U.S. Imports Demand for Cocoa Products by Country of Origin

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Abstract

In this paper, we utilize four functional approaches, AIDS, Rotterdam, CBS, and NBR to estimate the U.S. elasticities of import demand for chocolate products and cocoa beans by country of origin. Additionally, we estimate the general model and use likelihood ratio tests to choose which of the four competing models best fits the cocoa products import data. The likelihood ratio test indicates that the general model fails to reject the Rotterdam and CBS for the estimation of cocoa beans. With regards to chocolate products, the general model fails to reject the AIDS.

1. Introduction

Little 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 research on demand elasticities, very few (e.g. Husted and Kollintzas, 1984, Behrman, 1965, and A.C. Harberger, 1953) are done on import demand for cocoa products by country of origin and most of those studies are behind the times. On one hand, it is crucial to have latest elasticity estimates, which outcomes can be utilized by exporting and producing countries to make decisions relative to production and trade of cocoa. On the other hand, 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.

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, come after the Americas with 27%, and Asia and Africa denoting 14% and 2% respectively (ICCO, 2012). Also, the Inter-

national Cocoa Organization (ICCO) reported 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 (three per cent). However, the United States is the leading cocoa importing country worldwide with 21% of global net imports, followed by Germany at 13%, Belgium (7%), France and Russia (six per cent each). Figure 2 below 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 (see figure 3 below). In 2011, U.S. total imports of cocoa and cocoa products were valued to $940.9 millions and $870.5 millions 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 FAO statistics (Food and Agriculture Organization), 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, the trend in cocoa beans production was highly influenced by Brazil, Ghana and Nigeria as 2nd, 3rd and 4th producers of that crop (see Figure 1 below). Also, from 1999 to 2010, Indonesia cocoa beans production noticeably overtakes other countries production making it the second producer worldwide. Ghana, Nigeria and Brazil ranked 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 (Henry Theil, 1965; Anton Barten, 1993) and the Almost Ideal Demand System (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 constants 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 (CBS, Keller and Van Driel, 1985) and the hybrid of the Rotterdam (NBR, Neves, 1987) are all nonnested model. However, Barten (1993) proposed a general model that nests the four systems, and, with pair-wise and higher-order tests, one can evaluate which of them best fits the data.

Following Barten (1993) and Lee, Brown and Seale (1994), we utilize all of the four functional approaches (AIDS, Rotterdam, CBS, and NBR) to estimate U.S. price and income elasticities of import demand for two commodities, chocolate and cocoa beans by country of origin. 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 and use likelihood ratio tests to choose which of the four models best fits the cocoa products import data. This paper is organized as follow: first we review literature relevant to the import demand. Then, we discuss respectively the methodology and the data source. Finally, we analyze the results and conclude the paper.
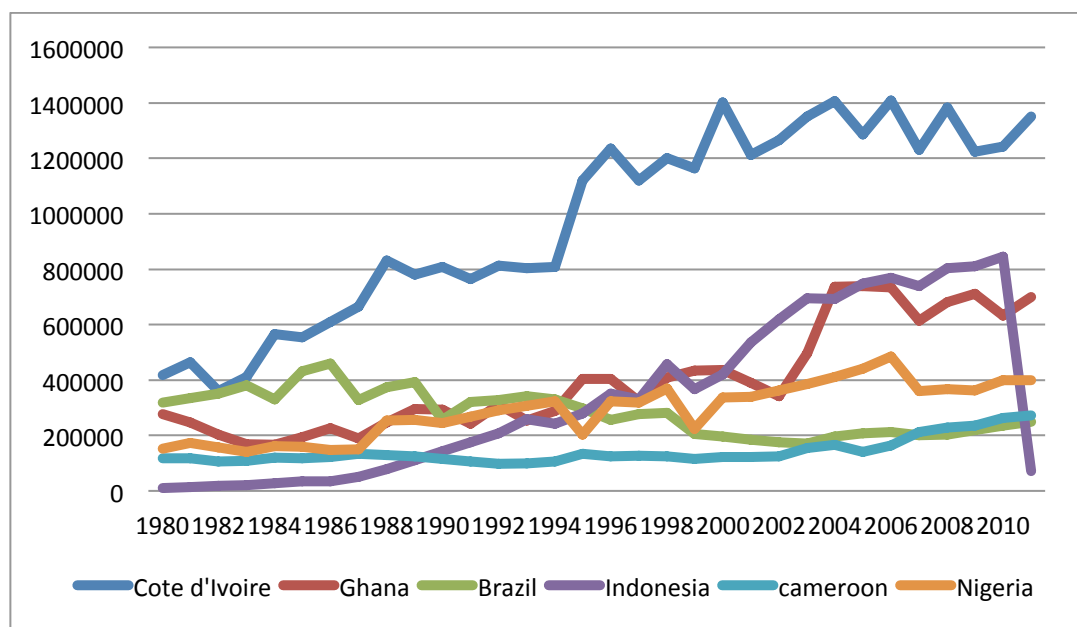

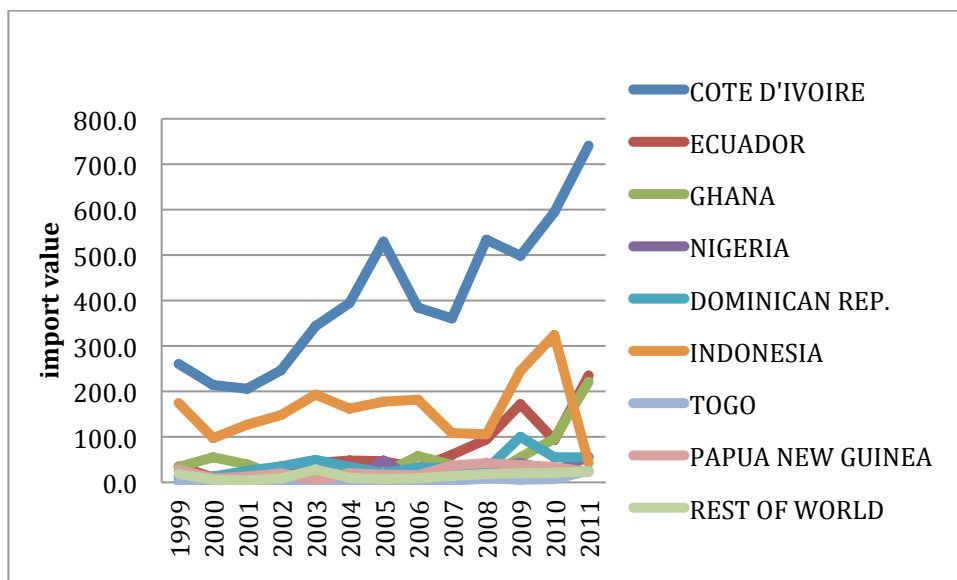Figure 1: Cocoa beans production (tonnes) from major cocoa beans producers

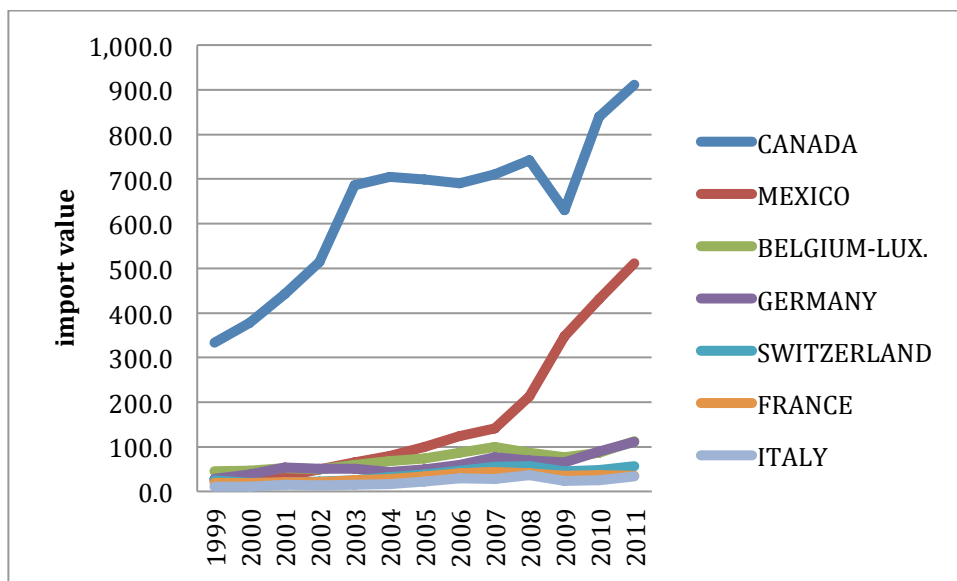Figure 2: U.S. import demand values (US $) of cocoa beans

Figure 3: U.S. import demand values of chocolate

2. Literature Review

Past studies have touched on elasticities of import demand using different specifications of demand models. These various demand systems involved "the linear and quadratic expenditure functions, the Working model, the Rotterdam model, translog models and the Almost Ideal Demand System, AIDS" (J-Y. Lee, M. Brown and J. Seale, Jr., 1994). 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 partners, Canada, Hong Kong, Singapore, and the United Kingdom using a Rotterdam model. Faroque (2008) uses both a Rotterdam and an AIDS (almost ideal demand system) model 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 better the data than the AIDS model.

Other researches were done on elasticities demand involving the AIDS system. Nzaku, Houston, and Fonsah (2011) examine the U.S. consumer demand for ten fresh tropical fruits and vegetables imports over the period 1989 to 2008 using the almost ideal demand system (AIDS) and including seasonal trigonometric variables, trend and a policy dummy variable (NAFTA variable) in the budget shares of the AIDS. Likewise, Seale, Marchant, and Basso (2002) apply the almost demand system (AIDS) model to evaluate U.S. import demand for red wine along with U.S. demand for domestic red wines. Findings show that 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.

Finally, other studies apply all four differential approaches, the Rotterdam, the

AIDS, the hybrid of the Rotterdam (NBR), and the hybrid of the AIDS (CBS) to determine demand elasticities. J-Y.Lee, M. Brown, and J L. Seale, Jr. (1994) use these four non-nested demand systems to study the effects of price and income on consumer demand for twelve commodity groups in Taiwan from 1970 to 1989.

3. Model specification

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

AIDS model

The AIDS (Almost Ideal Demand System) model was developed by Deaton and Muellbauer (1980). The theory of this demand system involves 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:

$$\log c(u,p) = (1-u)\log\{a(p)\} + u\log\{(b(p)\} \quad (1)$$

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

By using the functional forms of $\log a(p)$ and $\log b(p)$ we can write the AIDS cost function as:

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

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) and following Ronald Shephard (1953, 1970) the price derivatives equal the quantities demanded:

$\partial c(u,p) / \partial p_i = q_i$ (3)

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

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

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

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \mu \beta_0 \Pi p_j^{\beta_j} \qquad (5)$$

With $\gamma_{ij} = \frac{1}{2}(\gamma_{ij}^* + \gamma_{ji}^*)$ (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 (4) and (6), we obtain the AIDS demand function in budget share form:

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

Where P is a price index denoted by:

$$\log P = \alpha_0 + \sum_i \alpha_i \log p_i + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \log p_i \log p_j \qquad (8)$$

9

The restrictions on the parameters of (2) and (6) extrapolate to restrictions on (7). In order

for the budget shares to add up to unity ($\sum w_i = 1$), the adding up condition has to hold:

$$\sum_{i=1}^{n} \alpha_i = 1 \quad \sum_{i=1}^{n} \gamma_{ij} = 0 \quad \sum_{i=1}^{n} \gamma_{ij} = 0 \quad (9)$$

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

slutsky symmetry respectively:

$$\sum_{j} \gamma_{ij} = 0 \quad (10) \quad \text{and} \quad \gamma_{ij} = \gamma_{ji} \quad (11)$$

The first difference form of the AIDS equation (7) is given as:

$$dw_i = \beta_i d \log(\frac{m}{P}) + \sum_{j} \gamma_{ij} d \log p_j \quad (12)$$

Deaton and Muellbauer (1980) found that using the divisia index is an excellent approxi-

mation to stone index , $\sum w_i \log p_i$. Therefore, $d \log P$ in (12) is replaced by the divisia price

index , $\sum w_i d \log p_i$ to obtain:

$$dw_i = \beta_i (d \log m - \sum w_i d \log p_i) + \sum_{j} \gamma_{ij} d \log p_j \quad (13)$$

According to Barten (1993), starting with the logarithmic differential of the budget equa-

tion: $\sum_{i} p_i q_i = m$ gives the real income equation:

$$d \log m = \sum_{i} w_i d \log p_i + \sum_{i} w_i d \log q_i \quad (14)$$

Equivalently $\sum_i w_i d\log q_i = d\log m - \sum_i w_i d\log p_i$ (14a)

We insert equation (14a) into (13) to obtain a new form of the AIDS as:

$$dw_i = \beta_i d\log Q + \sum_j \gamma_{ij} d\log p_j \qquad (15)$$

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

Where $d\log Q = \sum w_i d\log q_i$

Rotterdam model

Theil (1965) developed the Rotterdam model by starting with the budget share

formula: $w_i = p_i q_i / m$ (16)

Where w_i is the budget share of commodity i, p_i is the price of commodity i, q_i is the quanti-

ty of commodity i, and m is the income or total expenditure.

The logarithmic function of (16) is:

$$\log w_i = \log p_i + \log q_i - \log m \qquad (17)$$

After transformation he continued with the relation below:

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

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

$$w_i d\log q_i = \theta_i(d\log m - \sum_i w_i d\log p_i) + \sum_j \pi_{ij} d\log p_j \qquad (17)$$

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

Set two equations:

$$\sum_i w_i d \log q_i = d \log m - \sum_j w_i d \log p_i \qquad (18)$$

$$d \log Q = \sum_i w_i d \log q_i, \quad d \log P = \sum_i w_i d \log p_i \qquad (19)$$

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

We will use equations (18) and (19) to rewrite the Rotterdam model in (17) as:

$$w_i d \log q_i = \theta_i d \log Q + \sum_j \pi_{ij} d \log p_j \qquad (20)$$

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

Adding-up: $\sum \theta_i = 1$ and $\sum \pi_{ij} = 0$

Homogeneity: $\sum \pi_{ij} = 0$

Symmetry: $\pi_{ij} = \pi_{ji}$

CBS model

The CBS model is a hybrid of the AIDS and Rotterdam models and was invented by Keller and van Driel (1985) of the Dutch Central Bureau of Statistics. To obtain the CBS system we start with the Rotterdam and the AIDS model. Both models have the same right hand sides and different left-hand sides but related (Barten, 1993). One can use the relations:

$$dw_i = w_i d \log q_i + w_i d \log p_i - w_i d \log m \qquad (21)$$

We replace $w_i d \log q_i$ in (21) by the right-hand side of (20); and replace $d \log m$ by (14) to have:

$$dw_i = \theta_i d \log Q + \sum_j \pi_{ij} d \log p_j + w_i d \log p_i - w_i d \log P - w_i d \log Q \qquad (22)$$

$$dw_i = (\theta_i - w_i)d\log Q + \sum_j \pi_{ij}d\log p_j + w_i d\log p_i - w_i \sum_i w_i d\log p_i \quad (23)$$

We use the kronecker delta equal to unity if i=j and zero otherwise to rewrite (23) as:

$$dw_i = (\theta_i - w_i)d\log Q + \sum_j (\pi_{ij} + w_i\delta_{ij} - w_i w_j)d\log p_j \quad (24)$$

Comparing (15) with (24) shows equivalence for

$$\beta_i = \theta_i - w_i$$

$$\gamma_{ij} = \pi_{ij} + w_i\delta_{ij} - w_i w_j$$

We replace in the Rotterdam model (20) θ_i by $\beta_i + w_i$ to obtain the CBS system as:

$$w_i d\log q_i = (\beta_i + w_i)d\log Q + \sum_j \pi_{ij}d\log p_j$$

The CBS model has the AIDS income coefficient and the Rotterdam price coefficient. Also, the CBS satisfy 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 was developed by Neves (1987). NBR system is obtained by replacing β_i in the AIDS system by $\theta_i - w_i$,

$$dw_i + w_i d\log Q = \theta_i d\log Q + \sum_j \gamma_{ij}d\log p_j$$

or $\quad w_i d\log q_i = \theta_i d\log Q + \sum_j \gamma_{ij} - w_i(\delta_{ij} - w_j)d\log p_j$

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

13

General Model

The four functional models accounted in our study are not nested, but a general form can be developed to nest all four models (Barten, 1993):

The general model is:

$$y_{Rt} = X_t\gamma + \delta_1(y_{Rt} - y_{Ct}) + \delta_2(y_{Rt} - y_{Nt}) + \upsilon_t \qquad (20)$$

Where

$$y_{Rt} - y_{Nt} = w_i d\log q_i - \{w_i(d\log p_i + d\log q_i - d\log P - d\log Q)\} - w_i d\log Q \qquad (21)$$

$$y_{Rt} - y_{Nt} = w_i(d\log P - d\log p_i) \qquad (21a)$$

$$X\gamma = \theta_i d\log Q + \sum_j \pi_{ij} d\log p_j \qquad (22)$$

We use (21) (21a) and (22) and the kronecker delta $\delta_{ij} = 1$ if i=j to rewrite the general model as:

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

or
$$w_i d\log q_i = (d_i + \delta_1 w_i)d\log Q + \sum_j [e_{ij} - \delta_2 w_i(\delta_{ij} - w_j)]*d\log p_j + \upsilon_t \quad (23)$$

where $\quad d_i = \delta_1\beta_i + (1-\delta_1)\theta_i \quad$ and $\quad e_{ij} = \delta_2\gamma_{ij} + (1-\delta_2)\pi_{ij}$

There are four parameters to be estimated in this general model, which are d_i, e_i, δ_1 and δ_2.

Equation (24) 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 $\delta_2 = 1$. We tes the null hypothesis H_0: one of the four models best fits the data against the alternative hypothesis H_a: the general model using the likelihood ratio test.

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

$$LRT = -2[\log L(\theta^*) - \log L(\theta)]$$

Where θ^* is the vector of the parameter estimates of each of the demand systems, AIDS, Rotterdam, CBS, NBR and θ is the vector 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 2 degrees of freedom. The degree of freedom is 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 follow:

Income elasticities

For the Rotterdam and NBR : $\eta_i = \theta_i / w_i$

For the AIDS and the CBS: $\eta_i = (\beta_i / w_i) + 1$

Price elasticities

 For the Rotterdam and CBS models: $\varepsilon_{ij} = \pi_{ij} / w_i$

For the AIDS and NBR: $\varepsilon_{ij} = (\gamma_{ij} / w_i) - 1 + w_j$

Additionally the income elasticity for the general model is :

$$\varepsilon_{ij} = (e_{ij} / w_i) + (\delta_2 * (-1 + w_i))$$

and the price elasticity is :

$$\eta_i = (d_i / w_i) + \delta_1$$

4. Data

The dataset used in this study is a 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. The countries under study for this research are Cote d'Ivoire, Indonesia, and Ecuador (major exporting countries of cocoa beans to U.S.) plus the rest of the world (ROW), which includes 73 countries. With regards to the chocolate product, the countries under study are 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.

5. Results and analysis

a. *Results for cocoa beans*

Table 1 illustrates log-likelihood values and test statistics for each model. Numbers in the column 2 are log-likelihoods, and numbers in column 3 are log-likelihood ratio test statistics for each model. The ratio tests show that the general model fail to reject two of the four systems, the Rotterdam and CBS models. This means that the latters fit better the data than the AIDS and NBR models. Therefore, we present results of the budget shares, and Slutsky price coefficients as well as income and price elasticities for the Rotterdam and CBS models. Results of the Rotterdam model show that all four marginal budget shares are positive and significant at $\alpha=0.05$ (see table 2). Also, of the four own prices Slutsky coefficients in table 2 only that of Cote d'Ivoire is significant and negative at 5% significant level.

Income elasticities or conditional expenditure elasticities of traded cocoa beans are greater than one and significant at 5% level for Cote d'Ivoire and Ecuador at the sample mean, implying they are elastic. This indicates that the import share of cocoa beans from these countries increases as total U.S. import expenditure on this crop increases (see table 3). However, the income elasticity for Indonesia is less than one, indicating inelastic term. This indicates that the import shares of cocoa beans from these countries are less sensitive to total U.S. import expenditure. The absolute value of the compensated own-price elasticity is elastic and significant for only Cote d'Ivoire at 5% level. This means that the percent change of quantity demanded of cocoa beans from this country is more sensitive to changes in own price. With regards to the CBS model, all marginal budget shares are statistically insignificant (see table 4). However, the own price Slutsky coefficient is negative and statistically different from zero for Cote d'Ivoire at the sample mean. Income elasticities are elastic for Cote d'Ivoire and Ecuador, but inelastic for Indonesia and the ROW at 5% level (see table 5). Furthermore, compensated own price elasticity for Cote d'Ivoire is different from zero and elastic.

b. *Results for chocolate product*

The likelihood ratio tests in table 6 indicate that the general model reject all other models but the AIDS, meaning that only the AIDS best fits the data at 1% significance level. Table 7 indicates that the marginal budget share is significant and negative at 5% level for Canada only. However, all Slutsky price coefficients are insignificant. Income elasticities are inelastic and significant for Canada and Germany respectively at 5% and 10% significance level at the sample mean (table 8). This means that quantities demanded of chocolate from Canada and Germany are less sensitive to changes in U.S. total expenditure on chocolate.

Additionally, the absolute values of the compensated own price elasticities of chocolate are elastic for Germany, implying that quantity demanded of chocolate are more sensitive to changes in price for Germany.

6. Conclusion

This paper aims to apply four functional approaches (AIDS, Rotterdam, CBS, and NBR) to estimate demand elasticities for cocoa beans and chocolate products respectively during the periods 1986 through 2010, and 1992 through 2010. A fifth model, the general model, is used to test which of the four demand systems best fits the data. Results indicate that both the Rotterdam and CBS models best suit the cocoa beans data, whereas the AIDS model best fits the chocolate data. Important take home messages can be derived from theses findings. First, because the compensated own price is elastic for Cote d'Ivoire, producers from Cote d'Ivoire can raise up their revenues from cocoa beans by reducing prices of cocoa beans. Similarly, chocolate industries in Germany can improve their revenues by reducing prices of chocolate products because the compensated own price is elastic for Germany. Additionally, income elasticities are elastic for Cote d'Ivoire (1.175) and Ecuador (1.345), and inelastic for Indonesia (.905). This means that as U.S. total expenditure or income on cocoa beans increases, U.S. is more likely to import more cocoa beans from Ecuador first, Cote d'Ivoire second, and Indonesia third. Also, income elasticities at the sample mean are inelastic for Canada (.618) and Germany (.606), indicating that U.S. will not increase much its chocolate imports from Germany and Canada even if its total expenditure on chocolate increases. However, U.S. will import more chocolate from Canada than Germany if its expenditure increases.

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Appendix: Tables

  A. *Results for cocoa beans*

Table 1: Test results of cocoa beans for the Rotterdam, CBS, AIDS, NBR, and General Model

Model	Log likelihoods	$-2\left[L\left(\theta^{*}\right)-L(\theta)\right]^{a}$
General model	160.857	
Rotterdam	158.762	4.19
CBS	157.990	5.734
AIDS	156.738	8.238
NBR	157.478	6.758

[a] The table 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

Table 2: Budget shares and Slutsky Price Coefficients for Rotterdam model for cocoa beans

Country	Slutsky coefficients				Marginal budget share
	Cote d'Ivoire	Indonesia	Ecuador	ROW	
Cote d'Ivoire	-.487* (.063)	.300* (.101)	-.366E-02 (.073)	.190** (.109)	.467* (.063)
Indonesia		-.080 (.138)	.080 (.072)	-.295* (.115)	.172* (.062)
Ecuador			-.115 (.079)	.038 (.089)	.104* (.041)
ROW				-.066 (.158)	.257* (.063)

** significance at 10%, *significance at 5%

Table 3: Income and price elasticities for the Rotterdam model for cocoa beans

| Country | Compensated price elasticity | | | | Income |
	Cote d'Ivoire	Indonesia	Ecuador	ROW	elasticity
		Sample Mean			
Cote d'Ivoire	-1.226* (.336)	.756* (.254)	-.921E-02 (.184)	.479** (.275)	1.175* (.158)
Indonesia		-.449 (.725)	.422 (.379)	-1.547* (.605)	.905* (.326)
Ecuador			-1.487 (1.036)	.493 (1.164)	1.345* (.526)
ROW				-.414E-16	.051 (.090)

Table 4: Budget shares and Slutsky Price Coefficients for CBS model for cocoa beans

| Country | Slutsky coefficients | | | | Marginal budget share |
	Cote d'Ivoire	Indonesia	Ecuador	ROW	
Cote d'Ivoire	-.540* (.133)	.296* (.104)	.207E-02 (.079)	.242* (.109)	.064 (.061)
Indonesia		-.082 (.146)	.083 (.078)	-.297* (.124)	-.492E-02 (.065)
Ecuador			-.139 (.093)	.054 (.122)	.020 (.039)
ROW				.137E-02 (.186)	-.079 (.065)

Table 5: Income and price elasticities for CBS model for cocoa beans

| Country | Compensated price elasticity | | | | Income |
	Cote d'Ivoire	Indonesia	Ecuador	ROW	Elasticity
Sample Mean					
Cote d'Ivoire	-1.397* (.330)	.740* (.261)	.059 (.180)	.598* (.274)	1.161* (.154)
Indonesia		-.432 (.768)	.443 (.375)	-1.55* (.645)	.974* (.343)
Ecuador			-1.335 (1.018)	-.064 (1.159)	1.261* (.502)
ROW				-.190 (.489)	.764* (.194)

B. Results for chocolate

Table 6: Test results for the Rotterdam Model, CBS, AIDS, NBR, and General Model for chocolate

Model	Log likelihoods	$-2\left[L\left(\theta^{*}\right)-L\left(\theta\right)\right]^{a}$
General model	142.366	
Rotterdam	138.498	15.284
CBS	137.662	9.408
AIDS	134.724	7.736
NBR	136.337	12.058

[a] The table value for $\chi^2_{(2)}$ =9.21 at α =0.01

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

Table 7: Marginal budget shares and Slutsky coefficients of the estimated AIDS model for chocolate

Country	Slutsky coefficients				Marginal budget share
	Canada	Mexico	Germany	ROW	
Canada	.092 (.131)	.013 (.046)	.318E-02 (.026)	-.109 (.126)	-.173* (.079)
Mexico		.034 (.032)	-.542E-02 (.010)	-.042 (.047)	-.048 (.049)
Germany			-.657E-02 (.023)	.881E-02 (.031)	-.018 (.016)
ROW				.141 (.141)	.239 (.086)

Table 8: Income and price elasticities for AIDS model for chocolate

Country	Compensated price elasticity				Income elasticity
	Canada	Mexico (Sample Mean)	Germany	ROW	
Canada	-.342 (.288)	-.517* (.102)	-.539* (.058)	-.824* (.278)	.618* (.174)
Mexico		-.455 (.445)	-1.003* (.143)	-.668* (.110)	.336 (.687)
Germany			-1.101* (.509)	-.570* (.054)	.606** (.353)
ROW				-.241 (.329)	1.557 (.200)