^{d} = \alpha_0 + \alpha_1 \Delta p_t^{w} + \alpha_2 \mu_{t-1} + \varepsilon_t \quad (4\text{-}2)$$

where $\mu_{t-1} = p_{t-1}^{d} - \beta_1 - \beta_2 p_{t-1}^{w}$ denotes the equilibrium error term and one period lagged value of the residual μ_t in Equation 4-1. α_1 denotes the short-run price transmission effect. α_2 is the estimate of the error correction term or equilibrium error term or speed of adjustment (Gujarati, 2003; Baffes and Gardner, 2003). ε_t is a random error term.

Equation 4-1 can be written as:

$$\mu_t = p_{it}^{d} - \beta_1 - \beta_2 p_t^{w} \quad (4\text{-}3)$$

Then, μ_{t-1} is derived from Equation 4-3. If the estimate of the equilibrium error term (μ_{t-1}) is statistically nonzero, it means that the model is not in equilibrium, and needs to be corrected to return to equilibrium, hence the name error correction model (ECM). If the equilibrium error term is statistically zero, then the model is in equilibrium, meaning that the dependent variable adjusts to the variations in the explanatory variable in the same time period (Gujarati, 2003, p. 825).

Data

The dataset for this study is time-series data ranging from 1975 to 2010. It comprises producer price data (in domestic currency) for five countries (i.e., Cote d'Ivoire, Ghana, Nigeria, Cameroon, and Indonesia) obtained from the Food and Agricultural Organization (FAO) statistics, world prices (in $ U.S) data obtained from the International Cocoa Organization (ICCO), and exchange rates data for the five countries obtained from the World Development Indicators (WDI) dataset. We use the countries' exchange rates to convert producer prices from their domestic currencies to U.S. dollars so that our prices are all in U.S. dollars. Also, we use the Atlas method of the World Bank for exchange rates. "The Atlas conversion factor for any year is the average of a country's exchange rate for that year and its exchange rates for the two preceding years, adjusted for the difference between the rate of inflation in the country and international inflation" (World Bank, 2014). The objective of the adjustment is to diminish any changes in exchange rates that can be caused by inflation.

When converting producer prices from domestic currencies to U.S. dollars, we obtain producer prices for Ghana and Nigeria higher than world prices for certain years. Hence, we decide to delete the years where Ghana and Nigeria's producer prices are higher than world prices from the price datasets for Ghana and Nigeria. So, we delete the year 1982 from the time period 1975-2010 for the Ghanaian time-series-price data, and we delete the years 1988 and 1994 to 1998 from the period 1975-2010 for the Nigerian time-series-price data.

Analysis of Results

We examine the effects of policy reforms on the transmission of world cocoa prices to producer prices in West African countries and the effects of the imposition of a VAT on the transmission of world cocoa prices to producer prices in Indonesia. First, we test the stationary of producer prices in Cote d'Ivoire, Ghana, Nigeria, and Cameroon before and after policy reforms and over the whole period of the study (1975-2010). Likewise, we test the stationary of producer prices in Indonesia before and after the imposition of a VAT and over the entire period of the study. The year of adoption of the reforms differs from one country to another. Results are reported in Table 4-1. The augmented Dicker-Fuller (ADF) unit root tests show that only Nigeria prices are stationary at the 5% level of significance after reforms (after 1986) and for the entire period. The Phillips-Perron (PP) unit root tests report that Ghana and Cameroon have stationary prices at the 5% level after reforms (after 2000) and before reforms (before 1995), respectively. Producer prices for Cote d'Ivoire and Indonesia are nonstationary at all periods. Although not reported in the results, taking the first difference of producer prices for Cote d'Ivoire and Indonesia will lead to stationary prices.

Next, we test for cointegration between world prices and producer prices in each West African country before and after market reforms and in Indonesia before and after the imposition of a VAT, using the OLS regression model (Equation 4-1). This allows us to examine the long-term relationships or long-run price transmission between the different sets of prices. We apply once again the augmented Dicker-Fuller (ADF) to test the stationarity of the residuals derived from the OLS regression. If these residuals are stationary, then the sets of prices are cointegrated and we use the ECM. If they are not stationary, the cointegrating regression results in a spurious regression, and we use the first-difference model.

Results of the OLS regressions or cointegrating regressions are reported in Table 4-2. For all four countries, OLS residuals are stationary for Cote d'Ivoire and for Ghana only after their reform adoptions. This indicates world prices are cointegrated with producer prices in Cote d'Ivoire and producer prices in Ghana after reforms, with elasticity estimates of 0.87 and 0.93, respectively. Similarly, OLS residuals are stationary for Cameroon only before reforms. This implies that world prices are cointegrated with producer prices in Cameroon, with elasticity estimate of 0.69.

Because the OLS residuals are nonstationary before the adoption of reforms in Cote d'Ivoire and Ghana, and are nonstationary after the adoption of policy reforms in Cameroon, cointegrating regressions lead to spurious regressions for Cote d'Ivoire and Ghana before reforms and for Cameroon after reforms. Thus, we use the first-difference model for Cote d'Ivoire, Ghana, and Cameroon instead of the ECM. However, Nigeria has stationary residuals both before and after the reforms, thus we use the ECM for Nigeria. The elasticity estimate for Nigeria increases from 0.69 before reforms to 1.53 after reforms, implying that world prices and producer prices in Nigeria are better cointegrated after policy reforms that before reforms. Additionally, Indonesia has stationary residuals before and after the imposition of a VAT, but this VAT leads to a slight decrease in the cointegration or long-run relationship between world prices and producer prices in Indonesia, decreasing from 0.67% to 0.58%. We use as well the ECM for Indonesia. Table 4-3 reports results of ECM, but we interpret only those of Nigeria and Indonesia because they have results of ECM for both before and after reforms, hence we can compare these results and observe the effects of reforms on the price transmission. Elasticity estimates obtained from the ECM represent short-run price transmission effects between world prices and producer prices. These estimates increase from 0.18% before the 1986 reform adoption in Nigeria to 0.49% after the reform adoption. This means that, in the short run, the reforms have lead to a faster price transmission of world prices to producer prices in Nigeria, thus producer prices in Nigeria get closer to world prices more quickly after the reforms than before the reforms. Also, in the short run, elasticity estimates for Indonesia increase as well from 0.07% before the imposition of a VAT in 1995 to 0.09% after the VAT. This means that in the short run world prices are slightly better transmitted to producer prices in Indonesia after the implementation of a VAT. This result was not expected. However, the difference is small and statistically the same as zero indicating there is no significant change in the speed of price transmission before and after the imposition of VAT. Perhaps this is due to exporters not having enough time in the short-run to pass on their tax burden to producers or farmers.

Cointegrating regressions for Cote d'Ivoire, Ghana, and Cameroon at certain periods (either before or after reforms) could be spurious because their residuals are nonstationary; hence we apply the first-difference model for these three countries. Results of the first-difference model are reported in Table 4-4. Estimates of the first-difference model show the adoption of reforms in Cote d'Ivoire, Ghana, and Cameroon has lead to a larger price transmission of world prices to producer prices, hence producer prices in these three countries move closer to world prices after the adoption of reforms. In fact, the short-run elasticity estimates increase from 0.16% before 1999 to 1.30% after 1999 for Cote d'Ivoire; from 0.04% before 2000 to 1.10% after 2000 for Ghana; and from -0.09% before 1995 to 0.67% after 1995 for Cameroon.

Summary of the Chapter

During the mid-1980s and early 1990s, governments in West Africa have implemented policy reforms in the cocoa sector aimed at improving producer prices. This paper examines the effects of policy reforms on the transmission of world prices to producer prices in four West African countries over the period 1975-2010. Our assumption is, if there is a larger transmission of world prices to producer prices after the reforms than before, the policy reforms have been effective. Additionally, for decades, the cocoa sector in Indonesia was free of any government intervention until

April 1, 1995 when the government imposed a VAT on cocoa exports. This paper examines as well the effect of the imposition of a VAT on the transmission of world prices to producer prices in Indonesia over the same period (1975 -2010). We expect that the imposition of a tax on cocoa exports in Indonesia will lead to a lower price transmission or would push producer prices in Indonesia further away from world prices.

Results from the OLS or cointegrating regression report that elasticity estimates of the long-run relationship or long-run price transmission between producer prices and world prices increase after the reforms for all four West African cocoa producing countries. This indicates that policy reforms led to a higher long-run price transmission, moving world prices and producer prices closer.

However, the elasticity estimate of the long-run relationship or long-run-price transmission between world prices and producer prices in Indonesia decreases slightly from 0.67% to 0.58% (a decrease of 0.09%) after the imposition of a VAT. Thus, the producer prices and world prices tend to move slightly away from each other in the long run after imposing VAT. It was expected that producer prices would move away from world prices after the tax imposition because as exporters pay taxes on their exports, they induce additional costs and tend to pass these costs to producers by reducing the prices of cocoa beans offered to farmers. However, we were expecting producer prices would move further away from world prices.

Furthermore, results of ECM indicate that once again policy reforms improve the short-run transmission of world prices to Nigerian producer prices, increasing the elasticity estimate from 0.18% before 1986 to 0.49% after 1986. As opposed to the long-run effect, the imposition of a VAT leads this time to a slight increase (0.02%) in the short-run-price transmission effect in Indonesia, but this increase is insignificant. Although this result was not expected, it does make sense because in the short run exporters do not have enough time to react and pass on their tax burden to producers, thus the transmission of world prices to producer prices would either stay the same or get slightly higher.

For Ghana, Cote d'Ivoire, and Cameroon, we use the first-difference model because their OLS residuals are nonstationary either before or after reforms, which could lead to spurious cointegrating regressions. Similar to Nigeria, elasticity estimates of the short-run effect increase after the market reforms, implying that policy reforms improve the short-run co-movements between world price signals and producer prices in Cote d'Ivoire, Ghana, and Cameroon. Hence, world prices and producer prices in Cote d'Ivoire, Ghana and Cameroon get closer after reforms than before reforms.

We can conclude that policy reforms undertaken by the major West African producing countries of cocoa beans were effective because they lead to a higher price transmission of world prices to producer prices in the long run and in the short run. However, the imposition of a VAT on Indonesia cocoa exports had no significant effect on price transmission. In fact, it had a slightly negative effect (a decrease of 0.09%) on the long run transmission of world prices to producer prices and a slightly positive effect (an increase of 0.02%) on the short run price transmission. We can expand this finding to West African cocoa producing countries, which have always been exposed to export taxes by giving an inverse interpretation for West African countries. So, eliminating export taxes in West African cocoa producing countries will positively affect the transmission of world prices to producer prices, but only in the long run because in the short run there will be either no effect or there will be a slightly negative effect. In fact, in the long run exporters will have enough time to pass on the increases in their revenues (due to the elimination of taxes) to farmers by offering higher prices to farmers, causing producer prices to get closer to world prices while in the short run they will not have enough time to pass on their increases in revenues so producer prices will still be low. Additionally, if we were to apply exactly the results obtained for Indonesia to West Africa, we can say that the elimination of export taxes will not significantly impact the transmission of world prices to producers' prices in West Africa because they did not significantly affect the transmission of world prices to producer prices in Indonesia (again we give an inverse interpretation for West Africa as compared to Indonesia).

Table 4-1. Stationary tests of producer prices and world prices, expressed in logarithm

		Pre-reform		Post reform		Whole period of study (1975-2010)	
	Reform year	ADF	PP	ADF	PP	ADF	PP
World	__	__	__	__	__	-2.774	-2.067
Cote d'Ivoire	1999-2000	-1.543	-1.741	-1.682	-1.381	-2.458	-2.416
Ghana	1999-2000	-1.934	-2.921	-0.527	-0.160	-2.327	-3.424*
Indonesia	1995	-1.676	-1.709	-1.279	-1.022	-1.824	-1.763
Nigeria	1986	-1.521	-2.002	-3.018*	-2.261	-2.250*	-2.756
Cameroon	1994-1995	-1.993	-3.036*	-0.832	-0.330	-0.388	-1.146

Notes: ADF is the Augmented-Dickey Fuller test and PP is the Philips-Perron test.
* indicates stationary time-series price data at the 5% significance level.
With regards to the ADF critical values, the 5% critical value for the whole period of study is -2.978; the 5% critical values before and after reforms are -3.000.
With regards to the PP critical values, the 5% critical value for the whole period of study is -2.067, and the 5% critical values before and after reforms are -3.000.

Table 4-2. Logarithmic OLS regression of time-series price data

		Pre-reform period			Post reform			Both combined (1975-2010)		
	Reform year	Constant		ADF	Constant		ADF	Constant		ADF
Cote d'Ivoire	1999-2000	—[a]	—	—	0.185	0.867***	-3.759	2.529***	0.564***	-3.078
		—	—		(1.972)	(0.266)		(0.934)	(0.125)	
Ghana	1999-2000	—	—	—	-0.133	0.928***	-4.496	1.114	0.740***	—
		—	—		(1.098)	(0.147)		(1.075)	(0.144)	
Indonesia	1995	1.923	0.667***	- 3.120	2.659)**	0.580***	-3.858	2.351***	0.616***	-3.827
		(1.172)	(0.155)		(1.212)	(0.163)		(0.829)	(0.111)	
Nigeria	1986	5.021**	0.313	-4.837	0.245	0.949***	-3.316	2.040**	0.702***	-4.744
		(1.949)	(0.251)		(0.980)	(0.133)		(0.853)	(0.113)	
Cameroon	1994-1995	1.362	0.687	-3.243	—	—	—	—	—	—
		(3.23)	(0.427)		—	—		—	—	

Notes: ADF is the Augmented-Dickey Fuller test and PP is the Philips-Perron test.
All reported ADF indicate stationary residuals at the 5% significance level.
[a] Dash(—)indicates not applicable.
Asterisks denote levels of significance: * for 10% ** for 5% *** for 1%.
denotes the long-run price transmission effect or the long-run relationship between the word prices and producer prices.
The 5% critical values of ADF test for the whole period of study is -2.994; and the 5% critical values of ADF test before and after reforms are -3.000.

Table 4-3. Logarithmic Error Correction Model (ECM)

		Pre-reform period			Post reform			Both combined (1975-2010)		
	Reform year	Constant	Short-run effect	Residuals lagged	Constant	Short-run effect	Residuals lagged	Constant	Short-run effect	Residuals lagged
Cote	1999-	—	—	—	-0.160	1.236**	-1.036**	0.033	0.313*	-0.615***
d'Ivoire	2000	—	—	—	(0.106)	(0.438)	(0.344)	(0.039)	(0.185)	(0.162)
Ghana	1999-	—	—	—	-0.010	1.127***	0.327	0.032	0.307	-0.064
	2000	—	—	—	(0.075)	(0.335)	(0.249)	(0.051)	(0.236)	(0.202)
Indonesia	1995	-0.029	0.074	-0.559	0.071	0.093	-0.674**	0.016	0.088	-0.585***
		(0.042)	(0.190)	(0.181)	(0.049)	(0.253)	(0.243)	(0.031)	(0.144)	(0.138)
Nigeria	1986	0.024	0.177	-0.374	0.027	0.486*	-0.374*	0.029	0.295**	-0.340***
		(0.038)	(0.137)	(0.143)	(0.046)	(0.267)	(0.208)	(0.031)	(0.139)	(0.127)
Cameroon	1994-	-0.260	-0.086	-1.150	—	—	—	—	—	—
	1995	(0.179)	(0.727)	(0.249)	—	—	—	—	—	—

Notes: ADF is the Augmented-Dickey Fuller test and PP is the Philips-Perron test.
All reported ADF indicate stationary lagged residuals at the 5% significance level.
[a] Dash(—)indicates not applicable.
Asterisks denote levels of significance: * for 10% ** for 5% *** for 1%.
denotes the short-run price transmission effect between the world prices and producer prices.

Table 4-4. Logarithmic first-difference model

	Reform year	Pre-reform period		Post reform		Both combined (1975-2010)	
		Constant	Short-run effect,	Constant	Short-run effect,	Constant	Short-run effect
Cote d'Ivoire	1999-2000	-0.014	0.163	-0.037	1.299*	0.002	0.478**
		(0.038)	(0.172)	(0.138)	(0.621)	(0.048)	(0.215)
Ghana	1999-2000	0.030	0.035	-0.039	1.104***	0.032	0.323
		(0.063)	(0.279)	(0.074)	(0.347)	(0.050)	(0.226)
Cameroon	1994-1995	0.018	-0.085	0.049	0.668	0.044	0.233
		(0.254)	(1.096)	(0.120)	(0.559)	(0.145)	(0.648)

Asterisks denote levels of significance: * for 10% ** for 5% *** for 1%
denotes the short-run price transmission effect between the world prices and producer prices.

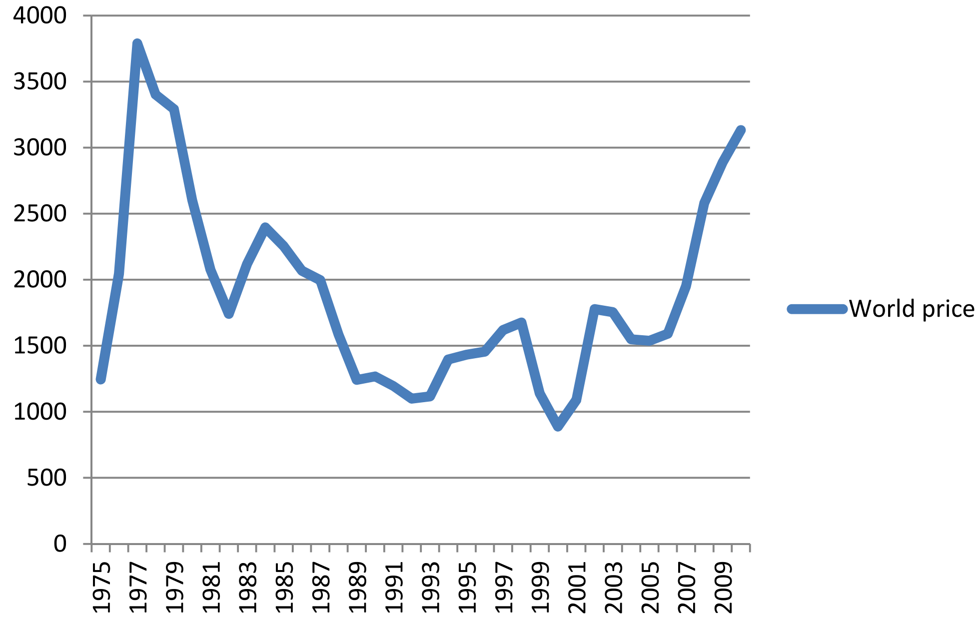

Figure 4-1. Trends in world prices of cocoa beans (in $US) from 1975 to 2010

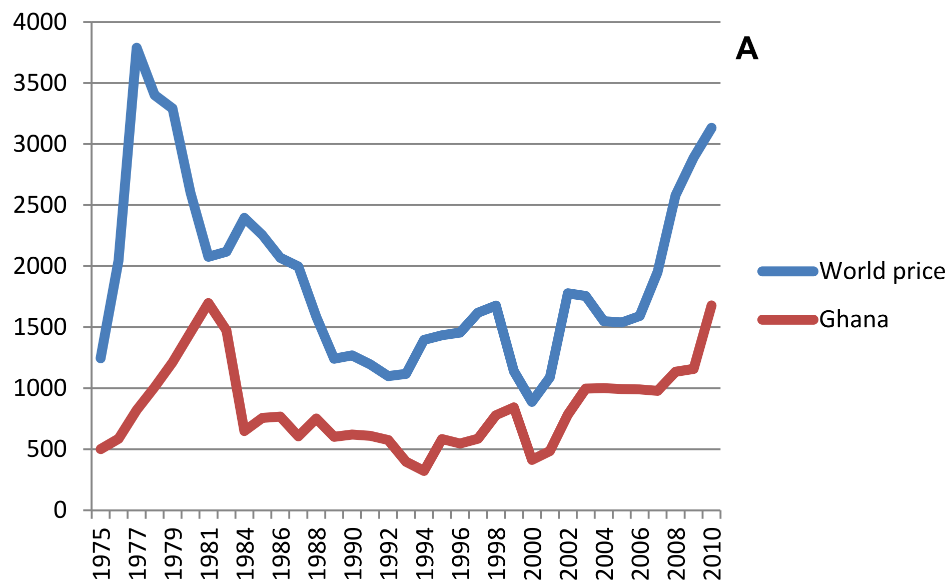

Figure 4-2. Comparisons in the trends between world prices and domestic prices of cocoa beans (in $US) from 1975 to 2010. A) Ghana B) Indonesia C) Cote d'Ivoire D) Cameroon E) Nigeria.

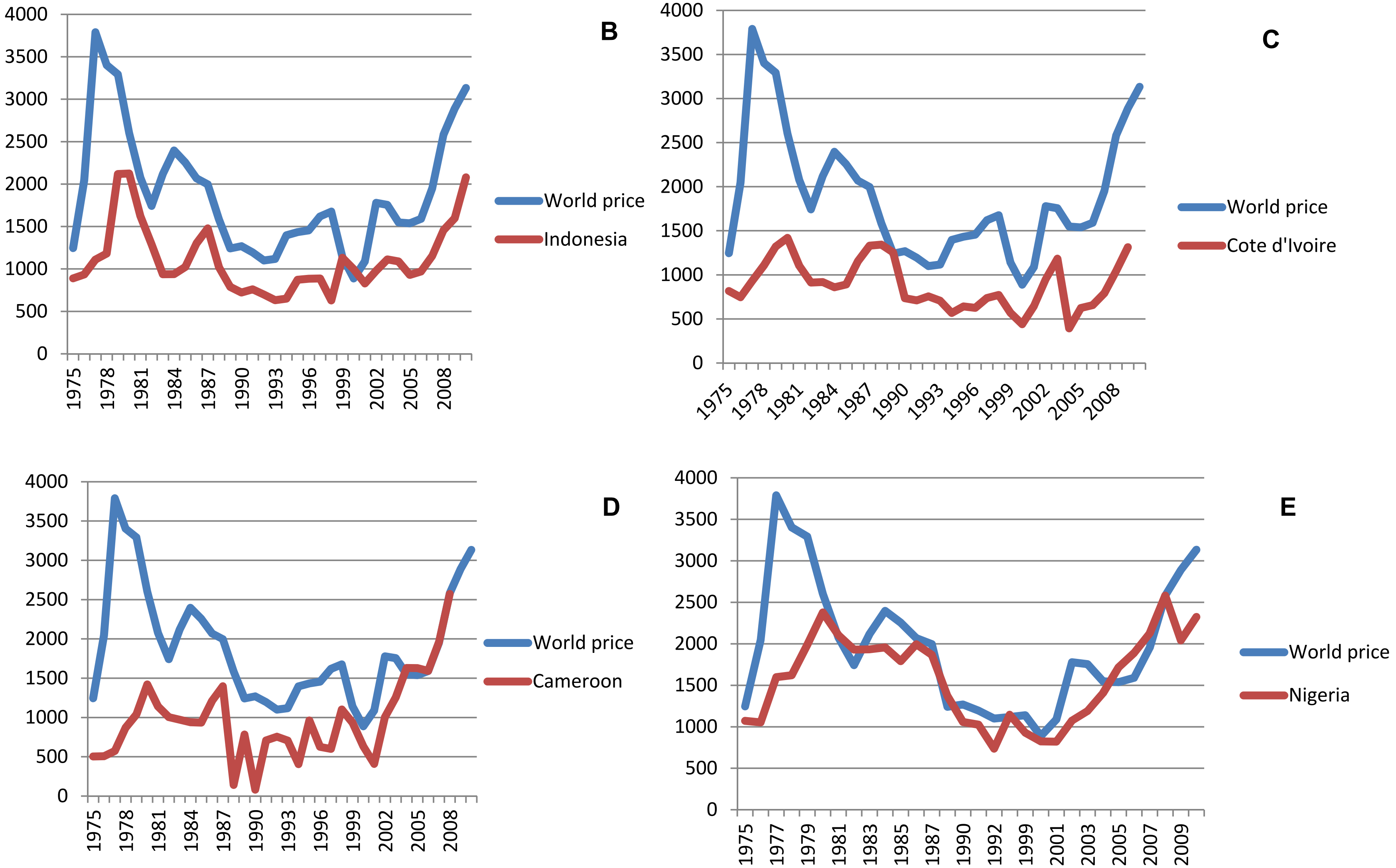

Figure 4-2. Continued

CHAPTER 5
CONCLUSION

This study analyzes three important issues related to the cocoa market and implicitly to cocoa producers and exporters. The first essay attempts to look for ways to increase revenues of cocoa and chocolate exporters from the marketing of cocoa products. In order to come up with the best cocoa pricing strategies, we estimate expenditure and price elasticities of U.S. import demand for cocoa beans and chocolate by country of origin, using four differential demand systems (i.e., the AIDS, the CBS model, the NBR model, and the Rotterdam model). The general model is then used to test which of the four demand systems best fits the data. The time period for this study ranges from 1986 to 2011 for cocoa beans data and from 1986 to 1991 for chocolate data. The likelihood-ratios test indicate that the Rotterdam model best fits the cocoa beans data, whereas the Rotterdam and CBS models both fit the chocolate data well. However, Barten (1993), Lee, Brown, and Seale (1994) argue that the general model is a more flexible model than the other demand models; hence we discuss only the outcomes of the general model and their implications.

The Cournot and Slutsky own-price elasticities indicate that demand of cocoa beans is elastic for Cote d'Ivoire and the ROW, but demand from Cote d'Ivoire is more elastic than that from the ROW. Thus, exporters of cocoa beans from both countries (Cote d'Ivoire and the ROW) will increase their revenues by reducing cocoa prices, but Cote d'Ivoire's exporters could reduce their prices more than the ROW's exporters in order to maximize revenues. Demand of cocoa beans from Indonesia is unitary own-price elastic, implying that the quantity demanded changes proportionally to the change in price. In this case, a change in own-price will not affect exporters' total revenues;

revenues will stay constant no matter the change in own-price. Similarly, chocolate industries in Germany can increase their revenues by reducing the price of chocolate because the Slutsky own-price and Cournot own-price of chocolate are elastic for Germany. Additionally, expenditure elasticities are elastic for Ecuador (1.38), Cote d'Ivoire (1.17), and Indonesia (1.01). This indicates that as U.S. total expenditure on cocoa beans increases by 1%, the U.S. will import 1.38% more cocoa beans from Ecuador, 1.17% more from Cote d'Ivoire, and 1.0% more from Indonesia. Also, expenditures at the sample mean are inelastic for Canada, indicating that the U.S. quantity demanded of chocolate from Canada increases by less than 1% (by exactly 0.61%) as U.S. total expenditure on chocolate increases by 1%.

Developing countries have faced obstacles (i.e. financial obstacles) in trading in agricultural and food products due to the food safety regulations initiated through the SPS agreement (Henson and Loader, 1999). Hence, the second essay primarily examines the effects of food safety standards, particularly the benalaxyl and pyrethrins pesticide standards on cocoa exports, but also examines the effects of other trade factors such as GDPs, population, colony ties, distance, and free trade agreement on cocoa exports. We find from the pooled data analysis that while the allowable levels of pesticide (i.e. MRLs of pesticide) used to control pests and fungus, benalaxyl, is actually beneficial to trade, those used to control pest during cocoa storage, pyrethrins, decrease cocoa trade. This indicates that if exporting/developing countries of cocoa are able to comply with the standards of benalaxyl pesticide, thus making importing countries to feel safe to import cocoa beans, importing countries will increase their cocoa imports. However, MRLs for pyrethrins decrease cocoa exports. Two main reasons could explain this result: the first reason could be either pyrethrins have been overused on cocoa in storage, implying that the standards are not properly met, thus importing countries will decrease their imports of cocoa beans; or costs induced by complying with MRLs for pyrethrins are so high (higher than costs induced by MRLs for benalaxyl) that producers decrease considerably their supply of cocoa beans. Thus, although the demand for cocoa beans increase when producing countries are able to comply with the standards, this increase in the demand does not outweigh the decrease in the cocoa supply, causing cocoa exports to decrease overall.

Additionally, we found positive effects of exporters and importers' GDPs on cocoa exports similar to Sandberg, Seale, and Taylor (2006), Sandberg and Seale (2011), and Disdier et al. (2008). While exporters' population has a positive and significant effect on cocoa trade, importers' population has a negative and insignificant effect on cocoa trade. Distance has a negative effect on cocoa trade as well whereas colonial ties and regional trade agreement positively impact cocoa trade.

During the mid-1980s and early 1990s, governments in West Africa countries, particularly in Cote d'Ivoire, Ghana, Nigeria, and Cameroon have implemented policy reforms in the cocoa sector aimed at improving producer prices. The third essay examines the effects of policy reforms on the transmission of world prices to producer prices in four West African countries over the period 1975-2010. Also, for decades, these governments have imposed export taxes on cocoa exports. Meanwhile, the cocoa sector in Indonesia was free of any government intervention until April 1, 1995 when the government imposed a VAT on cocoa exports. Hence, this essay examines as well the effect of the imposition of a VAT on the transmission of world prices to producer prices in Indonesia over the same period (1975 -2010).

Results from the OLS or cointegrating regression indicate that elasticity estimates of the long-run relationship or long-run price transmission between producer prices and world prices increase after the reforms for all four West African cocoa producing countries. This indicates that policy reforms led to a higher long-run price transmission, moving world prices and producer prices closer.

However, the elasticity estimate of the long-run relationship or long-run price transmission between world prices and producer prices in Indonesia decreases slightly from 0.67% to 0.58% (a decrease of 0.09%) after the imposition of a VAT. Thus, the producer prices and world prices tend to move slightly away from each other in the long run after imposing VAT.

Furthermore, results of ECM indicate that once again policy reforms improve the short-run transmission of world prices to Nigerian producer prices, with an increase in the elasticity estimate from 0.18% before 1986 to 0.49% after 1986. As opposed to the long-run effect, the imposition of a VAT leads this time to a slight increase (0.02%) in the short-run-price-transmission effect in Indonesia, but this increase is insignificant.

For Ghana, Cote d'Ivoire, and Cameroon, we use the first-difference model because the OLS residuals of these countries are nonstationary either before reforms or after reforms. Similar to Nigeria, elasticity estimates of the short-run effect increase after the market reforms, implying that policy reforms improve the short-run co-movements between world price signals and producer prices in Cote d'Ivoire, Ghana, and Cameroon. Hence, world prices and producer prices in Cote d'Ivoire, Ghana and Cameroon get closer after reforms than before reforms.

We can conclude that policy reforms undertaken by the major West African producing countries of cocoa beans were effective because they lead to a higher price transmission of world prices to producer prices in the long run and in the short run. However, the imposition of a VAT on Indonesia cocoa exports had no significant effect on the price transmission.

APPENDIX A
DERIVATION OF THE AIDS MODEL

In the appendix A, we demonstrate the steps to obtain the AIDS model in the form of Equation (2-15b). Let's recall the AIDS in Equation (2-15a) written as

$$dw_i = \beta d\log Q + \sum_j \gamma_{ij} d\log p_j . \tag{A-1}$$

We know that

$$dw_i = w_i d\log w_i \text{ and} \tag{A-2}$$

$$w_i = \frac{p_i q_i}{m} . \tag{A-3}$$

Equivalently we can write

$$d\log w_i = d\log p_i + d\log q_i - d\log m . \tag{A-4}$$

Thus,

$$dw_i = w_i(d\log p_i + d\log q_i - d\log m) . \tag{A-5}$$

We replace the left-hand side dw_i in Equation (A-1) by the right-hand side of Equation (A-2) to obtain

$$w_i(d\log p_i + d\log q_i - d\log m) = \beta d\log Q + \sum_j \gamma_{ij} d\log p_j , \tag{A-6}$$

$$w_i d\log q_i = d\log m - d\log p_i + \beta d\log Q + \sum_j \gamma_{ij} d\log p_j . \tag{A-7}$$

Furthermore, we have this relation from above,

$$d\log m = d\log P + d\log Q . \tag{A-8}$$

We substitute *dlogm* in Equation (A-7) by the right-hand side of Equation (A-8) to have

$$w_i d\log q_i = w_i d\log P + w_i d\log Q - w_i d\log p_i + \beta d\log Q + \sum_j \gamma_{ij} d\log p_j \tag{A-9}$$

We can transform (A-9) to have

$$w_i d\log q_i = (w_i + \beta) d\log Q + w_i (d\log P - d\log p_i) + \sum_j \gamma_{ij} d\log p_j \quad \text{(A-10)}$$

where

$$d\log P = \sum w_i d\log p_i . \quad \text{(A-11)}$$

Substituting Equation (A-11) into Equation (A-10) gives us

$$w_i d\log q_i = (w_i + \beta) d\log Q + w_i (\sum w_i d\log p_i - d\log p_i) + \sum_j \gamma_{ij} d\log p_j . \quad \text{(A-12)}$$

After transformation we obtain

$$w_i d\log q_i = (w_i + \beta) d\log Q - w_i (1 - \sum w_i) d\log p_i + \sum_j \gamma_{ij} d\log p_j . \quad \text{(A-13)}$$

Next, insert the kronecker delta, $\delta_{ij} = 1$ if i=j, $\delta_{ij} = 0$ if $i \neq j$, to obtain

$$w_i d\log q_i = (w_i + \beta\ ) d\log Q - w_i (\delta_{ij} - \sum_j w_j) d\log p_j + \sum_j \gamma_{ij} d\log p_j . \quad \text{(A-14)}$$

We finally obtain the AIDS in the form of Equation (2-15b) as

$$w_i d\log q_i = (w_i + \beta) d\log Q + \sum_j (\gamma_{ij} - w_i (\delta_{ij} - w_j)) d\log p_j . \quad \text{(A-15)}$$

APPENDIX B
DERIVATION OF THE GENERAL MODEL

In the appendix B, we demonstrate the steps to derive the general model. The four functional models accounted for in our study are unnested and can be written in a general form as (Barten, 1993):

$$y_{it} = X_t \beta_j + u_{jt} \, . \qquad \text{(B-1)}$$

where the n-vector y_{it} is the j-th nonlinear data transformation of a vector of basic endogenous variables. X_t is an n x k matrix of exogenous variables, and β_j is a vector of coefficients, specific for each system. The n-vector u_{jt} are disturbance terms.

Barten (1993) introduces two ways to derive the general model: the pairwise comparison and the higher-order comparison. For more convenience, we prefer to use the higher order comparison where we can write more generally,

$$\alpha_R y_{Rt} + \alpha_C y_{Ct} + \alpha_A y_{At} + \alpha_N y_{Nt} = X_t \gamma + \upsilon_t \, , \qquad \text{(B-2)}$$

where

$$\gamma = \alpha_R \beta_R + \alpha_C \beta_C + \alpha_A \beta_A + \alpha_N \beta_N \, . \qquad \text{(B-3)}$$

We normalize the function by allowing the α_j to add up to one, and we eliminate α_R.

We can write this relation as an extension of the pairwise comparison (see Barten, 1993 P-150):

$$y_{Rt} = X_t \gamma + \alpha_c (y_{Rt} - y_{Ct}) + \alpha_A (y_{Rt} - y_{At}) + \alpha_N (y_{Rt} - y_{Nt}) + \upsilon_t \, . \qquad \text{(B-4)}$$

Also we have

$$y_{Rt} - y_{Ct} + y_{At} - y_{Nt} = 0 \text{ and} \qquad \text{(B-5)}$$

$$(y_{Rt} - y_{Ct}) - (y_{Rt} - y_{At}) + (y_{Rt} - y_{Nt}) = 0 \, . \qquad \text{(B-6)}$$

We can use Equation (B-6) to rewrite the general model as

$$y_{Rt} = X_t\gamma + (\alpha_c + \alpha_A)(y_{Rt} - y_{Ct}) + (\alpha_A + \alpha_N)(y_{Rt} - y_{Nt}) + \upsilon_t$$
$$y_{Rt} = X_t\gamma + \delta_1(y_{Rt} - y_{Ct}) + \delta_2(y_{Rt} - y_{Nt}) + \upsilon_t \quad \text{(B-7)}$$

where

$$y_{Rt} - y_{Ct} = w_i d\log q_i - (w_i d\log q_i - w_i d\log Q) = w_i d\log Q \text{ and} \quad \text{(B-8)}$$

$$y_{Rt} - y_{Nt} = w_i d\log q_i - (dw_i + w_i d\log Q). \quad \text{(B-9)}$$

We use both relations

$$dw_i = w_i(d\log p_i + d\log q_i - d\log m) \text{ and} \quad \text{(B-10)}$$

$$d\log m = d\log P + d\log Q \quad \text{(B-11)}$$

to rewrite Equation (B-9) as

$$y_{Rt} - y_{Nt} = w_i d\log q_i - \{w_i(d\log p_i + d\log q_i - d\log P - d\log Q)\} - w_i d\log Q \quad \text{(B-12)}$$

$$y_{Rt} - y_{Nt} = w_i(d\log P - d\log p_i) \quad \text{(B-13)}$$

$$X\gamma = \theta_i d\log Q + \sum_j \pi_{ij} d\log p_j. \quad \text{(B-14)}$$

We can write the general model using Equations (B-8), (B-13), and (B-14):

$$w_i d\log q_i = \theta_i d\log Q + \delta_1 w_i d\log Q + \delta_2 w_i(d\log P - d\log p_i) + \sum_j \pi_{ij} d\log p_j + \upsilon_t. \quad \text{(B-15)}$$

We use the kronecker delta $\delta_{ij} = 1$ if i=j, $\delta_{ij} = 0$ if $i \neq j$ and make some transformation to obtain the general model as

$$w_i d\log q_i = (\theta_i + \delta_1 w_i) d\log Q + \sum_j [\pi_{ij} - \delta_2 w_i(\delta_{ij} - w_j)] d\log p_j + \upsilon_t. \quad \text{(B-16)}$$

Replacing θ_i by $d_i = \delta_1\beta_i + (1-\delta_1)\theta_i$ and π_{ij} by $e_{ij} = \delta_2\gamma_{ij} + (1-\delta_2)\pi_{ij}$, our general model is

$$w_i d\log q_i = (d_i + \delta_1 w_i) d\log Q + \sum_j [e_{ij} - \delta_2 w_i(\delta_{ij} - w_j)] d\log p_j + \upsilon_t \,. \qquad \text{(B-17)}$$

APPENDIX C
RESULTS OF CROSS-SECTION DATA ANALYSIS ACROSS TIME

We report results of the regression model on 10 annual cross-section datasets over the period 2003 throughout 2012. We perform a cross-section data analysis across time so that we can examine the effects of pesticide standards and other trade factors (i.e., GDPs, population, colony ties, distance, and free trade agreement) on cocoa trade year by year. MRLs of benalaxyl and pyrtehrins were constant throughout the considered time period, thus we do not expect much variations in their effects on cocoa exports over time.

Table C-1 reports the estimated coefficients along with the robust standard errors. MRL coefficients for benalaxyl are positive for all years except in 2004. The positive coefficients on benalaxyl vary from 1.06 to 43.15 contrary to our expectation, but only one is positive and significant, 43.15 in 2003 at the 10% significance level. The average of the parameters on the allowable level of benalaxyl is 18.96. On the contrary, the MRL coefficients for pyrethrins are negative for all years except in 2007. The negative ones vary from -7.86 to -0.70. However, the estimates are only negative and significant in 2008 (-7.86) and 2011 (-7.16) at the 10% significance level. The average of the parameters on the allowable level of pyrethrins is -3.32. Additionally, on average, exporting countries' GDPs per capita have positive effects on the cocoa exports except in the years 2003 to 2005. The positive parameters on exporting countries' GDPs per capita vary from 0.66 to 3.06. Importing countries' GDPs per capita have positive coefficients for all years except in 2007, with an average elasticity rof 8.33. This means that importing countries' GDPs per capita, on average, have positive effect on cocoa exports. The positive importing countries' GDPs per capita vary from 0.87 to 16.71.

Furthermore, elasticity estimates for exporters' population is equal to the difference between exporter's population-parameter estimates and exporter's-GDPs- per-capita -parameter estimates. Elasticity estimates for importers' population is equal to the difference between importer's population-parameter estimates and importer's-GDPs-per-capita -parameter estimates. Exporters' population, with an average elasticity of 1.11, positively impact cocoa trade while importers' population on average has a negative impacts on cocoa trade, with an average elasticity of -7.72. The negative elasticity estimates of exporters' population vary from -0.85 to -0.16 and the positive ones vary from 1.15 to 3.66. The negative elasticity estimates of importers' population vary from -15.49 to -1.85 and only the year 2007 has a positive elasticity estimates of importers' population, which is 1.43 On average, distance has a negative effect on cocoa trade as well, with an average elasticity estimate of -4.09. Coefficients of distance for all years are negative and vary from -7.36 to -1.33. Colonial ties and free trade agreement have positive effects on cocoa trade, with average elasticity estimates of 0.76 and 1.82, respectively. The negative coefficients of colonial ties vary from -1.69 to -0.71 and the positive ones vary from 0.77 to 2.65. Coefficients of free trade agreement are positive for all years, except in 2009 (-3.00), and they vary from 0.11 to 7.19. Also, if all variables in the model were zero, on average, African countries and South American countries would export more cocoa beans than Asian countries, with average coefficients of 3.76 and 6.41, respectively.

In the case of cross-section data analysis across time, the marginal effects of colonial ties, free trade agreement and continent dummies are determined by taking the exponential of their average parameters denoted $\bar{\beta}_m$. "The average parameter estimates are the arithmetic mean of the statistically non-zero estimates" (Sandberg, 2010). These average parameter values are determined as

$$\bar{\beta}_m = \frac{\sum_n \beta_m}{n} \qquad \text{C-1}$$

where *m* is a given binary or dummy variable and *n* is the number of years for which the parameter estimate is statistically different from zero. Therefore the marginal effect is calculated as

$$e^{\bar{\beta}_m} \,. \qquad \text{C-2}$$

The average parameter values for both colonial ties and free trade agreement are statistically zero because all parameter estimates for these two variables are statistically zero, insignificant. Hence, the marginal effect of colonial ties and that of free trade agreement are both statistically equal to one. This indicates that in the presence of colonial ties cocoa exporting countries trade one times the baseline trade volume of cocoa beans; in another word, they trade as much cocoa beans as those with no colonial ties. Similarly, cocoa exporting countries that have a free trade agreement with importing countries trade as much cocoa beans as those with no free trade agreement. The average parameter value for *Africa* dummy variable is 5.82; hence, the marginal effect of *Africa* is 336.97. This means that African countries trade 336.97 times the baseline volume of cocoa beans. The baseline volume is the volume of cocoa beans traded by Asian countries. The average parameter values for *South America* dummy variable is 8.35. The marginal effect of *South America* is 4230.18. This means that South American countries trade 4230.28 times the volume of cocoa beans traded by Asian countries.

Table C-1. Results of the logarithmic regression model for cross-section data across time

Variable	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average
Ln(gdpe)	-3.739**	-3.526**	-5.208***	1.599	2.702*	1.165	3.059	1.520	2.970*	0.662	0.120
	(1.832)	(1.787)	(1.655)	(1.905)	(1.456)	(1.559)	(1.977)	(1.776)	(1.734)	(1.361)	(1.704)
Ln(gdpi)	7.065	0.873	6.108	4.844	-1.677	15.148**	14.489***	11.363**	16.705***	8.405*	8.332
	(5.109)	(5.547)	(5.590)	(6.652)	(5.182)	(6.147)	(5.803)	(6.060)	(5.416)	(4.662)	(5.617)
Ln(pope)	-1.069	-1.521*	-1.551**	1.847**	2.546***	2.670***	2.208***	3.122	2.224***	1.812***	1.229
	(0.834)	(0.823)	(0.762)	(0.833)	(0.641)	(0.682)	(0.738)	(0.715)	(0.682)	(0.634)	(0.734)
Ln(popi)	-0.413	-0.980	-0.054	0.264	-0.246	0.974	0.054	0.604	1.214	0.689	0.211
	(0.937)	(0.951)	(0.880)	(0.980)	(0.756)	(0.841)	(0.886)	(0.908)	(0.865)	(0.783)	(0.879)
Ln(ben)	43.151*	-14.147	10.013	16.803	19.972	21.925	1.064	30.476	34.062	26.228	18.955
	(23.562)	(23.086)	(22.054)	(25.584)	(19.291)	(19.299)	(21.419)	(24.979)	(22.944)	(22.925)	(22.514)
Ln(pyr)	-0.697	-1.153	-4.890	-3.937	0.838	-7.859*	-4.822	-2.648	-7.164*	-0.833	-3.317
	(4.482)	(4.488)	(4.271)	(5.444)	(4.303)	(4.388)	(4.223)	(4.036)	(3.897)	(3.652)	(4.318)
Ln(dist)	-2.599	-3.134	-3.187	-1.326	-2.983	-4.817**	-7.36***	-4.782**	-6.732***	-4.015**	-4.094
	(2.270)	(2.280)	(2.126)	(2.813)	(2.137)	(2.096)	(2.277)	(2.186)	(2.077)	(1.943)	(2.221)
Colony ties	1.363	2.646	1.054	0.666	0.771	1.631	1.046	-0.705	0.765	-1.687	0.755
	(2.508)	(2.511)	(2.344)	(2.593)	(1.996)	(2.113)	(2.285)	(2.193)	(2.105)	(1.982)	(2.263)
FTA[a]	--	--	--	7.192	4.992	1.449	-3.003	0.758	0.112	1.261	1.823
	--	--	--	(6.876)	(5.241)	(2.485)	(1.817)	(1.713)	(1.603)	(1.492)	(3.032)
Africa	-5.424	-2.461	-6.863**	7.628**	8.095***	6.513**	4.753	6.820**	9.879***	8.667***	3.761
	(3.810)	(3.637)	(3.417)	(3.805)	(2.943)	(3.142)	(3.654)	(3.463)	(3.439)	(2.853)	(3.416)
S.America	1.066	2.560	2.003	7.948***	6.709***	8.386***	5.925***	9.293***	9.275***	10.942***	6.411
	(2.525)	(2.526)	(2.370)	(2.694)	(2.068)	(2.124)	(2.296)	(2.238)	(2.111)	(1.980)	(2.293)
Constant	9.517	95.752	43.058	-91.214	-16.334	-186.62***	-137.87*	-149.058*	-197.33***	-98.361	-72.846
	(61.782)	64.607	(65.595)	(77.385)	(64.757)	(74.354)	(71.993)	(76.682)	(69.420)	(59.661)	(68.624)

Asterisks denote levels of significance: * for 10% ** for 5% and [a] FTA means free trade agreemen

Table C-1. Continued

Table notes:

Lexp represents logarithm of export volume
Lgdpe represents logarithm of exporters' GDP
Lgdpi represents logarithm of importers' GDP
Lpope represents logarithm of exporters' population
Lpopi represents logarithm of importers' population
Lben represents logarithm of benalaxyl pesticide
Lpyr represents logarithm of pyrethrin pesticide
Ldist represents logarithm of distance
FTA represents free trade agreement

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Lucie Kadjo was born in Ghana and raised in Ivory Coast. She attended the University Hassan I of Settat in Morocco in 2002 where she received her Bachelor of Science degree in economics in 2006, with a minor in enterprise management. Lucie received her Master of Science degree in the Department of Food and Resource Economics at the University of Florida in 2010, with a specialization in trade and policy. Additionally, she pursued her PhD degree in the same department, starting in 2010. There, she specialized in economic development, demand and price analysis, international trade, environmental economics, agribusiness, and statistical marketing.