Aflatoxin Contamination and Regulation Policy Interventions: Economic Implications for Peanut Market Participants

by

Michael Agyekum

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Approved by

Curtis Jolly, Chair, Professor of Agricultural Economics and Rural Sociology
Henry Kinnucan, Professor of Agricultural Economics and Rural Sociology
Norbert Wilson, Associate Professor of Agricultural Economics and Rural Sociology
Asheber Abebe, Associate Professor of Mathematics and Statistics

Abstract

This dissertation is composed of three chapters covering topics about the impact of aflatoxin regulation policies on peanut suppliers and consumers.

Chapter One evaluates welfare implications of aflatoxin standards imposed on peanut imported into the European Union (EU) market. Price and quantity effects on peanut suppliers and consumers are determined. The equilibrium displacement modeling (EDM) approach is applied on a source-differentiated market; where standards compliance costs are modeled as import tax to understand the distribution of economic incidence. Findings show that aflatoxin regulation tightening leads to price and quantity drop for the United States and other exporters, while China benefits owing to price and quantity increases. This result contradicts popular belief that strict aflatoxin regulations hurt all exporters in terms of lost revenues. Also, import suppliers and consumers share in the costs from the policy although consumers pay much of the costs.

Chapter Two isolates the peanut industry in Ghana as a specific-country case and examines the distribution of economic impacts on domestic producers and consumers after incorporating important market features; namely trade status, and consumer demand for quality peanut. The EDM technique is employed in three nested models; autarkic peanut sector, small exporter with supply shift, and small exporter with both supply and demand shifts. Results from the autarkic model shows that domestic consumers experience greater economic loss. In the export model with supply shift only, producers bear the full economic burden due to Ghana's status as a small peanut trader. However, the third and more generalized model reveals that although producers bear the entire cost of the intervention, they could actually gain if consumer demand for quality peanut is incorporated into the analyses.

Although Chapter Two incorporates demand for quality peanut, the analysis is based on strong assumptions about consumer preference for safer peanut. Therefore, Chapter Three provides empirical evidence of consumers' willingness to pay (WTP) for quality peanut. Contingent Valuation survey was carried out on 652 individuals in Ghana. The study employs a semi-double-bounded dichotomous choice method based on random utility theory. Results indicate that 79% of consumers are willing to pay more for peanut with reduced aflatoxin levels; premiums range from 13% to 66%. Also, high income households, smaller family sizes, and younger people are more willing to pay for aflatoxin-free peanut than their counterparts. Interestingly, consumer characteristics such as region of residence, aflatoxin awareness, and one's level of formal education are found to have no influence on WTP. These findings are important to the research community and regulatory bodies regarding holistic assessments of aflatoxin interventions.

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Table of Contents

List of Tables

List of Figures

Introduction

Food safety concerns continue to command growing interest from the general public, research communities, and policy-making institutions (Grunert, 2005). The attention given to food safety issues is explained by the pervasiveness of contaminants found in both domestic and global food supply chains. There are numerous contaminants cited as prominent residues that account for much of the food contamination problems around the world. Mycotoxins — which have been at the heart of Sanitary and Phytosanitary Standards (SPS) discussions among trading countries in recent decades — are some of the dominant harmful agents that perennially pose serious threats to food safety.

Mycotoxins are naturally-occurring toxic substances that contaminate crops both at the pre- and post-harvest stages of food supply chains. These toxins are produced by fungi. Although many sub-groups of mycotoxins exist (such as fumonisins, zearalenone, and ochratoxins), this dissertation focuses on the most popular in recent years known as aflatoxins; due to their revealed toxicity and carcinogenicity to exposed individuals (Park et al., 2002; Jolly et al., 2006). Aflatoxins and other mycotoxins are noted for contaminating over one-quarter of food supply worldwide (Dohlman, 2003), causing enormous revenue losses in food trade (Otsuki, Wilson, and Sewadeh, 2001), as well as inducing severe illnesses/mortalities in humans and farm animals (Williams et al., 2004; Liu and Wu, 2010). Food crops that are often cited as susceptible to aflatoxin contamination include cereal grains, nuts, vegetables and fruits. This dissertation focuses on the aflatoxin contamination problem in peanut — in line with goals of the USAID Peanut Collaborative Research Support Program — though the issues discussed are fundamentally similar to many vulnerable food crop industries.

Aflatoxin contamination occurs in many food chains around the world, particularly in Africa and Asia (Wang et al., 2001; Dash et al., 2007). Environmental conditions in warm regions are known to present challenges to eliminating aflatoxins entirely (Dohlman, 2003). Therefore, the introduction and enforcement of aflatoxin standards (i.e. setting permissible thresholds) for food have been the natural policy interventions from governments and international regulators to control the problem. Public health interests primarily drive the need to minimize dietary aflatoxin exposure in order to protect consumers. A host of nations including the European Union (EU) and the United States (US) are implementing own aflatoxin regulations for peanut — 4 ppb and 20 ppb, respectively — aimed at safeguarding the health of the consuming public (Otsuki, Wilson, and Sewadeh, 2001). In the near future, as the world gets increasingly integrated, it is anticipated that most countries will converge in enforcing uniform food standards. It is, therefore, necessary to study the aflatoxin problem and show possible policy implications of regulations on important food industries. Against this background, the dissertation comprises of three chapters that explore central topics representing the following broad research objective: determining the economic implications of aflatoxin regulations on peanut market participants.

Specifically, Chapter One focuses on international trade in peanut by studying the impact of European aflatoxin standards on prices faced by exporting countries on one hand, and consumers in Europe on the other. The economic welfare implications are discussed.

In Chapter Two, the analysis in Chapter One is extended for a specific-country case; where I evaluate economic incidence owing to the introduction of aflatoxin regulations to the peanut sector in Ghana. Here, economic losses and gains derived from aflatoxin regulation enforcement are explored through price and quantity effects on market participants. The importance of trade status as well as consumer preferences are highlighted with respect to the distribution of policy impacts among suppliers and consumers.

Chapter Three complements the preceding two topics by studying consumer preferences for aflatoxin-free peanut. This goal is pursued with a focus on Ghana by analyzing consumers' willingness to pay for peanut with reduced aflatoxin levels. The final chapter offers completeness to the broad research objective in that it would be possible to empirically understand consumer valuation of safer peanut. Knowledge of consumer preference for aflatoxin-free peanut will enable policymakers to properly interpret whether inevitable increases in retail prices (shown in the preceding chapters) are welfare decreasing or not.

In what follows, detailed discussions on each of the three dissertation chapters are provided.

Chapter 1: Peanut Trade and Aflatoxin Standards in Europe: Economic Effects on Exporting Countries

1.1 Background and Problem Statement

Mycotoxins are one of the broad groups of food contaminants that receive close attention in international trade.[1] One of the most popular types of mycotoxins is aflatoxin, known to be carcinogenic and immunosuppressive (Wild and Hall, 1999; Williams et al., 2004; Dash et al., 2007).[2] The adverse health impacts of mycotoxins and other food residues are the reasons for growing food safety concerns among researchers and policy makers.

In recognition of the potential health risks posed by aflatoxins, the World Trade Organization (WTO) has an agreement on Sanitary and Phytosanitary Standards (SPS) that allows members to set their own standards for food when necessary to protect consumers (Yue, Beghin and Jensen, 2006). The WTO refers to this SPS policy as the 'precautionary principle'. Since 1998, food standards in industrialized countries have evolved with the European Commission announcing new aflatoxin regulations for imported food items (Otsuki, Wilson and Sewadeh,

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[1] Mycotoxins - one of the most prominent food contaminants - are composed of toxic chemical substances produced by fungi which contaminate crops during production and or in post-harvest handling.

[2] The major aflatoxins of concern are designated B1, B2, G1 and G2. These aflatoxins are usually found together in contaminated food items with B1 being the most toxic and accounting for 50-70% of total aflatoxins level. These compounds are regarded as carcinogenic food contaminants whose consumption should be reduced to 'reasonably acceptable' levels (see FAO-WHO 1997; Otsuki, Wilson and Sewadeh, 2001a, 2001b).

2001a, 2001b).[3] However, setting appropriate aflatoxin levels for food crops, especially peanut and peanut products, has been a controversial subject that has generated much interest among trading partners. For instance, the European Union (EU) aflatoxin standards require that peanuts for direct human consumption must contain levels not exceeding 4ppb. Interestingly, the joint FAO/WHO Codex Alimentarius Commission (Codex) which has the mandate of setting international food standards recommends an acceptable aflatoxin level of 15 ppb, while the United States of America (USA) accepts 20 ppb for all peanut products. Clearly, the EU has one of the strictest food regulations in the world market, and peanut is one of the most affected food crops whenever aflatoxin standards are tightened.[4] The EU together with Canada, Japan, and Mexico consume over 60% of world peanut trade; Europe alone imports about 40% of trade in peanut (FAOSTAT). Limited peanut production (less than 1.0% of consumption) explains Europe's heavy reliance on imports. The major peanut exporters to the EU market are China, USA, Latin America, and Africa. Boonsaeng, Fletcher, and Carpio (2008) indicate that Argentina, China, and the USA accounted for 70% of the world peanut exports in 2005. In terms of global peanut production (i.e. sum of domestic and export supply), developing countries produce over 60% of the crop (Upadhyaya *et al.*, 2003).

Imported peanuts are consumed directly and/or further processed into snacks, butter, candies, chocolate bars, among other peanut products.

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[3] According to Otsuki, Wilson and Sewadeh (2001b), EU members had country-specific aflatoxin standards until 1998 after which the EC fixed total aflatoxin levels for processed peanut at 15 ppb (8 ppb for B1) and in other nuts and dried fruits subject to further processing at 10 ppb (5 ppb for B1). Furthermore, cereals, dried fruits and nuts for direct human consumption were set at 4ppb (2 ppb for B1). These harmonized regulations were enacted and implemented by all EU member countries since 2002.

[4] Peanut (also called groundnut) is one of the world's most popular crops (Nwokolo, 1996).

Following increasing concerns over possible deleterious influences of standards on trade flow, a number of studies have emerged. Notable ones include Otsuki, Wilson, and Sewadeh (2001a, 2001b); Yue, Beghin, and Jensen (2006); Nogueira *et al.* (2008); and Nguyen, and Wilson (2009). Particularly, Otsuki, Wilson, and Sewadeh studied the impact of EU aflatoxin standards against that of Codex on Africa's food exports by using the gravity model. The authors found that African food exports to Europe are adversely affected by stringent aflatoxin standards. Acknowledging one major limitation of using gravity models to assess the impact of regulations on trade, Otsuki, Wilson, and Sewadeh (2001a, p. 272) state that "as a result of the structure of a gravity model, the separate effects of … standards on import demand and export supply cannot be isolated." Almost all existing studies that employ gravity models show negative SPS impact on trade. An exception is Xiong and Beghin (2010) whose follow up study — with reference to forecasts by Otsuki, Wilson and Sewadeh concerning impacts of EU aflatoxin standards on African peanut exports — yield no substantial trade quantity effect. Even though Xiong and Beghin also employed the gravity model, they improved on two limitations identified in Otsuki, Wilson and Sewadeh's work; namely the use of time-invariant aflatoxin-contamination data for the entire study period, as well as possible sample selection bias problem due to exclusion of zero trade records in the analysis. Xiong and Beghin (2010) argue that EU standards have no significant effects on Africa's peanut trade volumes because Africa has its own domestic barriers that undermine export trade.

In spite of the cited studies, literature on economic impacts of SPS on food exports is still limited as noted in Otsuki, Wilson and Sewadeh (2001b); and Maskus and Wilson (2001). Moreover, a sizeable proportion of research work regarding effects of food standards is descriptive with only a few quantitative studies (Josling and Roberts 2011) mostly employing the gravity model and its variants in assessing the impact of aflatoxin standards on trade flows. Furthermore, there is consensus among researchers on the lack of studies focusing on precise economic welfare effects of regulations (Otsuki, Wilson and Sewadeh, 2001b; Wilson, 2003; Roberts, 2009; and Xiong and Beghin, 2010); hence more research attention on economic effects is needed.

This chapter, therefore, contributes to the literature by determining price and quantity effects and, by implication, economic welfare impacts of EU aflatoxin regulation tightening on edible peanut trade. To this end, the equilibrium displacement modeling technique is employed to evaluate the economic incidence of EU aflatoxin standards on consumers and trade partners.[5]

1.2 Objectives

The principal objective of this study is to determine the effects of EU aflatoxin regulation tightening on prices received by peanut exporters to the European market, as well as consumer prices. This study focuses on trade in edible peanuts, both shelled and in-shell.[6] Peanut suppliers of interest are China, USA, and rest of the world (ROW) exporters.[7] ROW is composed of exporting countries from Latin America, Asia, and Africa.

[5] Henceforth, aflatoxin standards/regulations are equally referred to as *standards* or *regulation*

[6] The terms ‘peanut’ and ‘edible peanut’ are used interchangeably.

[7] China, USA and Argentina account for the bulk of edible peanut exports (Diop, Beghin and Sewadeh, 2004).

1.3 Theoretical Framework

Classic theories of tax incidence and economic equilibrium provide the structure for analyses in this study. Concerns about the distribution of tax burdens in affected systems — referred to as shiftability of tax — have motivated an extensive tax incidence literature following Ricardo's insights (Kittrel, 1957; Kotlikoff and Summers, 1987). The literature distinguishes between statutory burden (incidence) and economic burden of taxes. Statutory incidence refers to governments' distribution of obligatory tax payments among economic agents, whereas economic incidence determines the impact of such taxes on important equilibrium variables such as prices in a system (Kotlikoff and Summers, 1987; Metcalf, 2006). Tax incidence analysts, therefore, study the distribution of tax implications on the welfare of agents in a given system; appropriately focusing on economic incidence irrespective of which side of the market directly paying the tax. Generally, Kotlikoff and Summers (1987) show that the theory of economic equilibrium is invoked to analyze the effects of exogenous interventions, such as tax policies, on equilibrium prices in a system. Thus, tax incidence analysts assume perfectly competitive partial or general equilibrium frameworks to understand the distribution of tax burdens among market participants. Two important principles that have been established from economic analyses of tax incidence are as follows: (1) economic incidence of tax policies is absolutely insensitive to which side of the market the tax is imposed upon; and (2) greater share of any tax burden is borne by the less elastic side of the market, whether the supply or the demand side (Kotlikoff and Summers, 1987; Metcalf, 2006). In other words, statutory tax incidence is immaterial in economic analyses in that the absolute magnitudes of supply and demand elasticities determine the distributional impact of tax interventions on the welfare of economic agents.

In addition, analyses in this dissertation are primarily based on discussions in the trade literature concerning the quantification of non-tariff (or technical) trade barriers (Maskus and Wilson, 2001; Beghin, 2006). Thus, SPS policies are characterized as traditional tariff barriers in the assessment of economic impacts.

The theoretical foundations introduced in this section are conceptualized in the next section.

1.4 Conceptual Framework

This chapter applies the tariff equivalent method to quantifying SPS compliance costs using a price-wedge approach (Calvin and Krissoff, 1998; and Yue, Beghin and Jensen, 2006). Therefore, EU aflatoxin regulation for international trade in peanut is modeled as a tax.

The theories of economic equilibrium and tax incidence are characterized below through an application of the equilibrium displacement modeling (EDM) policy evaluation tool; to determine the distribution of EU aflatoxin tax burden on peanut trade. A partial equilibrium setting is used given that the size of the peanut sector in most producing countries is small relative to their economies. In line with the EDM literature, the following assumptions are made about the peanut trade market: (1) Perfect competition exists in the market; (2) Market clears; (3) Demand and supply curves shift in parallel fashion following the exogenous intervention (or shock) on equilibrium, as a result of aflatoxin-compliance tax. Sources in the literature that have worked with the preceding assumptions are Alston, Norton and Pardey, 1995, p. 60-63; Wohlgenant, 1999; and Sun and Kinnucan, 2001, among others.

Furthermore, this study operationalizes the effect of EU aflatoxin standards as an import tax since exporters' efforts to comply with regulations often introduce additional costs (Maskus and Wilson, 2001) into the international peanut supply chain. Aflatoxin contamination can occur at any point along the supply chain. Hence, peanut importers in Europe also face the aflatoxin tax although this is irrelevant to the ultimate distribution of economic burden from the tax.

Aflatoxin compliance costs collectively refer to additional expenses (and losses) incurred by peanut suppliers and importers as they attempt to conform to strict aflatoxin standards, both at the border and within EU countries, in order to sell to consumers.[8] Thus, compliance costs encapsulate utilization of proper storage environments; inspection, sampling, testing and certification costs; storage and handling costs of rejected supplies; discarded loads of contaminated peanut, costs incurred as a result of transportation to alternative and often less-attractive markets; as well as relatively low prices received from alternative uses of the rejected product such as feed, biofuels, among others. Therefore, an increase in aflatoxin regulation implies tighter standards leading to higher compliance costs which have economic welfare impacts identical to conventional tax incidence. In addition, this study models the EU aflatoxin compliance 'tax' as an import demand shifter, taking advantage of the principle that economic incidence of a tax is irrespective of statutory incidence. Precisely, the import demand curve shifts inward thereby lowering export supply price and raising EU import demand price. The import tax is assumed to constitute a major component of the wedge between peanut export and import prices.[9]

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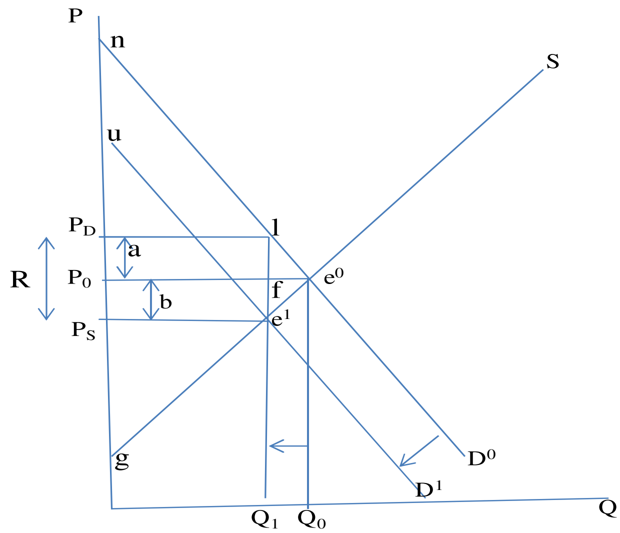
[8] See Shafaeddin (2007) for more on SPS compliance costs. Also, to understand the broad nature of mycotoxin control strategies, see Dohlman (2003) and Codex Alimentarius Commission (2003).

[9] Export prices used here are actually peanut producer prices because the FAOSTAT data report export and import unit prices as exactly identical. Thus, using producer prices helps to approximate aflatoxin

Figure 1.1 is a pictorial demonstration of the economic incidence on peanut market agents after introduction of the EU aflatoxin tax. As depicted in the graphical analyses, it is expected that the regulation tax, R, would be shared between the two sides of the market. Specifically, the magnitude of the tax is composed of ‘a’ and ‘b’, respectively borne by consumers and exporters. Thus, the consumer price is ultimately increased from P_0 to P_D, while the final price that goes to suppliers is depressed from P_0 to P_S. These price effects translate into losses in economic welfare on both sides of the peanut market. Before imposition of the tax, the economic welfare of exporters is measured as equivalent to the area of triangle P_0e_0g which reduces to the area of triangle P_Se_1g after the tax. Also, consumers face a decrease in economic surplus since the tax policy reduces their welfare from the area of triangle P_0e_0n to area of triangle P_Dln.

compliance costs.

Figure 1.1. Impact of Aflatoxin Tax on Peanut Prices and Quantities in the International Market



Following applications of EDM, structural elasticities are obtained from previous studies. The elasticities are then used in the model to generate reduced-form elasticities after shocking initial equilibrium with regulation tax. The resulting reduced-form elasticities reflect how export and import quantities and corresponding prices are impacted by a 1% change in compliance costs associated with aflatoxin regulation tightening. Also, simulations are performed to understand approximate levels of exporter and consumer welfare changes triggered by a 10% regulation tightening in Europe. The EU's decision to harmonize its regulation engendered drastic strictness in permissible aflatoxin levels in most member countries. For example, major importing countries, namely the Netherlands, Italy, Spain and Sweden tightened permissible aflatoxin levels to about 50% including Belgium, Greece, Ireland and Lexumbourg (Otsuki, Wilson and Sewadeh, 2001b).

Hence, those changes provide the basis for examining economic welfare implications of a 10% regulation tightening.

Typically, compliance costs data are not readily available (Henson et al., 2000). The scarcity of data drives the use of tariff equivalent rates of standards as indirect measures of compliance costs. Basically, tariff equivalent approaches are based on the price differential between domestic and import prices of a homogeneous commodity. That is, the tariff equivalent idea asserts that the effects of SPS can be approximated after separating tariffs, transportation and other transaction costs from the price gap (Calvin and Krissoff, 1998; and Yue, Beghin and Jensen, 2006). By virtue of the unavailability of direct data on aflatoxin compliance costs, this study applies a price-wedge approach to estimating compliance costs similar in principle to the tariff equivalent method (see the model section below). According to Beghin and Bureau (2001), "the price wedge measures the difference between the internal price of a good and the reference price of a comparable good, such as a border price. It attributes the price difference to trade barriers and transportation cost. The price wedge can be expressed as per unit (specific) tax/tariff, or ad valorem tax/tariff."

1.5 Method

A widely acknowledged limitation of the gravity model is its failure to isolate effects of regulations on supply and demand relations. Thus, studying the implications of food standards using gravity models, it is impossible to delineate welfare impacts on suppliers and consumers (Otsuki, Wilson and Sewadeh, 2001b; Wilson, 2003). The dissertation, therefore, addresses this gap in the literature by introducing the Equilibrium Displacement Modeling framework, grounded in the theory of tax incidence.[10] Piggot (1992) highlighted the importance of using the EDM technique as a tool for agricultural policy analysis. Consequently, influential studies such as Wohlgenant (1993); Davis and Espinoza (1998); Sun and Kinnucan (2001); Kinnucan and Myrland (2002, 2005); and Mutondo, Brorsen, and Henneberry (2009) have applied the EDM approach in analyzing various agricultural policies.

In this chapter, international trade in the EU market is characterized below through an application of the EDM method. As consignments of peanut move along the supply chain, costs related to compliance with EU aflatoxin standards are modeled as tax introduced into the peanut industry.

1.5.1 Structural Model for Peanut Trade in the EU Market

The structural model representing the EU market assumes that edible peanuts are differentiated by country of origin as shown in Boonsaeng, Fletcher, and Carpio (2008). Given the evidence that edible peanuts are source-differentiated, separate supply equations are specified for each exporting country and demand interrelationships included on the demand side. This chapter assumes that regulation tightening — which translates into increases in compliance costs (or tax) — is a demand shifter affecting only costs but not consumer preference for quality. In other words, this chapter ignores any quality-improvement effects of the aflatoxin standards and focuses on costs of compliance. Initial equilibrium in the peanut trade market is represented by the following structural model:

[10] Wohlgenant (2011) provides a good review on EDM.

(1) – (3) $M_i = M_i(P_1^D, P_2^D, P_3^D)$ $\{import\ demand\}$

(4) – (6) $P_i^D = P_i^S + T_i + C_i$ $\{price\ linkage\}$

(7) – (9) $X_i = X_i\left(P_i^S\right)$ $\{export\ supply\}$

(10) – (12) $X_i = M_i = Q_i$ $\{market\ clearing\}$

where M_i denotes quantity of EU import demand from an exporting country, X_i represents quantity of peanut supplied by different exporters to the EU market, P_i^D is import demand price for peanut from different origins, P_i^S is export price received by a particular peanut supplier, T_i is per-unit transportation cost, and C_i is per-unit compliance cost or 'tax' that captures aflatoxin regulation tightening. The superscripts *D* and *S* denote demand and supply, respectively. Subscript i= 1, 2, and 3; representing China, USA and ROW, respectively. Values for some of the variables have been provided below in Table 1.1. Endogenous variables in the model are M_i, X_i, P_i^D, and P_i^S while T_i and C_i are exogenous.

It is worth emphasizing that the compliance 'tax' variable is the exogenous variable of primary interest albeit there are several others that have been ignored for the purposes of this study.

Equations (1) - (3) capture EU import demand with respect to each of the exporting countries under consideration. These equations state that EU import demand for a given trading partner is determined by the demand price for that particular supplying country, and demand prices for the other suppliers.

The price-linkage equations (i.e. (4)-(6)) account for the relationship between country-specific export prices and import demand prices prevailing in the EU market. Owing to peanut trade liberalization policies (Beghin, Diop and Matthey, 2006), the wedge between export supply and import demand prices is assumed to comprise of standards compliance costs plus costs of transporting peanut to the EU market.[11] These price equations provide the necessary links to modeling the regulation as tax and ultimately distinguishing import price effects from export price effects. In other words, the price-wedge approach is critical to understanding the distributional impact of the aflatoxin regulation policy.

Furthermore, source-specific peanut export supply is assumed to be influenced by the exporter's supply price and this has been accounted for in equations (7)-(9). Export supply prices exclude all costs required to transfer peanuts from the supplying country to the EU market, as well as the cost of complying with aflatoxin standards.

Finally, the market clearing conditions, equations (10)-(12), ensure that the system is closed. Precisely, in equilibrium import demand quantities for each exporter are exactly identical to their corresponding export supply quantities.

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[11] Transportation costs have been suppressed in this model since the main focus is on compliance costs induced by regulation tightening. The basic price equations are $p_i^D = p_i^S + t_i + c_i$ where t_i is the per-unit transfer costs, and c_i is the per-unit compliance cost or "tax." After suppressing transfer costs, these equations are written in percentage changes as in equations (4')-(6') below.

Table 1.1. Variable Information, 1995 to 2007

Variable	Definition	Value			
		1995-2007	1995-1998	1999-2002	2003-2007
M_{china}	Import quantity from China (MT[a])	167804	133458	187697	179367
M_{usa}	Import quantity from USA (MT)	107071	147957	114428	68476
M_{row}	Import quantity from ROW (MT)	365316	352792	296165	430656
P^D_{china}	EU demand price for China's peanut (US$ /MT)	799	845	670	865
P^D_{usa}	EU demand price for USA's peanut (US$/MT)	1035	975	1031	1084
P^D_{row}	EU demand price for ROW's peanut (US$/MT)	796	795	1119	771
P^S_{china}	Export price for China's peanut (US$/MT)	460	464	395	508
P^S_{usa}	Export price for USA's peanut (US$/MT)	514	634	520	413
P^S_{row}	Export price for ROW's peanut (US$/MT)	385	399	312	433

Source: Computed from FAO Statistics (2010).
Note: [a]MT denotes 'metric tonnes' and import demand quantities are identical to corresponding export supply quantities.

We proceed by expressing the structural model in percentage changes (displaced form) as follows:

$$(1') - (3') \qquad M_i^* = \sum_{j=1}^{3} \eta_{ij} P_j^{D*} \qquad \{import\ demand\}$$

$$(4') - (6') \qquad P_i^{D*} = \alpha_i P_i^{S*} + \beta_i R^* \qquad \{price\ linkage\}$$

$$(7') - (9') \qquad X_i^* = \varepsilon_i P_i^{S*} \qquad \{export\ supply\}$$

$$(10') - (12') \qquad X_i^* = M_i^* = Q_i^* \qquad \{market\ clearing\}$$

All parameters in the displaced model are defined in Table 1.2 together with corresponding values. Asterisks indicate percentage changes in the respective variables; for instance, $X_i^* = \frac{dX_i}{X_i}$. In all, the displaced model consists of 12 endogenous variables (P_i^{S*}, P_i^{D*}, X_i^* and M_i^* where $i = china, usa\ and\ row$), and a single exogenous variable (R^*).

The exogenous variable, R^*, is the uniform percentage increase in standards (or compliance costs); translated by its coefficients as compliance tax (or standards) elasticities. The form of the model in equations (1')-(12') is referred to as equilibrium displacement model; facilitating the derivation of reduced-form elasticities (Kinnucan and Myrland, 2002; Wohlgenant, 2011). Empirical values for structural elasticities and parameters in the model are required to derive the needed reduced-form elasticities. Sources and rationale behind all parameter values selected for simulations in this chapter are later discussed in the data section.

Table 1.2. Parameters and Baseline Values

Parameter[a]	Definition	Value[b]
η_{11}	Own-price import demand elasticity; China	-1.743
η_{22}	Own-price import demand elasticity; USA	-1.868
η_{33}	Own-price import demand elasticity; ROW	-0.275
η_{12}	Cross-price import demand elasticity; China's quantity and USA's price	0.703
η_{21}	Cross-price import demand elasticity; USA's quantity and China's price	0.893
η_{13}	Cross-price import demand elasticity; China's quantity and ROW's price	0.074
η_{31}	Cross-price import demand elasticity; ROW's quantity and China's price	0.678
η_{23}	Cross-price import demand elasticity; USA's quantity and ROW's price	-0.441
η_{32}	Cross-price import demand elasticity; ROW's quantity and USA's price	-0.591
α_1	Price transmission elasticity for China	0.576
α_2	Price transmission elasticity for USA	0.497
α_3	Price transmission elasticity for ROW	0.484
β_1	Compliance tax rate for China[c]	0.111
β_2	Compliance tax rate for USA[c]	0.419
β_3	Compliance tax rate for ROW[c]	0.202
ε_1	China's peanut export supply elasticity[d]	18.766
ε_2	USA's peanut export supply elasticity[d]	4.625
ε_3	ROW's peanut export supply elasticity[d]	10.8

Notes: [a]Subscripts 1, 2 and 3 refer to China, USA, and ROW, respectively.
[b]Demand elasticities come from Boonsaeng, Fletcher, and Carpio (2008) and the remaining parameter values are computed from FAO Statistics (2010) data.
[c]See Appendix 1 for explanation on computation.
[d]See Appendix 1 for details. Also, Kinnucan and Myrland (2008) provide more information on computing theoretically-consistent export supply elasticities.

1.5.2 Computation of Reduced-Form Elasticities

Following Kinnucan and Myrland (2002, 2005), I solve the displaced model using matrix algebra to obtain the reduced-form elasticities — with the aid of Microsoft Excel spreadsheet. To clearly see the direct effect of standards tightening on demand quantities, the price equations (4')-(6') are plugged into (1')-(3') before proceeding to express the displaced model in matrix form. Performing the preceding substitution yields the tax-burdened import demand equations (13)-(15) as follows:

$$(13)-(15)\ \ M_i^* = \sum_{j=1}^{3} \alpha_j \eta_{ij} P_j^{S*} + \phi_i R^* \qquad \{tax - burdened\ import\ demand\}$$

where $\phi_i = \sum_{j=1}^{3} \beta_j \eta_{ij}$ is the composite standards elasticity that takes into account demand interrelationships among the various origins of peanut export supply. However, when the assumption that peanuts are source-differentiated is relaxed, the tax-burdened import demand equations (13)- (15) reduce to equations (16)- (18) below:

$$(16)-(18)\quad M_i^* = \alpha_i \eta_{ii} P_i^{S*} + \beta_i \eta_{ii} R^*$$

The latter import demand equations suggest that in the absence of demand interrelationships, one should expect an increase in R (i.e., regulation tightening) to cause a reduction in the quantity of peanut imported into Europe. We expect the foregoing result since price transmission elasticity (α_i) and compliance tax rate (β_i) are positive in sign, while own-price import demand elasticity (η_{ii}) is negative. Also, the preceding logic indicates that tightening the regulation lowers export prices whereas equations (4')-(6') show that import demand prices rise (see comparative statics below for more)[12]. However, maintaining the assumption that substitution effects exist among peanut from different sources (i.e. presence of demand interrelationships) leaves the composite standard elasticity (ϕ_i) with an indeterminate sign. The implication is that the nature and strength of substitution effects (i.e. cross-price elasticities) exert mixed impacts on exporter prices in that there is the possibility of some exporting countries actually benefiting from standards tightening while others suffer losses. It is, therefore, important to compare results from the two model scenarios i.e. with and without demand interrelationships.

Next, the displaced model is expressed in matrix form as follows:

$$\boldsymbol{\Pi Y} = \boldsymbol{\Gamma Z} \tag{19}$$

where **Π** is a 9 x 9 matrix of endogenous-variable coefficients (or parameters), **Y** is a 9 x 1 vector containing endogenous variables, **Γ** is a 9 x 1 vector of exogenous-variable coefficients, and **Z** is a 1 x 1 vector containing the only exogenous variable in the model. Equation (19) is then pre-multiplied by the inverse of **Π** which yields the following reduced-form equation:

$$\boldsymbol{Y} = \boldsymbol{EZ} \tag{20}$$

where $\boldsymbol{E} = \boldsymbol{\Pi}^{-1}\boldsymbol{\Gamma}$ is a **9** x 1 vector whose elements are the reduced-form elasticities. Notice that the number of endogenous variables is nine instead of twelve since the price-linkage equations were earlier substituted into the demand equations before carrying out the matrix algebra. Consequently, I derive the regulations effect on demand prices by plugging the appropriate percentage changes for export prices into the price-linkage equations, (4')-(6').

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[12] To clearly see effect of regulation tightening on export prices, we solve for P_i^{S*} in equations (16) – (18) which gives: $P_i^{S*} = \frac{1}{\alpha_i \eta_{ii}} M_i^* - \frac{\beta_i}{\alpha_i} R^* \quad where \quad i = china, usa\ and\ row.$

1.5.3 Comparative Statics

In what follows, analytical solutions for reduced-form elasticities are provided to highlight how the basic model works by deriving incidence relationships for the case where demand interrelationships are ignored. We proceed by substituting the demand equations (16)-(18) together with the supply equations (7')-(9') into the equilibrium equations (10')-(12') yielding:

$$(21)-(23)\quad \varepsilon_i P_i^{S*} = \alpha_i \eta_{ii} P_i^{S*} + \beta_i \eta_{ii} R^* \qquad i = \; china, usa \; and \; row$$

From equations (21)-(23), we solve for reduced-form elasticities regarding export supply prices as follows:

$$(24)-(26)\quad \frac{P_i^{S*}}{R^*} = \frac{\beta_i \eta_{ii}}{\varepsilon_i - \alpha_i \eta_{ii}} < 0 \qquad i = \; china, usa \; and \; row$$

Next, we derive effects of regulation tightening on import demand prices by plugging the above export price effects into the price equations (4')-(6'), resulting in the following price impact:

$$(27)-(29)\quad \frac{P_i^{D*}}{R^*} = \frac{\beta_i \varepsilon_i}{\varepsilon_i - \alpha_i \eta_{ii}} > 0 \qquad i = \; china, usa \; and \; row$$

Similarly, to obtain corresponding demand and supply quantity effects, we substitute the export price effects into either the export or import quantity equations above. Specifically, plugging equations (24)-(26) into (7')-(9') yields:

$$(30)-(32)\quad \frac{X_i^*}{R^*} = \frac{\beta_i \eta_{ii} \varepsilon_i}{\varepsilon_i - \alpha_i \eta_{ii}} < 0 \qquad i = \; china, usa \; and \; row$$

Hence, from the market clearing conditions,

$$\frac{X_i^*}{R^*} = \frac{M_i^*}{R^*} = \frac{Q_i^*}{R^*} < 0 \qquad i = \; china, usa \; and \; row$$

These comparative statics solutions (reduced-form elasticities) show the incidence relations of standards tightening on exporters and EU consumers.

The results suggest that the tightening of aflatoxin regulation reduces export prices received by suppliers and increases import prices faced by EU consumers, as illustrated earlier in Figure 1.1. In addition, the economics principle that the less elastic side of a market bears the greater incidence of policy interventions can be shown clearly. Stated differently, the less elastic side of the peanut market (i.e. the demand side since absolute values of demand elasticities are consistently less than supply elasticities in Table 1.2) is expected to bear the greater economic incidence of aflatoxin regulation tightening. For example, if export supply is perfectly elastic then equations (24)-(26) reduces to $\frac{P_i^{S*}}{R^*} = 0$, while equations (27)-(29) become $\frac{P_i^{D*}}{R^*} = \beta_i$; implying that the entire incidence of standards tightening would be borne by EU consumers.

1.5.4 Economic Welfare Changes

The estimated reduced-form elasticities are used in welfare measurement formulas derived from Figure 1.1 (see Wohlgenant, 1993, 1999; Alston, Norton and Pardey, 1995; Sun and Kinnucan, 2001; Mutondo, Brorsen and Henneberry, 2009). With the regulation tax intervention as demand shifter, the appropriate formulas for approximating producer and consumer economic surplus changes are stated in equations (33) through (38). In Figure 1.1 above, it is instructive to note that change in producer welfare equals the difference between the areas delineated by triangles P_0e_0g and P_Se_1g. Similarly, the change in consumer welfare is approximated by subtracting the area of triangle P_0e_0n from that of triangle P_Dln. Thus, both sides of the market are expected to experience losses in economic welfare, following imposition of the regulation tax. For each side of the market, economic surplus before the tax intervention exceeds the surplus after the policy.

$$(33)-(35) \qquad \Delta PS_i = P_i^S Q_i P_i^{S*}(1 + 0.5Q_i^*) \qquad i = china, usa \ and \ row$$

$$(36)-(38) \qquad \Delta CS_i = (V_i^D - P_i^{D*})P_i^D Q_i(1 + 0.5Q_i^*) \quad i = china, usa \ and \ row$$

where ΔPS_i is change in welfare (surplus) for a given exporter; ΔCS_i represents change in consumer welfare regarding demand for a given exporter's peanut; P_i^S is supply price received by a given exporter in the initial equilibrium; P_i^D is the initial equilibrium demand price faced by EU consumers for an exporter's product; Q_i is quantity traded in the initial equilibrium; P_i^{S*} and P_i^{D*} are as defined earlier; and V_i^D is the vertical shift in a particular demand as a result of regulation tightening. In the model scenario where demand interrelationships are ignored, $V_i^D = \frac{\beta_i}{-\alpha_i}R^* < 0$; where the negative sign indicates a downward (inward) demand shift in response to regulation tightening (see Appendix 1 for more on the derivation of V_i^D).[13]

1.6 Data and Sources

Peanut exporting countries covered in this chapter are China, USA, and ROW. According to Boonsaeng, Fletcher, and Carpio (2008), in-shell peanut exports from China and USA form over three-quarters of edible peanut imported into the EU (see Appendix 1A for details on import quantity shares).

[13] For details on how to correctly compute economic welfare changes when products are related in consumption (for example, existence of substitution effects in demand as in this study), see Alston, Norton and Pardey (1995, pp. 237-245).

Other prominent peanut exporting countries to the EU market, namely Argentina, India, Brazil, Vietnam and some African countries (Egypt, South Africa, Senegal, Sudan, Malawi and Gambia) have been aggregated as ROW.[14]

The EU data comprise aggregation of all member countries in the relevant period of this study.[15]

A panel of annual trade value and quantities for edible peanut was obtained from FAOSTAT (2010) database. Unit prices were derived from the trade value and quantity data.

Boonsaeng, Fletcher and Carpio (2008) analyzed EU import demand for in-shell peanuts from USA, China, and ROW. In the literature, the aforementioned work is the only study to have estimated EU peanut import demand hence their price elasticity values are employed in this chapter.[16] Boonsaeng, Fletcher and Carpio (2008) found peanut from China and USA to be highly substitutable. Similarly, cross-price elasticities suggest that Chinese and ROW peanut are gross substitutes. Conversely, USA and ROW peanut were found to be gross complements (see Table 1.2 for the demand elasticity values).

[14] Average prices and transportation costs for Argentina and India are used to represent ROW except for export and import quantities where all countries are used in the computation. Moreover, exporters that make up 'ROW' in the current paper may not be exactly identical to that of Boonsaeng, Fletcher, and Carpio (2008) but may be close since the aggregate comprises Latin American and African countries.

[15] The peanut demand quantities used for this paper cover the entire 27 EU member countries over the period 1995 through 2007. Average of import prices offered in the United Kingdom, the Netherlands and France markets are used to represent the EU due to the prominence of these importing countries in the European peanut market.

[16] Although Boonsaeng, Fletcher and Carpio's study focused on edible in-shell peanuts only, the current paper assumes that their elasticities can be generalized for all edible peanuts (i.e. both shelled and in-shell peanuts).

Regarding peanut export supply elasticities, no estimates are available in the literature. However, Kinnucan and Myrland (2008), provide a theoretically-consistent formula for approximating export supply elasticities. Hence, I apply the formula in this chapter (see Appendix 1.C for formulas and details on how export supply elasticities are computed in the present study). As evident in Table 1.2 above, supply elasticity values are all elastic given that peanut exports in each supplying country account for less than 15% of domestic production (see Appendix 1A for export quantity shares).

The last set of parameter values — compliance tax and price transmission elasticities — are computed using data from the following sources: (1) all source-specific import demand prices are obtained from FAOSTAT (2010) database as unit prices; (2) precise shipping cost for USA is 87 US$/MT, obtained from Oosterman (2000); and (3) using Jaffee (2003) as a guide, transportation costs for China and ROW are estimated to be 250 US$/MT each.

The sample period for this study is 1995 through 2007.

1.7 Results and Discussion

This section shows reduced-form elasticities computed for the entire sample period as well as the three sub-periods. In addition, corresponding economic welfare results are provided. Specifically, Table 1.3 shows results from baseline parameter values together with the three sub-periods in connection with the inception of EU standards harmonization (and tightening). For each period, results attained from incorporating demand interrelationships are juxtaposed against those obtained when peanut is assumed not to be source-differentiated. Finally, Table 1.4 displays approximated exporter and EU consumer welfare changes for the case where substitution effects are ignored in the model.

Table 1.3. Price and Quantity Effects of Aflatoxin Regulation in the EU Market, 1995-2007

	1995-2007[a]		1995-1998[b]		1999-2002[c]		2003-2007[d]	
Variables	*NSE*[e]	*SE*[f]	*NSE*[e]	*SE*[f]	*NSE*[e]	*SE*[f]	*NSE*[e]	*SE*[f]
P_c^S*	-0.0098	0.0034	-0.0136	-0.0054	-0.0033	0.0101	-0.0109	0.0063
P_{us}^S*	-0.1409	-0.1382	-0.0834	-0.0738	-0.1381	-0.1701	-0.1887	-0.1759
P_{rw}^S*	-0.0051	-0.017	-0.0046	-0.0067	-0.0126	-0.0276	-0.0029	-0.0205
P_c^D*	0.1054	0.113	0.1465	0.151	0.0351	0.043	0.1176	0.1277
P_{us}^D*	0.349	0.3503	0.2068	0.213	0.3424	0.3263	0.4671	0.472
P_{rw}^D*	0.1995	0.1938	0.1807	0.1796	0.4945	0.4903	0.1124	0.1025
Q_c*	-0.1837	0.0637	-0.2559	-0.101	-0.0611	0.1904	-0.2042	0.1177
Q_{us}*	-0.6518	-0.639	-0.3855	-0.3414	-0.6387	-0.7865	-0.8726	-0.8133
Q_{rw}*	-0.0549	-0.1838	-0.0498	-0.0726	-0.136	-0.2983	-0.0309	-0.2209

[a]Baseline period. [b]First sub-period. [c]Second sub-period. [d]Third sub-period.

[e]Results obtained when substitution effects are ignored (i.e. No Substitution Effects).

[f]Results obtained when substitution effects are included in the analysis (i.e. Substitution Effects considered).

From Table 1.3, it is evident that reduced-form elasticities (especially for the model scenario that ignores substitution effects in demand) conform to the expected incidence signs as a result of standards tightening. Thus, in the case where peanuts from different origins are treated as homogeneous, it is observed that regulation tightening causes all export prices and quantities to fall. For example, in the baseline period (i.e. 1995-2007), a 10% increase in the compliance costs associated with aflatoxin regulation tightening causes a 0.098% decrease in China's export price and a 1.837% drop in its quantity of peanut exported to the EU market. In the aforementioned situation — where demand interrelationships are ignored — all import demand prices increase. Specifically, import demand price offered to China rises by 1.054% and those of USA and ROW also go up by 3.490% and 1.995%, respectively when standards compliance tax increase by 10%. Comparisons of the magnitude of export price reductions associated with tighter standards indicate that USA faces the most severe price drop while ROW experiences the least impact.

It is also important to note that the intensity of the EU aflatoxin policy on import demand prices is greater than that of the corresponding supply prices. In other words, comparing absolute magnitudes of all price effects reveals that demand prices paid by EU consumers are more responsive to standards tightening than corresponding supply prices received by exporters. The preceding observation is in line with the principle of tax incidence given that EU peanut demand elasticity values are consistently less than the export supply elasticity values, in absolute terms (see Table 1.2). Thus, the less elastic side of the peanut trade market in Europe, namely consumers, appears to bear the greater incidence of stricter aflatoxin regulation policies. To highlight short-run effects of the policy, and to further demonstrate the principle that the less elastic side of the market bears the greater incidence, simulations have been provided in Appendix 1D where supply elasticities are set to zero. We observe that in the short run, where supply is perfectly inelastic (and therefore less than demand elasticities in absolute terms), the entire incidence of the policy is borne by exporters in that supply prices are lowered but EU consumer prices remain unaffected.

On the other hand, introduction of substitution effects into the model also leads to falling export prices and quantities for USA and ROW, while China enjoys rising export price and quantity. Precisely, a 10 percentage increase in the regulation compliance costs drives USA and ROW export prices down by 1.382% and 0.170%, respectively, whereas that of China moves up by 0.034%. Again, for import demand prices, EU consumers experience increases in peanut prices following aflatoxin regulation tightening.

It is worth emphasizing that due to the price-wedge setup, whenever export prices decrease and corresponding demand prices increase following regulation tightening, both sides of the market are deemed to be sharing the economic burden from regulation compliance costs; similar to the distribution of conventional tax incidence. With the foregoing in mind, China rather appears to benefit from standards tightening given that both of its supply and demand prices increase after standards tightening unlike its competitors who bear the effects of compliance tax with EU consumers. China's apparent gain could be explained by Boonsaeng, Fletcher, and Carpio's study which found that peanuts from USA and China are highly substitutable and that EU consumers are responsive to price changes. That is, since China's peanut is consistently cheaper than that of USA (see unit prices in Table1.1), EU consumers are likely to demand more of China's peanut following increasing regulation. Therefore, the presence of demand interrelationships seems to favor China in the face of higher compliance costs associated with stringent aflatoxin standards. However, USA apparently suffers lesser losses due to substitution effects as opposed to the case where there is no substitution effect, while ROW experiences heavier losses in the presence of demand interrelationships.

For deeper insight into how regulation tightening affects prices and quantities in different time periods, attention is extended to sub-period analysis. Particularly, the purpose of conducting the sub-period incidence analyses (see Table 1.3 for results) is to see how changing export requirements in those times (in terms of standards evolution) compare with the economic burden derived for the entire sample period.[17]

[17] The alpha and beta parameters are re-calibrated to reflect sub-period prices (see Appendix for values). However, import demand and export supply elasticities for the entire sample period are maintained for the sub-periods as well (see Appendix 1 for the sub-period export quantity shares which are close to the baseline values).

Diop, Beghin and Sewadeh (2004) note that USA and Africa lost market shares in the edible peanut market to Argentina and China over the past two decades (see Appendix 1A). The authors argue that on the part of African exporters, the fall in market share is explained by strict aflatoxin standards, while domestic peanut policies are partly to blame in the case of USA.[18] By inspection, results from virtually all three sub-periods exhibit qualitative similarities to the baseline results. In other words, tighter regulations influence on prices and quantities are similar to those of the baseline period discussed earlier. In the scenario where substitution effects are ignored, the results for the sub-periods are close to those of the entire sample period. A closer look reveals that the severity of the regulations effect on China's export price is most intense in the first sub-period and least in the second sub-period. For the USA, the degree of price lowering intensifies consistently from the first to the last sub-period with the latter effect greater than the baseline. However, in the case where substitution effects are included in the model, the point of departure from the baseline results occurs only in the first sub-period. Specifically, all export prices drop in the first sub-period unlike in the baseline where China enjoys a price increase. Essentially, the baseline results reasonably reflect the effects of regulation tightening on edible peanut prices and quantities in the EU market.

Finally, approximated economic welfare changes due to a 10% increase in compliance costs (following regulation tightening) are illustrated in Table 1.4 to underscore the importance of price and quantity effects of the aflatoxin policy. The effects of aflatoxin regulation on all prices and quantities used in the welfare estimation are captured through the reduced-form elasticities shown in Table 1.3.

[18]For details on aflatoxin standards enforced by the EU, see Otsuki, Wilson and Sewadeh (2001a, 2001b); and Xiong and Beghin (2010). Diop, Beghin and Sewadeh (2004) provide a lengthy discussion on domestic peanut policies for many peanut producing countries including USA.

Table 1.4. Welfare Changes (US$) Induced by 10% Regulation Tax Increase in the EU Market, 1995-2007

Exporters	Exporter Welfare	EU Consumer Welfare
China	-74850	-3960198
USA	-750370	-13000000
ROW	-71270	-18000000
Total	-896490	-34960198

Note: These welfare values are from the model with no demand interrelationships.

Evidently, in the case where demand interrelationships are not accounted for in the model, regulation tightening causes welfare losses to each side of the market — both exporters and consumers are adversely impacted. On the side of suppliers, China, USA, and ROW respectively face welfare losses estimated at US$ 74,850; US$ 750,370 and US$ 71,270 while on the demand side EU consumers also lose a total of US$ 34,960,198 in welfare. Therefore, given the price and quantity incidence of aflatoxin regulation tightening, one can accordingly infer that, in general, both sides of the market experience losses in economic welfare regardless of the presence or otherwise of demand interrelationships.

1.8 Summary and Conclusions

The main purpose of this chapter was to investigate price and quantity effects triggered by Europe’s stringent aflatoxin regulation policy on peanut imports; in order to shed light on attendant economic welfare impacts. To achieve this goal, the Equilibrium Displacement Modeling technique was employed to evaluate the aflatoxin policy. A major assumption is that edible peanuts from various exporting countries are differentiated according to origin by consumers in the European Union

(EU) market. Annual data from the period 1995 through 2007 was obtained from FAOSTAT database in addition to other sources cited in the text. Edible peanut exporters covered in the study are China, USA, and rest of the world (ROW). EU countries form the export market.

Overall, it is apparent from baseline results that if peanuts from various countries are assumed to be homogeneous then tighter regulations affect exporters differently as opposed to the case where peanut origins are treated by importers as heterogeneous. That is, in the scenario where substitution effects in the market are ignored, it is clear that tighter regulations depress all export prices and quantities. However, accounting for demand interrelationships reveals that although USA and ROW do experience decreases in export prices and quantities, China actually enjoys rising export price and quantity, following aflatoxin regulation tightening. China's benefits could be attributed to findings in the literature that edible peanuts from the two leading exporters (i.e. USA and China) are highly substitutable in the EU market. Thus, regulation tightening creates higher compliance cost which is translated into increased demand prices; causing importers to substitute away from USA and ROW toward China. Given evidence that peanuts in the EU market are source-differentiated, the latter result is revealing. Contrary to popular belief that strict aflatoxin regulation hurts all exporters in terms of lost revenues, it has been shown that, in fact, some exporters (such as China) do benefit. Interestingly, USA which is a rich exporter suffers losses together with ROW (which is predominantly composed of developing country exporters) when standards are raised.

Comparisons of the magnitude of export price reductions due to the aflatoxin policy indicate that USA faces the most severe price lowering effect, while ROW experiences the least impact.

However, USA is apparently harmed less due to substitution effects in demand as opposed to the case where there is no substitution effect, whereas ROW incurs greater losses in the presence of demand interrelationships compared to the other model scenario. It is worth stressing that most of the ROW countries are only fringe suppliers of edible peanut to the EU market unlike major exporters, namely China and USA (see Appendix 1A). Hence, the apparent welfare loss to ROW may not be substantial when disaggregated to the country level.

In general, regulation tightening for peanut aflatoxin (which is modeled in this study as import tax) depresses export prices and raises demand prices in the EU market. Also, results confirm the tax incidence principle that the less elastic side of a market (i.e. the demand side of the peanut market) bears the greater incidence of interventions. Thus, given that absolute values of peanut demand elasticities are less than supply elasticities in the EU market, consumers consequently experience greater price and quantity effects from standards tightening than exporters. Hence, EU consumers ultimately pay most of the costs from the aflatoxin policy.

Furthermore, regarding the economic welfare implications of strict standards, price and quantity effects evaluated in theoretically-consistent welfare formulas highlight findings that all sides of the peanut trade suffer economic losses.

Therefore, based on the findings of this chapter, strict aflatoxin standards imposed on peanut trade hurts each side of the international market since some exporters lose revenue, whereas consumers in importing countries face higher retail prices. As presented in this chapter, the greater share of the economic burden owing to aflatoxin standards tightening is borne by EU consumers. Exporters' economic impacts are modest compared to EU consumers who bear the major costs of the aflatoxin intervention.

Hence, the market can be interpreted as fair and efficient; since EU consumers who are the intended beneficiaries of the strict aflatoxin standards also pay the greater share of the compliance cost.

Findings from this chapter underscore the need for closer collaboration among trading countries, both exporters and importers, with a collective goal of effectively controlling the aflatoxin contamination problem; such partnerships would be helpful to all parties involved in cross-border trade. The interaction may include the transfer of technical know-how, assistance with requisite resources, and standards harmonization. Moreover, in order to minimize the attendant economic losses to either side of the market, policy makers would have to enforce realistic aflatoxin standards scientifically proven to be safe to consumers. Thus, the negative economic welfare implications resulting from strict aflatoxin interventions provide guidance to policy makers in rich importing countries to implement standards that do not harm trade partners and consumers.

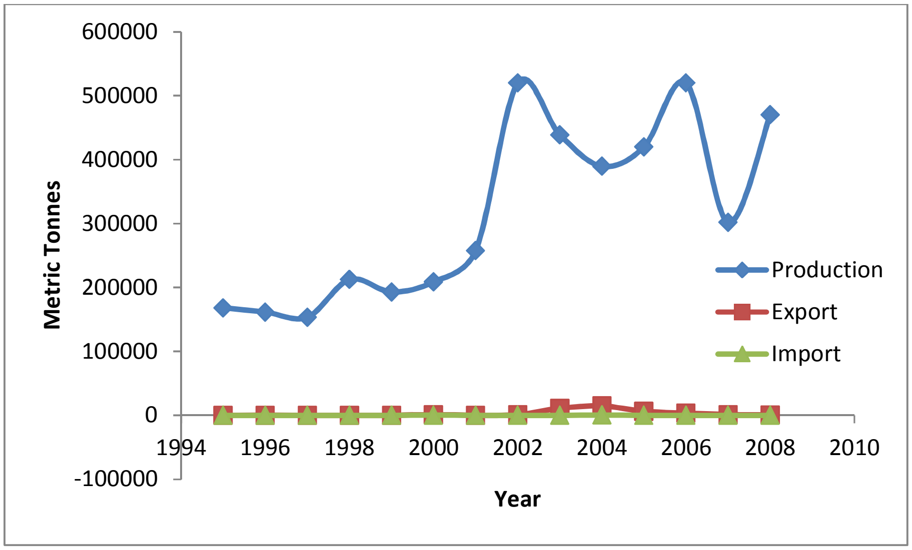
Chapter 2: Economic Analysis of Aflatoxin Interventions in Developing Countries: The Peanut Sector in Ghana

2.1 Background and Problem Statement

Peanut (*Arachis hypogaea*), also known as groundnut, is an important food crop produced in many Sub-Saharan African countries. Due to heavy domestic consumption, proportions traded internationally are often low (Diop, Beghin and Sewadeh, 2004). Examples of food products derived from peanut include butter, confectionaries, oil, and cake. Promising markets exist for peanut particularly in the snack food industries in North America and Europe, and in popular Asian cuisines (ARD, 2008).

Peanut is a key source of protein in Ghana. The crop is dominantly grown in the northern regions of the country (Atuahene-Amankwa, Hossain, and Assibi, 1990). Figure 2.1 displays peanut production and demand in Ghana from 1995 through 2008. Domestic consumption of the crop is high and nearly matches total production. The chart generally reveals an increasing trend in supply and local consumption, in spite of fluctuations over the period. Cross-border trade in peanut (including peanut oil) is marginal and fairly stable over the period in question. Similarly, Table 2.1 reveals that Ghana is largely a net peanut exporter although quantity traded abroad is only a minute fraction relative to that of the domestic market.

Figure 2.1. Peanut Production and Distribution in Ghana from 1995-2008



Source: Computed from FAO Statistics (2011)

Table 2.1 Peanut Production Quantities in Ghana; 1995-2008

Year	Production	Export	Import
1995	168201	1	1
1996	161631	201	1
1997	153649	47	1
1998	212491	7	12
1999	193001	44	1
2000	209001	1199	279
2001	258001	178	2
2002	520001	1104	1
2003	439001	11001	38
2004	389650	14584	505
2005	420001	6462	1
2006	520001	3319	1
2007	301771	1324	1
2008	470101	648	96

Note: Quantities are in Metric Tonnes.

Source: FAO Statistics (2011)

As observed in most basic food staples in the developing world, peanut is susceptible to mycotoxin contamination; especially aflatoxins (Jolly et al., 2006).[19] Environmental conditions in tropical and sub-tropical regions of the world — high temperature and humidity, insect infestation, improper hygiene, among others — are known to be conducive to the growth of mycotoxin-producing fungi (Dohlman, 2003). Hence, mycotoxins are more likely to present challenges to public health and economic welfare of populations living in warm countries. Extensive research show strong association between aflatoxins exposure and a host of negative health outcomes (Wang et al., 2001; Turner et al., 2003; Williams et al., 2004; Lewis et al., 2005; Wu, 2006; Liu and Wu, 2010; Wu and Khlangwiset, 2010). Although aflatoxins and other mycotoxins impact people across the world, the problem deserves urgent attention in developing countries, particularly for the following reasons: (1) Food items that serve as basic staples to consumers are prominent substrates for toxin-producing fungi (Wang et al., 2001; Shephard, 2003); (2) Low-income conditions generally compel individuals to consume contaminated food due to availability of limited resources (Jolly et al., 2006); (3) Given that the mycotoxin problem is pronounced among low-income populations, and since greater percentage of the world's population reside in developing countries (Todaro and Smith, 2012), one would expect that most of the people exposed to high levels of mycotoxins live in those regions; and (4) Incidence and prevalence of Hepatitis B is disproportionately high in low-income countries (WHO, 2008), and this has been shown to be strongly

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[19] Mycotoxins are composed of chemical substances produced by fungi which contaminate crops during production and after harvest. Aflatoxins of concern are designated B1, B2, G1 and G2 (Park et al., 2002).

associated with high burden of diseases such as liver cancers (Montesano, Hainaut, and Wild, 1997; Wild and Hall, 1999; and Dash et al., 2007).

To protect public health, regulatory bodies respond to the mycotoxin problem through the introduction and enforcement of residue regulation policies. Although international food standards exist, the World Trade Organization also allows countries to enforce own standards when necessary.[20] For example, the international aflatoxin standard set by Codex is 15 ppb, whereas the European Union (EU) enforces 4ppb, and the United States requires 20 ppb (Otsuki, Wilson and Sewadeh, 2001a, 2001b).[21] The presence of aflatoxin regulations in developed countries such as Europe and the United States is a manifestation of heightened interest in food safety. Ultimately, the goal is to establish uniform mycotoxin standards worldwide (Council for Agricultural Science and Technology, 2003). Therefore, with increasing globalization, it is inevitable that developing countries will pursue regulation policies in harmony with rich countries — to safeguard public health and promote trade locally and abroad. Against this backdrop, this chapter isolates Ghana (because of its high peanut consumption) to study possible economic impact of the aflatoxin contamination problem on its populace. According to FAO (2004), Ghana has no comprehensive national mycotoxin standards that cover peanut aflatoxin in detail. However, Ghana is building capacity on Sanitary and Phytosanitary Standards (SPS) with support from the Danish International Development Agency; as part of a Trade Sector Support

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[20] Each nation is permitted to set its own level of maximum contamination according to the "Precautionary Principle". This principle is essentially the World Trade Organization's recognition of a country's right to issue standards to protect its people: 1) whenever it deems necessary and 2) with no obligation to show any scientific proof of the potential threat (Yue, Beghin and Jensen, 2006).

[21] Codex refers to the joint FAO/WHO Codex Alimentarius Commission responsible for setting food standards. For details, see Otsuki, Wilson and Sewadeh, 2001a, 2001b. Also, ppb means 'parts per billion'.

Program (TSSP). Under the TSSP, there are a number of SPS projects with one specifically geared toward enforcement in domestic markets and eventual harmonization with West African countries (Ministry of Food and Agriculture, 2008). As Ghana prepares to enforce mycotoxin standards, it is important to assess possible policy implications given that food standards introduce additional costs into the supply chain.

The majority of studies on food standards focus entirely on trade volume effects (Otsuki, Wilson and Sewadeh, 2001a, 2001b; Yue, Beghin and Jensen, 2006; Nogueira et al., 2008; Nguyen and Wilson, 2009), much to the neglect of price effects on market participants. Moreover, benefits of aflatoxin standards to populations in developing countries — due to the assurance of safer food — are mostly ignored. Thus, to a large extent, the literature on regulations is devoted to effects on exporters trading with rich countries that impose strict standards. The literature's focus on trade flows has, therefore, led to limited attention on how economic welfare of domestic producers and consumers in developing countries is affected by the mycotoxin problem. Consequently, the impacts of aflatoxin regulations on food prices are largely unknown although prices are crucial to understanding the economic implications of policy interventions, as far as market participants within a country are concerned. Furthermore, to the best of my knowledge, the potential benefits associated with consumption of peanut with reduced contamination (i.e. quality peanut) have not been incorporated into any evaluation of the economic impacts driven by aflatoxin policy interventions.

2.2 Objectives

The purpose of this chapter is to determine the economic impacts of aflatoxin regulation on peanut market participants in Ghana. Also, I explore how trade status and the demand for quality peanut affect distribution of economic gains/losses among domestic market participants. Thus, the primary goal is to gain insights into the incidence of economic burden or benefits from the aflatoxin policy intervention, whether the peanut sector is closed or open to cross-border trade.

2.3 Theoretical and Conceptual Framework

The theoretical foundation of this study hinges on the standard theories of tax incidence and economic equilibrium introduced in Chapter One. Similarly, this chapter applies the tariff equivalent method to quantifying SPS compliance costs using a price-wedge approach (Calvin and Krissoff, 1998; and Yue, Beghin and Jensen, 2006).

In Ghana, the contribution of the peanut sector to the national economy is not substantial. Hence, economic incidence of the aflatoxin policy is analyzed in a partial equilibrium setting as opposed to a general equilibrium framework (Kotlikoff and Summers, 1987). To characterize the model, the following simplifying assumptions are made about the peanut market in Ghana: (1) The market is perfectly competitive; (2) Complete market clearing occurs in equilibrium; (3) There are parallel shifts in demand and supply curves in response to shocks on equilibrium caused by exogenous factors such as the aflatoxin-compliance tax. In the literature, economic incidence analysts including Alston, Norton and Pardey (1995); Wohlgenant (1999); and Sun and Kinnucan (2001) have imposed similar assumptions.

Another key assumption in this study is that regulation tightening leads to increases in compliance costs along the peanut supply chain (Maskus and Wilson, 2001; Otsuki, Wilson and Sewadeh, 2001a). Mycotoxins contamination largely occur through post-harvest practices such as mode of transportation; storage type and duration; handling methods during processing and marketing; among others (Dohlman, 2003; Amoako-Attah et al., 2007; N'dede et al., 2012). In fact, studies conducted in Ghana (Amoako-Attah et al., 2007) and Benin (N'dede et al., 2012) indicate that effective post-harvest handling measures, such as proper drying and sorting, do attract additional peanut supply costs. As a result, regulation compliance cost is treated in the analysis as tax (i.e. shock variable) imposed on the production side that shifts the peanut supply curve inwards; following the exogenous policy intervention. Hence, the economic incidence of aflatoxin compliance costs is assumed to be similar to standard tax incidence. Compliance costs, in connection with food standards, refer to all expenses incurred by the private and public sectors within a particular supply chain.[22] Thus, cost outlays and losses borne by peanut suppliers — due to aflatoxin standards — are considered as compliance costs. It is also important to stress that stricter standards will necessitate higher expenditure from food suppliers in order to comply with such regulations. Consequently, compliance costs for EU standards would be higher than those associated with the United States and Codex's standards. Notable elements of compliance costs for peanut aflatoxin regulations involve expenses on sorting; drying; proper storage and materials; and good hygiene practices. Moreover, peanut supplies that fail to meet standards for human food are usually relegated to financially-unattractive outlets such as animal feed, biofuels, or completely discarded leading to revenue losses.

[22] See Shafaeddin (2007) for more on SPS compliance costs. Also, to understand the broad nature of mycotoxin control strategies, see Dohlman (2003) and Codex Alimentarius Commission (2003).

For example, Jolly et al. (2010) show that the high aflatoxin contamination found in peanuts in Ghana means that suppliers would have to discard over 50% per standards from EU, World Health Organization, and the United States; with EU regulations causing the greatest losses. In short, this chapter assumes that if a country moves away from a no-standards policy regime and adopts any of the three standards mentioned, then market participants would face compliance costs/tax. Similarly, if a country switches away from lenient standards to more stringent ones, the market participants in question, again, deal with higher aflatoxin compliance costs.

Furthermore, it is assumed that all peanut suppliers are legally obliged to conform to regulations enforced by the Ghana Standards Authority. Therefore, transactions between sellers and buyers would occur only after inspection and approval from the national regulatory body. This working assumption circumvents possible transactions that may occur in the informal (or unregulated) markets thereby simplifying the analyses.

2.4 Method and Models

The distributional impact of aflatoxin regulation is operationalized in an Equilibrium Displacement Model (EDM) framework. Thus, this chapter determines price and quantity effects of Ghana's domestic aflatoxin-compliance tax using EDM method, where policy evaluation is conducted within a system of supply and demand (see Piggot, 1992; Davis and Espinoza, 1998; Metcalfe, 2002; Kinnucan and Myrland, 2005). Structural demand and supply elasticity estimates are obtained from the literature and used in the model to generate reduced-form price and quantity impacts, following marginal increases in aflatoxin compliance costs.

The results demonstrate how peanut producer and consumer prices are impacted by a rise in compliance costs associated with aflatoxin regulation in Ghana. Price and quantity effects are subsequently translated into approximate welfare losses or gains.

In what follows, the peanut sector in Ghana is introduced in three nested models conditional on trade status and/or consumer preference for quality. Thus, economic implications of the aflatoxin policy are evaluated such that the distribution of losses or gains is determined for a closed sector versus the case where the peanut industry is open to cross-border trade (i.e. market liberalization).

2.4.1 Model One: Autarky in the Peanut Market

This model assumes that Ghana is self-sufficient in the supply of peanut. Table 2.1 (and Figure 2.1) shows that domestic production and consumption are nearly identical since exports form a small fraction of supply. The apparent self-sufficiency in the sector provides the basis for analyzing a closed economy. Initial equilibrium in the autarkic sector is represented by the following structural model:

(1) $$Q_D = Q_D(P_D) \qquad \{domestic\ demand\}$$

(2) $$Q_S = Q_S(P_S) \qquad \{domestic\ supply\}$$

(3) $$P_D = P_S + T + R \qquad \{price\ linkage\}$$

(4) $$Q_S = Q_D = Q \qquad \{market\ clearing\}$$

where Q_D denotes quantity of peanut demanded, Q_S represents quantity of peanut supplied, P_D is the consumer price of peanut in the Ghanaian market, P_S is the producer price received by peanut suppliers, T is the per-unit transaction costs incurred as peanuts are moved from producers to final consumers excluding standards compliance costs, and R is the per-unit compliance costs or 'tax' that captures aflatoxin regulation tightening.

The subscripts *D* and *S* denote demand and supply, respectively. Detail information on the variables is provided in Table 2.2. Endogenous variables in the model are Q_D, Q_S, P_D, and P_S, whereas T and R are exogenous.

Regulation compliance tax is the exogenous variable of interest although there are several others that have been suppressed for simplicity.

Equation (1) is the demand equation. The equation states that the quantity of edible peanut demanded in Ghana is determined by the retail price.

Furthermore, the quantity of peanut produced is assumed to be influenced by the supply price. Equation (2) represents the supply equation. Producer price excludes costs required to transfer peanut from the farm to the consumer (including cost of complying with the standards).

The price-wedge equation, i.e. (3), accounts for the relationship between supply and demand prices in the Ghanaian market. The price differential is attributed to market transaction costs, including costs associated with aflatoxin minimization practices such as proper drying.[23] Equation (3) provides the important link to modeling the regulation as a tax and ultimately distinguishing consumer price effects from those of producers.

Finally, a market clearing condition is imposed in equation (4) to ensure that the system is closed. Stated differently, in equilibrium, quantity demanded is exactly identical to quantity supplied in the market.

[23] Henceforth, other transaction costs are suppressed since the primary focus is on compliance costs induced by regulation tightening. The basic price equation is $P_D = P_S + T + R$ and after suppressing transaction costs, the price equation is written in percentage changes as in equation (3').

Table 2.2. Average Peanut Market Information in Ghana, 1995 to 2008

Variable	Definition	Value
Q_D	Quantity demanded domestically in Ghana (MT[a])	312497.10
Q_X	Quantity exported abroad (MT)	2864.64
Q_S	Total quantity produced in Ghana (MT)	315463.40
P_D	Price paid by consumers in Ghana (US$/MT)	796.00
P_S	Price received by peanut producers in Ghana (US$/MT)	610.87
T	Transaction costs (US$/MT)	186.00
R	Aflatoxin regulation compliance costs (US$/MT)	50.22

Source: Computed from FAO Statistics (2011).
Note: [a]MT denotes metric tonnes.

Next, the structural model is expressed in percentage changes (or displaced form) as shown below:

$$(1') \quad Q_D^* = \eta_D P_D^* \quad where\ \eta_D < 0 \quad \{domestic\ demand\}$$

$$(2') \quad Q_S^* = \varepsilon_S P_S^* \quad where\ \varepsilon_S \geq 0 \quad \{domestic\ supply\}$$

$$(3') \quad P_D^* = \alpha P_S^* + \beta R^* \ where\ \alpha = \frac{P_S}{P_D} > 0\ and\ \beta = \frac{R}{P_D} > 0 \quad \{price\ linkage\}$$

$$(4') \quad Q_S^* = Q_D^* = Q^* \quad \{market\ clearing\}$$

Table 2.3 provides information on parameters in the displaced model. Asterisks attached to the variables denote percentage changes. For example, $P^* = \frac{dP}{P}$. The displaced model consists of four endogenous variables, namely Q_S^*, Q_D^*, P_S^* and P_D^*, in four equations. The only exogenous variable in the model is R^* given that all other exogenous variables are suppressed. Since the current study models regulation tax as a supply shifter, we solve for P_S^* in $(3')$ and substitute the result into $(2')$ to obtain the tax-burdened supply equation. Precisely, Q_S^* is rewritten as a function of P_D^* and R^* as illustrated below:

$$(5) \quad P_S^* = \frac{P_D^*}{\alpha} - \frac{\beta}{\alpha} R^*$$

Therefore, plugging (5) into (2′) yields the following supply equation;

$$(6) \quad Q_S^* = \frac{\varepsilon_S}{\alpha} P_D^* - \frac{\varepsilon_S \beta}{\alpha} R^* \qquad \{tax - burdened\ domestic\ supply\}$$

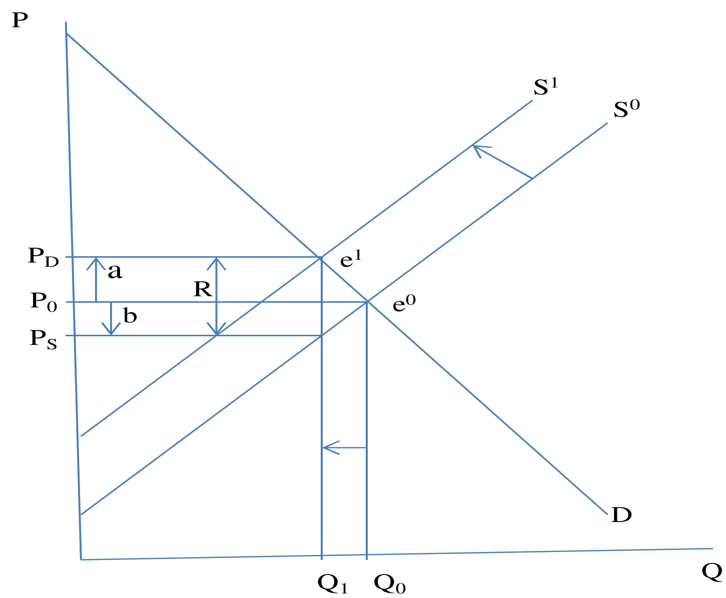
Table 2.3. Parameter Values

Parameter	Definition	Value
ηD	Own-price elasticity of domestic demand	-0.2000
ηX	Own-price elasticity of export demand	-1.9000
εS	Own-price elasticity of domestic supply	0.3500
εX	Own-price elasticity of export supply	25.8740
α	Price transmission elasticity	0.7663
β	Aflatoxin regulation compliance tax rate	0.0631
KD	Share of domestic production consumed locally	0.9900
KX	Share of domestic production exported	0.0100

Notes: See the data section below for sources and computation of entries in the table.

Applying simple algebra, the endogenous variables in the displaced model are simultaneously solved for as reduced-form elasticities (expressed as functions of structural elasticities in the model). Matrix algebra and spreadsheets are typically employed in sophisticated models with a system of equations (for details see Kinnucan and Myrland, 2002). The simple models in this study provide the opportunity to manually solve for the reduced-form elasticities and illustrate how the model works through comparative statics. Figure 2.2 shows the distribution of economic burden in autarky following enforcement of regulation policy in Ghana.

Figure 2.2. Incidence of Aflatoxin Tax on the Peanut Sector in Ghana



2.4.1.1 Comparative Statics and Computation of Reduced-Form Elasticities

This section provides analytical solutions for the reduced-form elasticities. In addition, the comparative statics demonstrate how the model works in deriving economic incidence relationships, as shown graphically in Figure 2.2 above. We proceed by substituting (6) and $(1')$ into $(4')$ and subsequently solving for consumer price effect as follows:

$$(7) \quad \frac{P_D^*}{R^*} = \frac{\varepsilon_S \beta}{\varepsilon_S - \alpha \eta_D} > 0$$

At this point, (7) is in reduced-form hence plugging it into any of the remaining price and quantity equations in the displaced model yields the other relevant reduced-form elasticities. We, therefore, derive the reduced-form elasticity for producer price by substituting (7) into (5) which gives the following;

$$(8) \quad \frac{P_S^*}{R^*} = \frac{\beta\eta_D}{\varepsilon_S - \alpha\eta_D} < 0$$

Finally, quantity effects are obtained by putting (7) into $(1')$ for demand elasticity, and similarly, (8) into $(2')$ for supply elasticity:

$$(9) \quad \frac{Q_D^*}{R^*} = \frac{Q_S^*}{R^*} = \frac{Q^*}{R^*} = \frac{\varepsilon_S\beta\eta_D}{\varepsilon_S - \alpha\eta_D} < 0$$

From the comparative statics results and the graphical analysis provided in Figure 2.2, the following hypotheses are derived about the economic incidence of the aflatoxin compliance tax:

(a) consumer prices will rise, from P_0 to P_D; (b) supply prices will drop, from P_0 to P_S; (c) quantity of peanuts traded in Ghana will decrease, from Q_0 to Q_1; (d) the effect of regulation tax, R, is shared between peanut producers and consumers in regions 'b' and 'a', respectively; and (e) the impact of the policy crucially depends on the relative magnitudes of elasticities. To emphasize the importance of the latter statement, we assume that the supply of peanut is perfectly inelastic in the short run (i.e. $\varepsilon_S = 0$). The short-run assumption reveals that producers alone bear all the consequences of compliance tax increases, while the incidence on consumers is nil (see equations (7) and (8) when $\varepsilon_S = 0$). Thus, the less elastic side of the peanut market in Ghana — suppliers or consumers — will experience the greater impact from the aflatoxin policy intervention.

2.4.2 Model Two: Small Open Economy; Exporter with Supply Shift

In model Two, the autarky assumption imposed earlier in Model One (that Ghana is self-sufficient and has a closed peanut sector) is relaxed. Evidently, one can argue that Ghana's peanut sector is not isolated from the rest of the world (see Table 2.1).

In other words, peanuts are imported in times of deficit and exports occur in the presence of surplus. Accordingly, we model Ghana as a small open economy, and a net exporter of peanut to understand the incidence of regulations under this scenario. Notice that Ghana is a net exporter of peanut since production slightly outweighs domestic consumption, and exports consistently exceed imports (see Figure 2.1 and Table 2.1). In addition, no single African country is known to be a major player in edible peanut trade. In fact, African countries are fringe suppliers of edible peanut in international trade relative to dominant suppliers, namely China and the United States (Diop, Beghin and Sewadeh, 2004; Boonsaeng, Fletcher and Carpio, 2008). These reasons reinforce the assertion that Ghana is a small player in the international peanut market.

One major assumption in this model is that Ghanaian peanut exporters face a perfectly elastic export demand abroad (see Figure 2.3 below for a pictorial illustration of standards effects in this open-market case). Also, this model assumes that the aflatoxin regulation policy, which introduces compliance costs (or tax), is a supply shifter affecting only peanut supply costs but not consumer preference for quality.

Initial equilibrium in the extended model is as follows:

(10) $$Q_D = Q_D(P_D) \qquad \{domestic\ demand\}$$

(11) $$Q_X = Q_X(P_X) \qquad \{export\ demand\}$$

(12) $$Q_S = Q_S(P_S) \qquad \{domestic\ supply\}$$

(13) $$P_D = P_S + T + R \qquad \{price\ linkage\}$$

(14) $$P_D = P_X \qquad \{law\ of\ one\ price\}$$

(15) $$Q_S = Q_D + Q_X \qquad \{market\ clearing\}$$

where Q_X denotes quantity of peanut exported to consumers abroad, P_X is the consumer price of peanut in the international market, and the remaining variables are defined in Model One. The subscript X represents export. Additional endogenous variables (relative to Model One) are Q_X and P_X ; while the exogenous variables remain as before.

Equation (11) is the export demand equation where the quantity of peanuts purchased by consumers abroad is influenced by the international price.

Also, Equation (14) imposes the Law of one Price (LOP). This implies that domestic and export consumer prices are identical.

Again, Equation (15) is the market clearing condition; total peanut from suppliers in Ghana (producers) equals total demand from domestic consumers as well as demand from buyers abroad.

The remaining equations are the same as in Model One. Next, Model Two is rewritten in displaced form as follows:

$$(10') \quad Q_D^* = \eta_D P_D^* \quad \text{where } \eta_D < 0 \qquad \{domestic\ demand\}$$

$$(11') \quad Q_X^* = \eta_X P_X^* \quad \text{where } \eta_X < 0 \qquad \{export\ demand\}$$

$$(12') \quad Q_S^* = \varepsilon_S P_S^* \quad \text{where } \varepsilon_S \geq 0 \qquad \{domestic\ supply\}$$

$$(13') \quad P_D^* = \alpha P_S^* + \beta R^* \ \text{where } \alpha > 0 \text{ and } \beta > 0 \qquad \{price\ linkage\}$$

$$(14') \quad P_D^* = P_X^* \qquad \{law\ of\ one\ price\}$$

$$(15') \quad Q_S^* = K_D Q_D^* + K_X Q_X^* : \quad K_D = \frac{Q_D}{Q_S} > 0\ ;\ K_X = \frac{Q_X}{Q_S} > 0 \qquad \{market\ clearing\}$$

where K_D and K_X are parameters defined in Table 2.3.

In an open economy, equilibrium in trade is required to complete the model. This is achieved as follows:

First, we derive the implied export supply equation by dropping $(11')$ so that P_X is temporarily treated as exogenous (see Muth, 1965).

Next, we solve the model simultaneously using the remaining equations to derive the export supply, Q_X^*. Specifically, $(10')$ and $(12')$ are substituted into $(15')$ and, thereafter, information in $(13')$ and $(14')$ are applied yielding the following supply relation:

$$(16) \qquad Q_X^* = \varepsilon_X P_X^* - \frac{\varepsilon_S \beta}{\alpha K_X} R^*$$

where ε_X is the export supply elasticity expressed as follows;

$$(17) \qquad \varepsilon_X = \frac{\varepsilon_S - \alpha K_D \eta_D}{\alpha K_X} > 0$$

Next, equilibrium in the peanut export market is imposed by equating (16) and $(11')$. Subsequently, reduced-form elasticities for the two consumer prices are obtained as follows:

$$(18) \qquad \frac{P_X^*}{R^*} = \frac{P_D^*}{R^*} = \frac{\varepsilon_S \beta}{\alpha K_X (\varepsilon_X - \eta_X)} > 0$$

Alternatively, we can use information in (17) to rewrite (18) as shown below:

$$(18') \qquad \frac{P_X^*}{R^*} = \frac{P_D^*}{R^*} = \frac{\varepsilon_S \beta}{\varepsilon_S - \eta} > 0 \ where\, \eta = \alpha(K_D \eta_D + K_X \eta_X) < 0$$

and noting that η is the overall demand elasticity faced by peanut producers in Ghana. Following the approach in Model One, the remaining price and quantity effects are derived as shown below:

$$(19) \qquad \frac{P_S^*}{R^*} = \frac{\beta}{\alpha} \left[\frac{\eta}{\varepsilon_S - \eta}\right] < 0$$

$$(20) \qquad \frac{Q_D^*}{R^*} = \frac{\varepsilon_S \beta \eta_D}{\varepsilon_S - \eta} < 0$$

$$(21) \qquad \frac{Q_X^*}{R^*} = \frac{\varepsilon_S \beta \eta_X}{\varepsilon_S - \eta} < 0$$

$$(22) \qquad \frac{Q_S^*}{R^*} = \frac{\varepsilon_S \beta}{\alpha} \left[\frac{\eta}{\varepsilon_S - \eta}\right] < 0$$

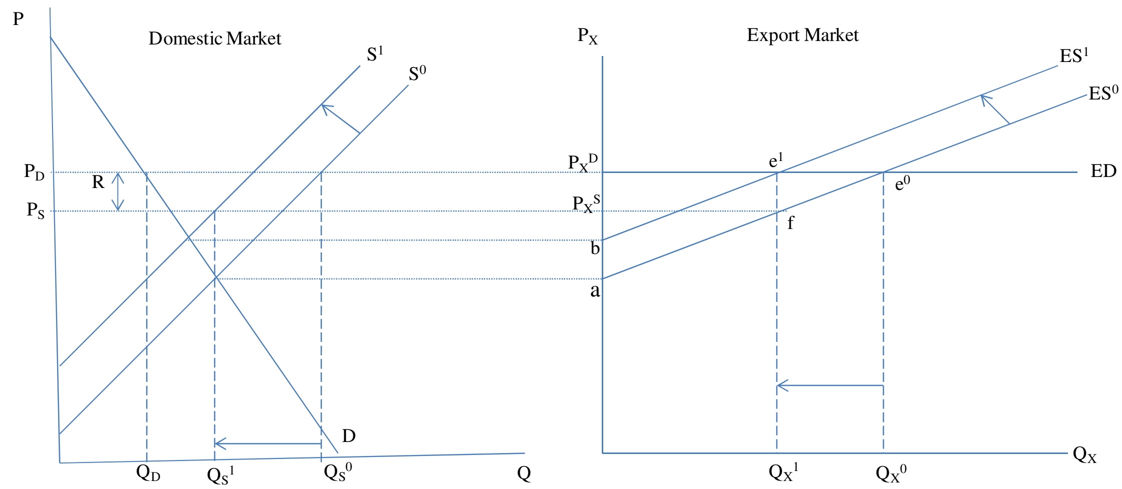
The comparative statics results derived here are consistent with those in Model One in that consumer prices increase following increases in compliance cost, while supply prices drop. Given that Ghana is a small peanut exporter, the above policy incidence relationships (i.e. equations (18) through (22)) respectively reduce to the following:[24]

$\frac{P_X^*}{R^*} = \frac{P_D^*}{R^*} = 0$; $\frac{P_S^*}{R^*} = \frac{\beta}{-\alpha} < 0$; $\frac{Q_D^*}{R^*} = 0$; $\frac{Q_X^*}{R^*} = 0$; and $\frac{Q_S^*}{R^*} = \frac{\varepsilon_S \beta}{-\alpha} < 0$.

In addition, Figure 2.3 visually illustrates the economic incidence of the aflatoxin policy with Ghana as a small peanut exporter facing a perfectly elastic demand in the world market. Note that the first panel in Figure 2.3 represents the domestic peanut market while the second panel depicts the export market. Also, 'ES' denotes Export Supply (i.e. Excess Supply) and 'ED' means Export Demand (or Excess Demand).

[24] Using L'Hôpital's Rule, the numerator and denominator of equations (18) through (22) are separately differentiated with respect to η since a perfectly elastic export demand means $\eta_X = -\infty$ which also implies that $\eta = -\infty$.

Figure 2.3. Incidence of Peanut Aflatoxin Tax on Ghana's Domestic and Export Markets



The incidence analyses — provided analytically above and graphically in Figure 2.3 — indicate that producers would experience the full economic burden of the aflatoxin regulation with no impact at all on consumers. Thus, increased compliance costs from the policy will lead to a decrease in producers' profits since peanut supply prices would be depressed in order to accommodate the additional costs.

2.4.2.1 Measurement of Economic Welfare

From the export market in Figure 2.3 above, we observe that suppliers' pre-tax economic welfare is approximated by the area of triangle $P_X^D e^0 a$, whereas the post-tax welfare is identical to the area of triangle $P_X^S fa$. Since export demand is perfectly elastic, peanut suppliers bear the full burden of the tax which translates into a loss in economic surplus approximated by the difference between the areas of triangles $P_X^De^0a$ and P_X^Sfa. This reduction in producer welfare is clearly seen in Figure 2.3, where the economic surplus before the tax is greater than after the intervention.

The economic welfare changes for both sides of the market are computed by adapting formulas in Sun and Kinnucan (2001). Modeling the aflatoxin compliance tax as a supply shifter, the formulas for producer and consumer welfare changes are as follows;

(23) $$\Delta CS = -P_D Q_D P_D^* \, (1 + 0.5 Q_D^*)$$

(24) $$\Delta PS = (P_S^* - V_S \,) P_S Q_S (1 + 0.5 Q_S^*)$$

where ΔPS is change in producer surplus (welfare); ΔCS represents change in consumer surplus; V_S is the vertical shift in the peanut supply curve as a result of regulation compliance costs (see Appendix 2 for the derivation of V_S) ; and

(25) $$V_S = \beta R^*$$

2.4.3 Model Three: Small Open Economy; Exporter with Supply and Demand Shifts

The present model is a less restrictive form of Model Two in that it incorporates an upward demand shift to account for potential improvements in peanut quality, as a result of the regulation enforcement. Therefore, Model Three extends the preceding model by determining the distributional impact of the aflatoxin policy when supply and demand curves shift simultaneously. The assumed shifts in supply and demand are supported by Otsuki, Wilson and Sewadeh (2001a, p. 272) who note that "on the demand side, tighter standards imply higher product quality, thereby increasing demand. [Whereas] on the supply side, tighter standards work as a barrier to trade, as they tend to lead to … the imposition of higher compliance costs". To characterize this extension, quality assurance from the regulation is assumed to vertically shift demand upwards in the direction of the price axis (for a discussion of vertical shift parameters, see Muth, 1965; Kinnucan, Xiao, and Yu, 2000). Thus, following Muth (1965), vertical/proportionate shift parameters associated with increase in demand for aflatoxin-free peanut are included in the displaced form of Model Two. For instance, the inverse domestic demand shown below in equation (26) is derived from the domestic demand in equation (10'); with a vertical shift parameter appropriately taken into account:

(26) $$P_D^* = \frac{1}{\eta_D} Q_D^* + \delta \quad where \;\; \eta_D < 0 \; and \; \delta > 0$$

and δ is the vertical (proportionate) shift in the domestic demand curve induced by quality assurance from the aflatoxin standard, holding Q_D constant at its initial equilibrium level. The sign of δ is assumed to be positive, reflecting the upward (or increased) shift in demand for quality peanut, and the resulting increase in consumer price. For example, if δ = 0.10 then the regulation is interpreted as shifting the demand curve in the price direction by 10% due to the rise in consumer demand for quality peanut. Thus, this vertical demand shift is expected to cause increases in retail price in the process. Solving equation (26) for Q_D^* yields the following ordinary demand curve:

(27) $$Q_D^* = \eta_D (P_D^* - \delta) \quad where \;\; \eta_D < 0 \; and \; \delta > 0$$

Subsequently, equation (27) is specified in Model Three as the domestic demand, replacing equation (10') in Model Two. A similar specification is made for the export demand equation with identical upward and vertical shift in demand as a result of foreign consumers' increased demand for quality peanut from Ghana (see equation (28) below).

The two ordinary demand relationships (i.e. equations (27) and (28)) indicate that the quantity of peanut sold to consumers, both in the domestic and export markets, is not only determined by price but also quality (translated through the shift parameter).

Model Three is presented in displaced form as follows:

(27) $Q_D^* = \eta_D(P_D^* - \delta)$ $where\ \eta_D < 0\ and\ \delta > 0$ $\{domestic\ demand\}$

(28) $Q_X^* = \eta_X(P_X^* - \delta)$ $where\ \eta_X < 0\ and\ \delta > 0$ $\{export\ demand\}$

(29) $Q_S^* = \varepsilon_S P_S^*$ $where\ \varepsilon_S \geq 0$ $\{domestic\ supply\}$

(30) $P_D^* = \alpha P_S^* + \beta'$ $where\ \alpha > 0\ and\ \beta' > 0$ $\{price\ linkage\}$

(31) $P_D^* = P_X^*$ $\{law\ of\ one\ price\}$

(32) $Q_S^* = K_D Q_D^* + K_X Q_X^*$: $K_D = \frac{Q_D}{Q_S} > 0$; $K_X = \frac{Q_X}{Q_S} > 0$ $\{market\ clearing\}$

where $\beta' = \frac{dR}{P_D}$ is the proportionate cost of the aflatoxin regulation (or proportional tax). For purposes of comparing the shifts in supply and demand curves owing to the policy intervention, the form of the price wedge equation in Model Two (i.e. equation (13')) has been rewritten in Model Three (as shown in equation (30)) in order to interpret regulation compliance costs as *ad valorem* tax on the market.[25] For example, using data in Table 2.2, $\beta' = \frac{50.22}{796}$; suggesting that aflatoxin regulation in Ghana imposes a proportionate tax on the peanut industry equal to 6.3%. The remaining equations in the present model, as well as variables and parameters, are defined in Model Two above (see Tables 2.2 and 2.3).

With shift parameters on both the supply and demand sides of the market, we proceed to determine the distribution of economic burden and/or gains between peanut suppliers and consumers.

[25] Notice that from equation (13'), $P_D^* = \alpha P_S^* + \beta R^*$ where $\beta = \frac{R}{P_D}$ and $R^* = \frac{dR}{R}$. Hence, substituting β and R^* yields equation (30), $P_D^* = \alpha P_S^* + \beta'$ where $\beta' = \frac{dR}{P_D}$.

Following the procedure in Model Two, the system of equations is solved by first deriving the implied export supply equation shown below:

$$(33) \qquad Q_X^* = \varepsilon_X P_X^* - \frac{\varepsilon_S(\beta' - \delta) + \alpha K_X \varepsilon_X \delta}{\alpha K_X}$$

where ε_X is the export supply elasticity; $\varepsilon_X = \frac{\varepsilon_S - \alpha K_D \eta_D}{\alpha K_X} > 0$

Next, the market clearing condition is applied in the export market and all reduced-form relationships are subsequently developed in the following subsection.

2.4.3.1 Economic Incidence Relationships from Model Three

The relevant reduced-form equations representing price and quantity incidence of aflatoxin interventions (with simultaneous shifts in peanut supply and demand) are provided below.

For consumer prices, the impact of the policy intervention is as follows:

$$(34) \quad P_X^* = P_D^* = \frac{\varepsilon_S \beta' - \alpha \eta' \delta}{\alpha K_X(\varepsilon_X - \eta_X)} > 0$$

where $\eta' = K_D\eta_D + K_X\eta_X < 0$; η' is the composite demand elasticity facing peanut suppliers in Ghana. Given the small exporter status used in the model, the form of equation (34) changes to the following equation: [26]

$$(34') \quad P_X^* = P_D^* = \delta > 0$$

The incidence relationship presented in equation (34) (and (34')) shows that retail prices for peanut would go up following enforcement of the aflatoxin policy. This analytical result is consistent with those obtained in the previous models. Although the two shift parameters are important in determining the degree of increase in the

[26] Employing L'Hôpital's Rule, the numerator and denominator of equation (34) above are separately differentiated with respect to η_X noting that $\eta' = K_D\eta_D + K_X\eta_X$.

domestic and export demand prices, these cost and quality changes have counter-effects on the economic welfare of consumers. Precisely, compliance cost from the policy is expected to be welfare decreasing to consumers, whereas quality assurance would be beneficial.

However, the effect of the aflatoxin regulation on producer prices (to be received by peanut suppliers) is indeterminate as shown in the following incidence relationship:

$$(35)\quad P_S^* = \frac{\eta'(\beta' - \delta)}{\alpha K_X(\varepsilon_X - \eta_X)} \gtrless 0$$

Thus, since the expression in the denominator is positive, the direction of impact from the policy intervention depends critically on relative magnitudes of the two shift parameters representing compliance cost (β'), and quality peanut (δ). To illustrate, if the proportionate shifts in supply and demand curves are such that $\beta' > \delta$ (e.g. 6% versus 5%, respectively) then one would expect producer prices to be depressed as a result of the policy. The foregoing scenario means that suppliers face a net loss since the decrease in producer price due to compliance costs outweighs the rise in price owing to increased demand for quality peanut. Conversely, supply prices would increase (i.e. net gain to producers) following the introduction of the policy, if $\beta' < \delta$ (e.g. 6% versus 10%, respectively). Furthermore, if the shift in supply happens to be exactly identical to that of demand (i.e. $\beta' = \delta$) then we would expect peanut suppliers to be unaffected by the policy since losses from the regulation cost would be nullified by gains from the quality-induced increase in demand.

With Ghana as a small exporter in the world peanut market facing a perfectly elastic demand (where $\eta_X = -\infty \; and \; \eta' = -\infty$), the policy incidence provided in equation (35) reduces to the following relationship:

$$(35') \quad P_S^* = \frac{(\beta' - \delta)}{-\alpha} \gtreqless 0$$

Having shown that peanut suppliers in Ghana bear the full burden of the aflatoxin policy, as demonstrated in Model Two and Figure 2.3, it is noteworthy that equations (35) and (35') provide conditions that can mitigate the regulation's impact on producers. Specifically, it is possible to derive the break-even demand shift. That is, given compliance costs, we can determine the demand shift that would render the regulation costless to peanut producers by setting equations (35) or (35') to zero. In the preceding case, the quality-induced increase in supply price would just offset the cost-induced decrease in supply price.

Furthermore, the remaining incidence relationships shown below demonstrate impacts of the policy on quantities of peanut in the market:

$$(36) \quad Q_D^* = \frac{\varepsilon_S \eta_D (\beta' - \delta)}{\alpha K_X (\varepsilon_X - \eta_X)} \gtreqless 0$$

$$(37) \quad Q_X^* = \frac{\varepsilon_S \eta_X (\beta' - \delta)}{\alpha K_X (\varepsilon_X - \eta_X)} \gtreqless 0$$

$$(38) \quad Q_S^* = \frac{\varepsilon_S \eta' (\beta' - \delta)}{\alpha K_X (\varepsilon_X - \eta_X)} \gtreqless 0$$

Thus, effects of the policy intervention on quantities supplied and demanded in the domestic and export markets are indeterminate. Evaluating equations (36) through (38) with perfectly elastic export demand elasticity yields the following relationships:

$$(36') \quad Q_D^* = 0$$

$$(37') \quad Q_X^* = \frac{\varepsilon_S (\beta' - \delta)}{-\alpha K_X} \gtreqless 0$$

$$(38') \quad Q_S^* = \frac{\varepsilon_S (\beta' - \delta)}{-\alpha} \gtreqless 0$$

Equations (36) through (38), except for (36'), indicate that net impacts of the regulation policy are crucially determined by relative sizes of the cost and quality factors (i.e. the two shift parameters in the model).

2.5 Data and Sources

The sources of information used in this chapter, including parameters, are mentioned in this section. Data on both shelled and in-shell peanuts are used.

Annual trade value and quantities for Ghana was obtained from FAOSTAT (2011) database. Domestic quantity of peanuts demanded was computed by deducting total exports (i.e. shelled and in-shell plus oil) from total production. The quantity of peanut oil exported was converted into unshelled peanuts using a conversion ratio of 3 tonnes of unshelled to 1 tonne of oil (Pattee and Young, 1982; Diop, Beghin and Sewadeh, 2004). Unit prices of Ghanaian peanut were derived from the reported trade value and quantity data.

Aflatoxin compliance costs are obtained from Amoako-Attah et al. (2007). The authors estimate costs associated with four alternative post-harvest handling methods for peanut before storage. After carrying out the various drying techniques, the authors recorded the corresponding costs, as well as the aflatoxin contamination levels. The study by Amoako-Attah et al. (2007) was conducted in different locations and seasons in Ghana. Consequently, the authors recommended two best practices for drying peanut with regard to minimizing aflatoxin contamination after harvest. Therefore, this chapter employs cost estimates for the best drying practices provided in Amoako-Attah et al. (2007).

Beghin and Matthey (2003) present domestic peanut supply and demand elasticities for selected peanut-producing African countries, especially in the West

African sub-region. The reported elasticity values — identical for the listed African countries — are used for Ghana. Also, United States' export demand elasticity (-1.9), estimated by Boonsaeng, Fletcher and Carpio (2008), is used in a sensitivity analysis where Ghana's supply to the world market becomes comparable to existing large exporters.[27]

The study period is 1995 through 2008.

2.6 Results and Discussion

This section presents simulation results obtained after applying empirical data to the comparative statics equations (i.e. the reduced-form relationships) derived earlier. Specifically, Table 2.4 exhibits reduced-form elasticities from the first two models together with results from sensitivity analyses. Similarly, results for Model Three are provided in Table 2.5. Finally, price and quantity effects from Models One and Two are applied to estimate changes in economic surplus due to aflatoxin regulation. Thus, attendant welfare for producers and consumers are displayed in Table 2.6.

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[27] Note that Ghana is currently a small peanut exporter and, therefore, faces a perfectly elastic export demand curve (i.e. $|\eta_X|=\infty$). This is a major assumption in this chapter and hence it is used as the baseline case.

Table 2.4. Percentage Changes in Ghana's Peanut Prices and Quantities, 1995-2008

	Exogenous variable: percentage change in regulation compliance tax (R*)			
Variables	Model 1	Model 1A[a]	Model 2	Model 2A[b]
P_D*	0.0439	0.0000	0.0000	0.0428
P_X*	–	–	0.0000	0.0428
P_S*	-0.0251	-0.0823	-0.0823	-0.0265
Q_D*	-0.0088	0.0000	0.0000	-0.0086
Q_X*	–	–	0.0000	-0.0813
Q_S*	-0.0088	0.0000	-0.0288	-0.0093

[a]Sensitivity analysis: in the short run, domestic peanut supply is assumed to be perfectly inelastic (i.e. $\varepsilon S=0$).
[b]Sensitivity analysis for the case where Ghana becomes a larger open economy. Here, export demand is not perfectly elastic (i.e. $|\eta X| = 1.9 < \infty$) suggesting that Ghana faces a much less elastic export demand than the baseline case.
Note: In models 2 and 2A, domestic and foreign consumer prices are identical due to the Law of One Price. Also, equilibrium in export trade implies that export supply equals export demand.

From Table 2.4, reduced-form elasticities conform to expected incidence signs. In Model 1, it is observed that increases in aflatoxin compliance costs cause producer price and quantity to fall. Specifically, 10% rise in compliance costs associated with regulation enforcement leads to a 0.25% decrease in supply price, and 0.09% drop in quantity of peanut production. Domestic consumer price, on the other hand, goes up following an increase in compliance costs. Precisely, prices of peanut faced by consumers in Ghana will rise by 0.44% due to 10% increase in compliance costs explained by the introduction of domestic standards. Comparing the magnitudes of price effects associated with tighter aflatoxin standards suggests that the intensity is greater on domestic consumers as opposed to producers. In other words, juxtaposing absolute sizes of the reduced-form elasticities indicate that consumer prices are more responsive to standards tightening than supply prices. The preceding observation is in line with tax incidence theory given that the domestic demand elasticity value, in absolute terms, is less than supply elasticity (see Table 2.3). Thus, consumers — the less elastic side of the peanut market in Ghana — would bear the greater economic incidence of aflatoxin policy interventions that cause supply costs to increase.

Underscoring the importance of elasticities in the distribution of policy impacts, simulations are performed in Model 1A to represent a short-run situation where peanut supply is perfectly inelastic. We observe that the entire cost (or incidence) of the policy is borne by peanut suppliers since supply prices are depressed, whereas consumer prices are unaffected. It is worth emphasizing that in the foregoing case, supply elasticity of peanut is less than demand (in absolute terms).

In the case where the peanut sector is open to international trade (i.e. peanuts are freely exported and imported when necessary), Model 2 shows results that are qualitatively similar to those in the Autarkic case. Given that Ghana is a small peanut exporter in world trade, the overall demand for its peanut is perfectly elastic (see equation (18')). Results indicate that 10% increase in compliance costs drives producer price and quantity down by 0.82% and 0.29%, respectively. However, both domestic and export consumer prices and quantities demanded are not impacted at all. In this trade model, peanut producers in Ghana — being on the less elastic side of the market — experience all the effects of the aflatoxin regulation. Conversely, Model 2A presents the distribution of standards effects in a scenario where Ghana's peanut export demand is assumed to be in the neighborhood of larger exporters such as the United States and China. In this case, the export demand faced by Ghana would be less than perfectly elastic (i.e. $|\eta_X|=1.9$ is assumed). In fact, the overall demand would then be inelastic and less than supply elasticity, in absolute terms. As a result, consumers are more affected by compliance cost increases than producers. Thus, both domestic and export consumer prices rise by 0.49%, while supply price decreases by 0.27% following 10% increase in regulation compliance cost. All quantities drop, even though quantity demanded abroad decreases the most.

In Model 3, where potential enhancement in consumer demand for aflatoxin-free peanut is accounted for, the corresponding reduced-form equations derived earlier generally produced indeterminate policy incidence. Since definite effects of the intervention depends on relative sizes of the supply and demand shift parameters, three different scenarios are shown based on relative magnitudes of the two shift parameters (see Table 2.5 for simulation results). Except for the demand shift parameter, all values used in the simulations are baseline values, including the compliance cost parameter.

Table 2.5. Relative Changes in Peanut Prices and Quantities, 1995-2008

Simulation Results from Model 3			
Variables	Case 1 $\beta' > \delta$	Case 2 $\beta' = \delta$	Case 3 $\beta' < \delta$
P_D*	5.0000	6.3100	10.0000
P_X*	5.0000	6.3100	10.0000
P_S*	-1.7100	0.0000	4.8000
Q_D*	0.0000	0.0000	0.0000
Q_X*	-59.8300	0.0000	168.5400
Q_S*	-0.5983	0.0000	1.6900

Note: β' (i.e. the regulation compliance cost) is identical in all three cases, whereas δ (i.e. upward demand shift) is assumed to be 5%, 6.31%, and 10%, respectively for Cases 1, 2, and 3.

From Case 1, if the regulation imposes 6.3% compliance tax on the peanut industry, then both domestic and export consumer prices face a net increase of 5%, given that the market experiences a 5% upward shift in demand owing to quality assurance from the policy. That is, the proportionate rise in consumer prices is solely due to the increase in demand for peanut with reduced aflatoxin contamination, guaranteed by the regulation.

However, the price received by peanut suppliers experiences a net decrease of 1.7%. Notice that in the present scenario, the regulation compliance cost exceeds the rise in demand. Since the overall demand for peanut in Ghana is perfectly elastic, the suppliers pay the full cost of the policy, although proceeds from the high demand for quality peanut helps to ameliorate the economic burden on producers. Similarly, the quantities of peanut supplied domestically and abroad also go down following the pronounced effect of the aflatoxin cost parameter. However, quantity demanded in the domestic market is unaffected by the policy, an observation common to all the three cases shown in Table 2.5.

For Case 2, where the proportionate increase in demand equals that of the regulation compliance cost, it is observed that the aflatoxin policy would be costless to peanut suppliers. To the peanut suppliers, the quality-induced increase in supply price is exactly identical to the cost-induced decrease in that same price. Therefore, the present scenario demonstrates the break-even demand shift, where the increase in retail price fully defrays the reduction in producer price. Consequently, quantities of peanut in the domestic and export markets are completely unaffected.

In Case 3, where the quality-induced demand shift (10%) exceeds the cost-induced supply shift (6.31%), we observe that producers experience a net gain from the regulation even though they bear the entire cost of the policy. Specifically, if the aflatoxin intervention introduces a 6.31% compliance cost into the industry, then a 10% increase in demand for quality peanut would generate the following price and quantity effects: retail prices increase by 10% (proportional to the vertical shift in demand); supply price increases by 4.8%; quantity of peanut produced will increase by 1.7%; quantity traded in the export market rises by 168.5%; and quantity demanded in the domestic market remains unchanged.

In the present scenario, the gain in price received by producers owing to the enhanced demand for quality peanut outweighs the reduction in that supply price as a result of regulation compliance costs.

2.6.1 Approximated Welfare Implications: Model One versus Model Two

Finally, estimated economic welfare changes triggered by a 10% rise in standards compliance costs are shown in Table 2.6. This scenario is akin to the introduction and enforcement of strict aflatoxin standards. Notice that the quality improvement effects of the aflatoxin policy are suppressed in the welfare estimates shown in Table 2.6 below.

Table 2.6. Welfare Changes (million US$) Induced by 10% Rise in Compliance Cost in Ghana

Results	Autarkic Case		Small-Open-Economy Case		
	PS	CS	PS	CS^D	CS^X
Baseline	-47.4020	-105.3864	-137.0000	0.0000	0.0000
Sensitivity Analysis	-160.0000	0.0000	-49.8505	-101.8861	-0.5792

Note: *PS* and *CS* mean '*Producer Surplus*' and '*Consumer Surplus*', respectively. The superscripts *D* and *X,* respectively, denote '*Domestic'* and '*Export*'. Also, *Autarkic Case* refers to *Model One* while *Small-Open-Economy Case* represents *Model Two*.

Ignoring possible demand enhancement due to the regulation, results in Table 2.6 show that increases in costs associated with aflatoxin minimization are largely welfare decreasing, regardless of trade status. Where the Ghanaian peanut market is entirely domestic, producers and consumers lose over US$ 47 million and US$ 105 million, respectively. However, peanut suppliers experience economic welfare loss of US$ 160 million in the short-run, with consumers completely unscathed.

In addition, accounting for cross-border trade with Ghana as a small exporter in the world market (i.e. Model Two which ignores potential increase in demand for quality peanut) reveals a lopsided welfare loss of US$ 137 million for producers. Thus, peanut suppliers pay the full cost of complying with the aflatoxin regulation imposed on the industry. On the other hand, a scenario change analysis indicates that if Ghana were a large exporter then producers would be less impacted than consumers. Precisely, producers lose about US$ 50 million, while domestic and export consumers experience welfare reductions in excess of US$ 100 million and US$ 0.5 million, respectively.

2.7 Summary and Concluding Remarks

The primary objective of this chapter was to evaluate the distribution of economic impacts generated by enforcement of aflatoxin regulation on the peanut sector in Ghana, after incorporating trade status and potential increase in demand due to quality assurance from the intervention. By implication, the paper sought to bring to the fore any possible economic welfare incidence on domestic market participants following the enforcement of aflatoxin standards. To achieve that goal, the Equilibrium Displacement Modeling technique was employed. The economic framework was presented in three nested model scenarios, namely an autarkic peanut sector, a small exporter with supply shift only, and a small exporter with simultaneous shifts in supply and demand. Data covering the period 1995 through 2008 was obtained from FAO Statistics/database in addition to other sources cited in the text.

In the autarkic model, results suggest that increases in aflatoxin compliance cost causes producer price of peanut to fall, and raises consumer prices. Hence, both producers and consumers share the cost of the aflatoxin policy intervention in Ghana. However, a comparison of the size of price effects due to the regulation indicates that peanut consumers are impacted more than producers. Consumers are more responsive to the policy since domestic demand is less elastic than supply (in absolute terms). In other words, consumers being the less elastic side of the peanut market accordingly bear the greater economic incidence of the aflatoxin policy. Moreover, price and quantity effects of the policy translate into changes in economic welfare on the part of market participants. Hence, according to the autarkic model, approximated welfare effects generally indicate losses for both producers and consumers in Ghana.

On the other hand, opening up the peanut economy to cross-border trade, without accounting for improvements in peanut quality, shows that producers bear the entire economic burden, whereas domestic and export consumer prices (and quantities demanded) are unaffected by the policy intervention. In the present model scenario, peanut producers bear the full incidence of the policy because the overall demand they face is perfectly elastic due to Ghana's small trade status.

In spite of peanut producers bearing the full cost of the aflatoxin policy (as a result of Ghana's small export trade), this study also shows that if demand for quality peanut is accounted for in the policy evaluation then it is possible that the adverse effects on suppliers could be mitigated, and that producers could even benefit from the intervention. Thus, incorporating demand for quality enhancement in peanut following the aflatoxin regulation policy, the incidence analyses conducted in this chapter reveal interesting results of policy relevance. Precisely, if the induced shift in demand owing to quality assurance exceeds the induced shift in supply due to aflatoxin compliance cost, then suppliers would gain from the policy intervention even though they bear the entire cost of the regulation due to Ghana's status as a small peanut exporter.

Overall, the government of Ghana may consider trade status, as well as aflatoxin-free food promotions (i.e. to raise awareness among economic agents regarding the aflatoxin problem) as important policy instruments to be employed in order to alleviate any economic burden on the population, following enforcement of aflatoxin regulations.

Chapter 3: Willingness to Pay for Safer Foods: Consumer Preference for Aflatoxin-free Peanut in Ghana

3.1 Problem Statement

In tandem with the broad objective of determining aflatoxin policy implications on the economic welfare of food market participants, it is important to assess how consumers value peanut with reduced aflatoxin contamination (considered safe for consumption). Such knowledge would be useful to scientists and policymakers in the evaluation of aflatoxin interventions. Moreover, understanding peanut consumers' willingness to pay for aflatoxin-free peanut is critical to the success and sustainability of efforts to reduce aflatoxin (and other mycotoxins) contamination.

Findings from the first two chapters of this dissertation generally indicate that aflatoxin regulation may result in economic losses to both producers and consumers since peanut prices and quantities are negatively impacted. From Chapter One in particular, compliance costs in peanut supply chains (following aflatoxin standards enforcement) have been shown to lead to rising retail prices often interpreted as welfare decreasing to consumers. However, the first dissertation chapter is limited in the sense that it ignores possible rise in demand for aflatoxin-free peanut due to safety assurance from the aflatoxin policy intervention. In addition, analyses performed in Chapter Two reveal that economic losses from the policy are ameliorated (and, in fact, gains are sometimes recorded) when consumer demand for quality peanut is appropriately taken into account in the evaluation.

However, the foregoing conclusion is strongly based on the assumption that consumers would be willing to pay for quality assurance from the regulation policy. That is, there is no empirical evidence of consumer preference and willingness to pay (WTP) for peanut with reduced aflatoxin contamination. Therefore, the present study contributes to knowledge in that it focuses on consumers' willingness to pay price premiums for quality (or safer) peanut assured from governments' enforcement of aflatoxin standards.

3.2 Objectives

This chapter accounts for quality-improvement effects of aflatoxin regulation in Ghana by studying consumers' valuation of peanut with reduced contamination. Specific objectives of the present research are as follows:

(1) To evaluate consumers' familiarity or awareness of aflatoxin contamination and other food contaminants.

(2) To determine whether consumers in Ghana are willing to pay more (i.e. price premium) for the supply of aflatoxin-free peanut.

(3) To isolate some important socioeconomic characteristics of consumers in Ghana that may influence their willingness to pay for aflatoxin-free peanut.

3.3 Related Literature

This section reviews relevant studies in the contingent valuation (CV) literature.

First, emphasis is placed on existing research with regard to consumers' stated and revealed preferences for safer food products; using CV surveys. Next, we highlight relevant features/methods in the CV literature aimed at improving the realization of valid WTP estimates.

3.3.1 Importance of Food Safety to Consumers

Using the best-worst scaling method, Lusk and Briggeman (2009) investigate the stability of consumer preferences for a set of food values. The authors found that 'safety' was among the most important food attributes. Food safety was also shown to be related to people's stated and revealed preferences.

Wang, Mao, and Gale (2008) carried out a CV survey in China concerning consumer interest in food safety issues. Report from their study reveals that consumers are willing to pay price premiums for milk products certified under the Hazard Analysis Critical Control Point (HACCP). The authors employed a hedonic price model to analyze their survey data.

In Taiwan, Jan, Fu, and Huang (2005) estimate consumers' demand and WTP for safer hypothetical cigarettes known to reduce lung cancer risk. The authors conducted a contingent valuation survey on 264 smokers and subsequently employed a dichotomous-choice model in a random utility framework. Jan, Fu, and Huang found that consumers were willing to pay an average price premium of 152% relative to existing market prices. The authors argue that the high WTP values indicate people's demand for healthy products.

In spite of the high stated preference for safe cigarettes, the authors acknowledge that the study's findings may be limited due to its small sample size. A study by Eom (1994) also shows that consumers in the United States are willing to pay high price premiums to avoid adverse health issues associated with pesticide residues in food. Eom (1994) integrates important concepts on food safety, namely "perceptions, behavior, and valuation", in a random utility framework. Individuals' stated preferences were estimated using discrete choice models.

The literature generally suggests that people are concerned about food safety and are, therefore, willing to pay more for safer food products and services.

3.3.2 Hypothetical Bias in Contingent Valuation Studies

One of the important methodological challenges in the application of CV surveys is minimizing 'hypothetical bias'; defined as the difference between people's WTP in hypothetical markets (where products are hypothetical and money is not involved) as opposed to experimental market settings where real products and money transactions occur (see Cummings and Taylor, 1999; List and Gallet, 2001; Alfnes, Yue, and Jensen. 2010).

List and Gallet (2001) conducted meta-analyses to identify factors that affect hypothetical bias in WTP values. They indicate, among others, that the problem of hypothetical bias is 'systematically' less prevalent in WTP as against willingness-to-accept (WTA) surveys. Also, the authors show that hypothetical bias occurs more frequently in CV studies involving public goods than with private goods, even though Murphy et al. (2005) found 'weak evidence' in support of that claim.

Furthermore, Whitehead et al. (1995) argue that the 'validity and reliability' of WTP values obtained from CV surveys are enhanced when participants are familiar with the goods and services in question; as opposed to the case where respondents are not used to the product/service. Therefore, the hypothetical CV survey discussed in this chapter is appropriate given that peanut is a private good and an important food product in Ghana.

3.3.3 Use of Double-bounded Dichotomous Choice Models

Discrete-choice models have been widely applied in the analyses of numerous CV surveys. Double-bounded dichotomous choice models are known to perform better than the single-bounded dichotomous choice alternative, in terms of providing more efficient WTP estimates (Hanemann, Loomis, and Kanninen, 1991; Kanninen, 1993; McCluskey et al., 2003). This subsection briefly highlights some selected studies that have employed double-bounded dichotomous choice methods to evaluate a number of contingent valuation problems.

With the application of a standard double-bounded dichotomous choice model on CV data, Lin et al. (2005) evaluate consumers' WTP for biotech rice and soybean oil in China. Findings suggest that people in China prefer non-biotech foods to biotech products — consumers are willing to pay high premiums for non-biotech foods. The stated WTP for non-biotech rice is between 41.5% and 74%. Similarly, WTP for non-biotech soybean oil ranges from 23.4% to 52.6%. The authors argue that food safety considerations influence consumers' WTP since the stated price premiums for rice, an important food staple, appear substantial than soybean oil. Notwithstanding the key role played by food safety fears, the authors partly attribute the high price premium to possible hypothetical bias from the CV survey.

McCluskey et al. (2003) analyze consumer preference for genetically modified (GM) foods in Japan. The authors applied a semi-double-bounded dichotomous choice model on their contingent valuation survey data. Results indicate that 80% of respondents were not willing to accept GM foods even with price discounts. McCluskey et al., therefore, show that consumer behavior is influenced by food safety concerns.

De Groote and Kimenju (2008b) investigate Kenyan's preference for yellow (biofortified) maize versus white maize. The authors applied the semi-double-bounded dichotomous choice method on contingent valuation survey data collected on urban consumers. Although standard white maize is often deficient in vitamin A, the authors indicate that people in Kenya consider biofortified yellow maize as inferior to white maize. De Groote and Kimenju, therefore, ignored the possibility of price premiums and concentrated on consumer acceptance of yellow maize, with and without discounts. Hence, their study had three WTP response categories. De Groote and Kimenju (2008b) show that urban consumers exhibited strong preference for white maize and would only buy yellow/biofortified maize on discounts. However, there was some interest in fortified maize meal although price premiums were modest, ranging from 6% to 7.4%. In addition, Kimenju and De Groote (2008a) explore how consumer willingness to pay for genetically modified food is determined by awareness, perceptions, and socioeconomic characteristics. The authors employ a standard double-bounded dichotomous choice model and find that even though most people in Kenya accept GM foods their willingness to pay is negatively affected by safety concerns.

The findings are consistent with studies conducted in other parts of the world regarding the importance of food safety and health considerations in consumer decisions.

3.3.4 Addition to the Food Safety Discussion

As discussed earlier, the literature on consumers' willingness to pay premiums (or accept discounts) for consumption goods or services is quite extensive. Food safety and environmental concerns have largely motivated discussions in published studies.

On food safety, the existing research on consumer preferences only highlight acceptance of genetically modified foods, as well as consumer interests in the reduction of chemical residues in food products. To the best of my knowledge, the CV literature provides no information on consumer behavior toward the mycotoxin problem; in spite of the predominant role of these toxins in global food safety concerns. Therefore, it is important to study consumer awareness and willingness to pay for food products with reduced aflatoxin contamination.

3.4 Theoretical/Conceptual Framework

Analyses in this study are based on the random utility theory predominantly applied in contingent valuation problems. Using consumer theory, this research invokes the key assumption that individuals make choices to maximize their utility in the face of limited budgets (Hanemann and Kanninen, 1998; Lusk and Hudson, 2004; De Groote and Kimenju, 2008b; Gallardo et al. 2009). That is, the central goal of this chapter is to study and understand the importance of quality food products to consumer utility.

This is achieved below through the assessment of individuals' stated preferences for peanut with reduced aflatoxin content.

3.4.1 Contingent Valuation Survey in Ghana

The data used in this chapter were collected in a survey carried out in Ghana from May through July, 2012. Contingent valuation (CV) questionnaires were used in face-to-face interviews with peanut consumers who agreed to participate in the survey (see Appendix 3 for questionnaire, and interview guide). In CV methods, researchers conduct surveys on subjects sampled from target populations and elicit their willingness to pay more (price premium) or accept compensation (price discount) for a proposed change in products/services. Individuals' willingness to pay (WTP) for a given change is determined in hypothetical market settings using survey instruments such as questionnaires; with interactions through mails, telephones, or face-to-face interviews.

In the present research, survey design and questionnaire administration were carefully executed in accordance with recommended practices in the CV literature (Portney, 1994; Carson et al., 2003; McCluskey et al., 2003; Gallardo et al., 2009). For instance, interviewers explained to respondents that researchers have found strong evidence of the association between aflatoxin exposure and health problems, namely aflatoxicosis, immune system suppression, liver cancer, among others (Wang et al., 2001). In view of the negative health issues associated with dietary aflatoxin exposure, survey participants were briefed on potential benefits of consuming peanut with zero or reduced contamination. Furthermore, the referendum format of value elicitation was adopted in that respondents were offered the opportunity to vote either in favor or against aflatoxin policy interventions that would ensure availability of safer peanuts in markets but at higher prices. Consumers who vote in favor of regulation enforcement are subsequently asked to state the premium they are willing to pay for aflatoxin-free peanuts. Thus, information on respondents WTP was solicited using both referendum voting and open-ended questions where consumers indicate precisely how much they are willing to pay relative to existing local market prices (reference points). Since peanut is an important food crop consumed in various forms in Ghana, the use of CV methodology is legitimate. Wedgwood and Sansom (2003 p.7) argue that “when the CV method is used to estimate the use of goods and services with which the individuals are familiar...CV surveys that are carefully designed and administered can yield accurate and useful information on household preferences (Cummings et al, 1986).”

A sample of 652 peanut consumers was randomly selected to participate in the survey, after pre-testing the questionnaire on 30 consumers in Kumasi. Survey participants were sampled from five (out of ten) administrative regions of Ghana. The purposively selected regions are Ashanti, Brong Ahafo, Western, Central, and Eastern (see Table 3.1). Capital cities of the listed regions were selected since urban centers are prominent destination markets for peanut produced in the northern part of the country.

Table 3.1 shows the proportional samples of consumers in the selected regions according to population size. The overall sample size was drawn from the administrative regions such that regions with larger populations contributed many survey participants compared to the smaller ones. This proportional sampling was adopted to reflect the importance of large regions as major peanut markets.

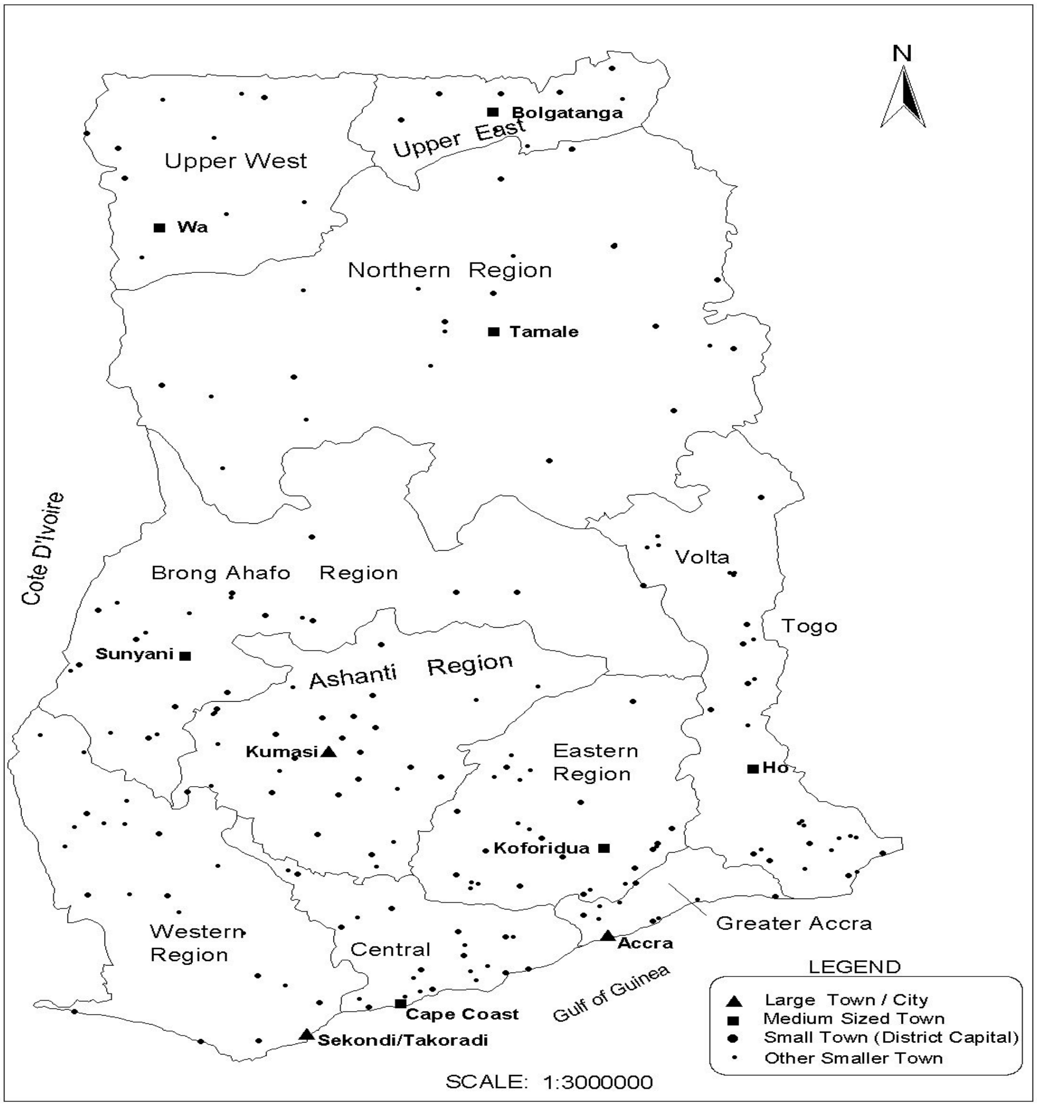
Table 3.1. Selected Regions in Ghana and Sample Sizes

Region	Population*	Sample Size	Capital City
Ashanti	4,780,380	299	Kumasi
Eastern	2,633,154	109	Koforidua
Western	2,376,021	92	Takoradi
Brong Ahafo	2,310,983	86	Sunyani
Central	2,201,863	66	Cape Coast
Total Sample Size		652	

*Population figures obtained from Ghana Statistical Service (2012).

Various sub-metropolitan areas within each capital city were identified and peanut consumers chosen from those areas. A total of 68 areas (referred to as 'suburbs') were covered. The sampling procedure for choosing peanut consumers was systematic where every third individual (representing a household) along a given street was interviewed. In cases where the selected individual failed to qualify as a respondent, the interviewers moved to the next person and repeated the sampling order after successfully identifying a peanut consumer. Figure 3.1 shows the geographical distribution of the survey regions and corresponding urban centers.

Figure 3.1. Map of Ghana Showing Distribution of Regions and Urban Centers



Source: adapted from Owusu (2005).

The survey was approved by the Auburn University Institutional Review Board. Furthermore, before proceeding with the survey, the interviewers sought the approval of participants after reading out consent protocols to them.

The questionnaires were administered by trained interviewers in the face-to-face interviews conducted with peanut consumers who agreed to participate in the survey.

It is worth emphasizing that interviewers explained to respondents the goal of the survey and also provided concise description of the peanut aflatoxin issue with possible regulation enforcement in the future. In the course of the interviews, respondents were shown printed photographs of three peanut samples labelled as follows: ‘Sample A’, ‘Sample B’, and ‘Sample C’ where ‘C’ was a clean and well-sorted peanut sample with no moldy, broken or shriveled kernels whereas ‘A’ was a sample with high proportion of moldy, broken and shriveled kernels plus other foreign materials; Sample B was moderately sorted peanuts with lower percentage of broken/shriveled kernels. Thus, Sample A would typically possess the highest possibility of aflatoxin contamination while Sample C would have the least contamination among the three, and therefore, the safest product. Respondents were then asked to make their choices and state whether they would vote for aflatoxin regulation that will ensure availability of aflatoxin-free peanuts in local markets (such as Sample C), and most likely result in increased prices. Consumers who indicated their willingness to pay were subsequently asked to state how much they would be willing to pay for aflatoxin-free peanuts. Respondents were frequently prompted to make objective choices (or take decisions) in the context of their peculiar preferences, limited income, and food expenditure patterns.

3.4.2 Methods of Estimating Willingness to Pay

There are two main methods commonly used to elicit people’s WTP, namely the application of single-bounded dichotomous-choice approach, or the use of double-bounded dichotomous-choice procedures. However, the double-bounded dichotomous-choice method has been the preferred approach over the past two decades due to its desirable property of yielding more efficient WTP estimates (Hanemann, Loomis, and Kanninen, 1991; Kanninen, 1993; McCluskey et al., 2003). The double-bounded dichotomous-choice method introduces an additional dichotomous-choice question in order to obtain more reliable results. Since the double-bounded dichotomous-choice technique is a generalized version of the single-bounded dichotomous-choice method, we first discuss the latter, and subsequently introduce the former and its variant form which is the focus of this chapter. This subsection adapts theoretical derivations in De Groote and Kimenju (2008a, 2008b).

3.4.2.1 Single-Bounded Dichotomous-Choice Method

The random utility model is operationalized in dichotomous-choice contingent valuation functions as shown below. Although consumers are assumed to know their preferences with certainty, investigators and econometricians perceive individual utility functions as consisting of systematic and random or unobservable components (Hanemann, 1984; Hanemann and Kanninen, 1998). To the investigator, therefore, a given peanut consumer's utility is stated as follows;

(1) $$U_i = f(y_i, z_i, e_i)$$

where y is the individual's income, z is a vector of the respondent's socioeconomic and/or demographic characteristics, e is the random term and subscript i represents the consumer. Given that consumer utility is directly unobservable to researchers, probability of utility maximization is obtained from individuals' observed behavior. In dichotomous-choice questions, people are required to indicate whether they would agree to pay a proposed price or not.

Owing to the utility maximization objective, consumers would be willing to pay for a new product if they believe that the proposed change (such as the introduction of aflatoxin-free peanut) will increase or retain their existing utility (Hanemann, 1984; Hanemann and Kanninen, 1998). The preceding assumption is expressed below in probabilities;

(2) $$P_i = P(U_{i1}(y_i - B_i, z_i, e_{i1}) \geq U_{i0}(y_i, z_i, e_{i0}))$$

where P_i is the probability of a consumer's willingness to pay a bid price of B_i for the new product; U_{i1} is the final utility after acquiring the new product; U_{i0} is the initial utility before buying the new product; $y_i$is the consumer's income; z_i is a vector of the individual's demographic information; and e_{i1} is the random component after obtaining the new product, while e_{i0} is the random term for the case without the new product. Notice that the bid price is paid directly from the consumer's income.

Therefore, consumers will agree to pay a bid price when their willingness to pay equals or exceeds the offered price of the aflatoxin-free peanut, otherwise they will reject the bid. This consumer behavior is illustrated in the next two equations:

(3) $$\Pr(No\ to\ B) = Pr(B > \max WTP)$$

and

(4) $$\Pr(Yes\ to\ B) = Pr(B \leq \max WTP)$$

Equation (3) indicates that an individual will reject (or say 'No' to) the supply of aflatoxin-free peanut if the proposed bid price is greater than his maximum willingness to pay. On the other hand, a consumer will accept (or say 'Yes') to an offer on condition that his maximum willingness to pay outweighs or, at least, is identical to the bid price of the new product.

Derivations presented so far imply that consumer willingness to pay for new products depends on bid price, as well as individual/demographic factors.

Hence, the distribution of maximum willingness to pay i.e. $G(B;\theta)$ is presented as a cumulative distribution function of the bid price (B), and a vector of parameters θ. Equations (3) and (4) are respectively expressed in suitable distribution functions as follows:

(5) $$\pi^n(B) = Pr(B > \max WTP) = G(B;\theta)$$

and

(6) $$\pi^y(B) = Pr(B \leq \max WTP) = 1 - G(B;\theta)$$

where π^n is the probability of bid rejection, whereas π^y is the probability of a consumer agreeing to pay a bid price.

Typically, the logistic distribution is employed. The S-shape of the logistic distribution function with values ranging from 1 to 0 provides the opportunity to estimate the probability of consumers' willingness to pay given a bid price. Consistent with consumer theory, CV studies assume a downward-sloping logistic function in order to represent the decreasing probabilities of consumers' willingness to pay as the bid price increases (see De Groote and Kimenju, 2008b). Thus, assuming the logistic functional form, we can express the two possible outcomes of individuals' willingness to pay, from Equations (5) and (6) respectively, as follows:

(7) $$\pi^n(B) = G(B;\theta) = {}^{1}\!/_{(1 + \exp(-(\alpha - \rho B)))}$$

(8) $$\pi^y(B) = 1 - G(B;\theta) = 1 - {}^{1}\!/_{(1 + \exp(-(\alpha - \rho B)))}$$

where

(9) $G(B;\theta) = {}^{1}\!/_{(1 + \exp(-v))}$ is the cumulative distribution function (cdf) for the logistic distribution; $v = (\alpha - \rho B)$ is an index function assumed to be linear in bid price; and α and ρ are elements of the parameter vector, θ. It must be emphasized that the sign of ρ is positive, thereby ensuring a downward-sloping demand curve

(i.e. probability of WTP) consistent with economic theory.

The corresponding log likelihood function is derived as follows;

$$(10) \quad \mathrm{L}(\theta) = \sum_{i=1}^{N} (d_i^y \, ln\pi^{\mathrm{y}}(B_i) + d_i^n ln\pi^{\mathrm{n}}(B_i))$$

OR

$$(10') \; \mathrm{L}(\theta) = \sum_{i=1}^{N} (d_i^y \ln(1 - G(B;\theta)) + d_i^n lnG(B;\theta))$$

where d_i^y is a binary-indicator variable which equals 1 if the ith respondent accepts the bid price, and 0 otherwise; similarly, d_i^n equals 1 if the ith respondent rejects the bid price and 0 otherwise. Estimation of the vector of parameters in the log likelihood function is then achieved using the maximum likelihood estimator. Subsequently, the mean (and median) willingness to pay is derived from the estimated parameters using the following formula:

$$(11) \qquad mean\; WTP = {}^{\alpha}/_{\rho}$$

3.4.2.2 Double-Bounded Dichotomous-Choice Method

Here, derivations for the single-bounded CV case are extended to the double-bounded dichotomous-choice model, where each respondent faces two bid prices with the magnitude of the second price contingent on the individual's answer to the first price (see De Groote and Kimenju, 2008a, 2008b). That is, each person is offered a first dichotomous-choice question with a proposed price B^1 and if the individual agrees to pay this price then the interviewer follows up with another dichotomous-choice question with a higher price, B^{H}. However, if the respondent rejects the first bid B^1 then he is offered a second dichotomous-choice question with a lower bid price B^{L}.

The double-bounded dichotomous-choice method, therefore, produces four possible outcomes with the following WTP probabilities:

$$(12)\ \pi^{yy}(B_i^U) = Pr(B_i^U \leq \max WTP_i) = 1 - G(B_i^U; \theta)$$

$$(13)\ \pi^{yn}(B_i^1, B_i^U) = Pr(B_i^1 \leq \max WTP_i \leq B_i^U) = G(B_i^U; \theta) - G(B_i^1; \theta)$$

$$(14)\ \pi^{ny}(B_i^1, B_i^L) = Pr(B_i^L \leq \max WTP_i \leq B_i^1) = G(B_i^1; \theta) - G(B_i^L; \theta)$$

and

$$(15)\quad \pi^{nn}(B_i^L) = Pr(B_i^L > \max WTP_i) = G(B_i^L; \theta)$$

where π^{yy} is the probability of a respondent accepting both first and second bid prices; π^{yn} is the probability of a respondent accepting the first bid but rejecting the second price; π^{ny} is the probability of a respondent rejecting the first price but accepting the second price; π^{nn} is the probability of a respondent rejecting both first and second bid prices; $B_i^L < B_i^1 < B_i^U$ and $G(.)$ is assumed to be a logistic distribution. The corresponding log likelihood function is;

$$(16)\ L(\theta) = \sum_{i=1}^{N} (d_i^{yy} \ln \pi^{yy}(B_i^U) + d_i^{yn} \ln \pi^{yn}(B_i^1, B_i^U) + d_i^{ny} \ln \pi^{ny}(B_i^1, B_i^L) + d_i^{nn} \ln \pi^{nn}(B_i^L))$$

where d_i^{yy} is a binary-indicator variable which equals 1 if the ith respondent accepts both bids, and 0 otherwise; d_i^{yn} equals 1 if the ith respondent accepts the first price but rejects the second bid price and 0 otherwise; d_i^{ny} equals 1 if the ith respondent rejects the first price but accepts the second bid and 0 otherwise; and d_i^{nn} equals 1 if the ith respondent rejects both prices, and 0 otherwise.

The maximum likelihood estimator is then employed to estimate parameters in the log likelihood function, and the mean willingness to pay is derived as in the single-bounded CV case presented earlier.

3.4.2.3 Application of Semi Double-Bounded Dichotomous-Choice Method

The present study has three WTP (response) categories discussed below. As a result, this chapter estimates a modified version of the double-bounded dichotomous-choice approach. Specifically, we estimate a Semi Double-Bounded (SDB) logistic model — a special form of the standard double-bounded logistic method (McCluskey et al., 2003; De Groote and Kimenju, 2008b; Meenakshi et al., 2012). In this dissertation, the SDB model is employed to determine the probability of consumers' willingness to pay for safer peanuts as a function of prices, as well as relevant socioeconomic factors. This research focuses on willingness to pay price premiums for quality peanut, where a consumer's stated price for aflatoxin-free peanut must exceed the existing peanut price in his local market. As a result, prices in respondents' preferred markets serve as their lower-bound prices. The reduction of aflatoxin levels in peanut is assumed to be product-enhancing. Therefore, we ignore discount prices in this study since aflatoxin-free peanuts would be of superior quality relative to peanut commonly available in Ghanaian local markets. Precisely, the following three response levels are used to measure consumers WTP for peanut with reduced aflatoxin contamination:

1.) "No" : This means rejection of both first-bid and second-bid prices;

2.) "Yes–No": Acceptance of first-bid price but a rejection of a second-bid price;

3.) "Yes–Yes": Acceptance of both first-bid and second-bid prices;

where the *first-bid price* refers to the initial stated price that strictly exceeds existing price in a respondent's preferred market, whereas the *second-bid price* is a respondent's next stated price (following acceptance of the first-bid price) that must necessarily be greater than his previously stated price.

This implies that a respondent who rejects the first-bid price would not be willing to pay any premium for aflatoxin-free peanuts. In this study, if a consumer agrees to the first bid B_i^1, he is subsequently asked for a second higher bid B_i^U. However, if the respondent answers 'No' to the first bid then that terminates the elicitation process. Therefore, following the procedure and assumptions invoked for the two dichotomous-choice methods derived earlier, the corresponding probabilities for all three WTP-response categories in this study are presented as follows:

(17) $\pi^{n}(B_i^1) = Pr(B_i^1 > \max WTP_i) = G(B_i^1; \theta)$

(18) $\pi^{yn}(B_i^1, B_i^U) = Pr(B_i^1 \leq \max WTP_i \leq B_i^U) = G(B_i^U; \theta) - G(B_i^1; \theta)$

and

(19) $\pi^{yy}(B_i^U) = Pr(B_i^U \leq \max WTP_i) = 1 - G(B_i^U; \theta)$

where π^{yy} is the probability of a respondent accepting both first and second bid prices; π^{yn} is the probability of a respondent accepting the first bid but rejecting the second price; π^{n} is the probability of a respondent rejecting the first price and, by implication, the second bid price; the WTP probabilities and bid prices respectively have the following order, $\pi^{yy} > \pi^{yn} > \pi^{n}$ and $B_i^U > B_i^1$; and $G(.)$ is the cumulative distribution function for the logistic distribution.

Equation (17) shows the probability of consumers who would not be willing to pay a price premium for aflatoxin-free peanuts. That is, their maximum WTP are lower than bids that exceed prevailing prices in their preferred markets. In Equation (18), the probability of a consumer offering a price premium but declining to further increase the premium in a follow-up question suggests that his maximum WTP falls between his stated price and a higher bid. Finally, from Equation (19), we note that the probability of a consumer agreeing to pay a premium through his stated first and second bid prices indicates that his maximum WTP is above the highest bid he offers to pay.

With the WTP probabilities specified, the corresponding log likelihood function is shown below:

$$(20)\quad L(\theta) = \sum_{i=1}^{N} (d_i^{yy}\, ln\pi^{yy}(B_i^U) + d_i^{yn} ln\pi^{yn}(B_i^1, B_i^U) + d_i^{n} ln\pi^{n}(B_i^1))$$

where d_i^{yy} is a binary-indicator variable which equals 1 if the ith consumer accepts both bids, and 0 otherwise; d_i^{yn} equals 1 if the ith consumer accepts the first price but rejects the second bid price, and 0 otherwise; and d_i^{n} equals 1 if the ith consumer rejects both prices, and 0 otherwise. Similarly, the maximum likelihood estimator is employed to estimate parameters in the log likelihood function. Also, the median WTP can be computed as shown in Equation (11) after estimating a simple polytomous ordered logistic regression; where the WTP categories are regressed on maximum bid prices stated by the respondents.

In addition to mean WTP, this study estimates the impact of socioeconomic and demographic characteristics on individuals' willingness to pay for aflatoxin-free peanuts. This is achieved by augmenting the model's index function through the inclusion of important factors that may influence consumers WTP. Thus, the probabilities of respondents' WTP for safer peanuts would depend on bid prices as well as relevant consumer characteristics, as stated below:

$$(21)\qquad \pi(B, Z; \theta) = \pi(v; \theta)$$

where

$(22)\qquad v = \alpha - \rho B + \lambda Z + \boldsymbol{\varepsilon}$ is the expanded index function assumed to be linear in bid prices, B, and consumer characteristics, Z; α, ρ, and λ are elements of the vector of parameters θ; and $\boldsymbol{\varepsilon}$ is an error term.

To illustrate, the probability of a consumer agreeing to pay a price premium by accepting both bids (as in Equation (19)) is stated as follows:

$$(23)\quad \pi^{yy}(B_i^U, Z_i) = 1 - G(B_i^U, Z_i; \theta)$$

$$= 1 - {}^{1}\!\big/\!\left(1 + \exp\left(-(\alpha - \rho B_i^U + \lambda Z_i + \boldsymbol{\varepsilon})\right)\right)$$

In this study, the vector Z is comprised of consumer characteristics such as age, sex, household income, household size, level of formal education, awareness of aflatoxin contamination, region of residence, availability of peanut substitutes, peanut consumption frequency, among others.

3.5 Empirical Model and Information on Variables

This subsection specifies the model to be estimated and presents a description of all variables used in this chapter. Due to the presence of inherently ordered WTP categories (i.e. $\pi^{yy} > \pi^{yn} > \pi^{n}$), ordered logistic regressions are estimated using the LOGISTIC procedure in SAS (SAS Institute Inc., 2008). Specifically, the cumulative logistic regression is specified as follows:

$$(24)\quad \text{logit}\left(\text{wtp\_order}_j\right)$$

$$= \alpha_j + \rho(\text{max\_price}) + \lambda_1(\text{income\_gp}) + \lambda_2(\text{hhsize2})$$

$$+ \lambda_3(\text{age\_group}) + \lambda_4(\text{edu\_class}) + \lambda_5(\text{substitute}) + \lambda_6(\text{sex})$$

$$+ \lambda_7(\text{region1}) + \lambda_8(\text{awareness}) + \lambda_9(\text{frequency}) + \mathcal{E}$$

where α, ρ, and $\lambda's$ are parameters to be estimated; $\mathcal{E}$ is the error term with a cumulative logistic distribution; subscript j represents unique functions and intercepts for each category of the response variable; and all variables in the model are defined in Table 3.2.

Table 3.2. Definition of Variables

Variable Name	Variable Label	Categories and Codes[1]	Units
hhincome	Household income per month	---------	Ghana cedis
income_gp	Income group of household	(1=Low) and 2=High	---------
hhsize	Household size	---------	---------
hhsize2	Category of household size	(1=Small) and 2=Large	---------
max_price	Maximum bids offered	---------	Ghana cedis
bid_index	Bids relative to market prices	---------	Percent
premium	Price premiums offered	---------	Percent
peanutp	Existing peanut market prices	---------	Ghana cedis
amount	Weekly peanut consumption	---------	Cups
age	Age of respondent	---------	Years
age_group	Age group of respondent	1=Young and (2=Old)	---------
mstatus2	Marital Status of respondent	(1=Married) and 2=Single	---------
edu_class	Education Level	(1=Primary sch), 2=Middle sch, 3=High sch, 4=College/University	---------
frequency	Peanut consumption frequency	(1=Low) and 2=High	---------
wtp_order	Willingness to Pay	1=No, 2=Yes-No, (3=Yes-Yes)	---------
wtp_order2	Willingness to Pay	1=No and (2=Yes)	---------
wtp	Aflatoxin regulation	1=In favor, 2=Against, 3=Undecided	---------
substitute	Peanut substitutes	1=Yes and (2=No)	---------
sex	Sex of respondent	(1=Male) and 2=Female	---------
region1	Region of survey	(1=Ashanti), 2=BA, 3=Central, 4=Eastern, 5=Western	---------
aware_g	General awareness of food contaminants	1= Aware and (2=Not aware)	---------
awareness	Aflatoxin awareness	1= Aware and (2=Not aware)	---------

[1]Reference levels of categorical variables used in regressions are in parentheses.

Source: Survey Data

Shortly, descriptive analyses on selected variables from the survey are provided; in Tables 3.3 and 3.4, we show summary statistics on relevant socioeconomic characteristics of consumers interviewed in the survey. Also, detailed discussions of some of the variables are introduced in the next section.

Table 3.3 highlights the distribution of monthly household income in Ghana cedis (as at July 2012, the average exchange rate was 1 US Dollar = 1.8 Ghana cedis).

The median household income is 500 Ghana cedis per month for a typical household comprising of four individuals (see the distribution of household size in Table 3.3).

Also, information in Table 3.3 suggests that the average household member who accepted to participate in the survey was 30 years old. Furthermore, the average household in Ghana consumes about 1.8 'margarine cups' (i.e. 0.67kg or 1.5lbs) of shelled peanut every week.[28]

Table 3.3. Summary Statistics for the Continuous Variables

Variable	N	Mean	Median	Std Dev	Minimum	Maximum
max_price	652	2.8	2.5	1.1	1.2	7
bid_index	652	184.1	166.7	73	100	466.7
premium	652	84.1	66.7	73	0	366.7
amount	652	1.8	1.8	1.1	0.3	10
peanutp	652	1.5	1.5	0.2	0.9	2
hhincome	652	577.6	500	342.8	80	4000
age	652	32.9	30	9.6	18	68
hhsize	652	4.5	4	2.4	1	20

Note: Prices and income are stated in Ghana cedis (1 U.S. Dollar=1.8 Ghana cedis).
Source: Survey Data

Interestingly, from Table 3.4, nearly a half of the survey sample is made up of individuals who described their marital status as 'single', whereas the remaining participants indicated their status as 'married'. The 'single' group of respondents consists of people who are widowed, separated or have never been married.

The survey apparently captured many female household members than males, as displayed in Table 3.4. The imbalance in gender representation is partly explained by lower interview decline rates among females as opposed to males.

[28] Six local 'margarine cups' equal one 'olonka cup'. On average, an 'olonka' of shelled peanut weighs 2.24 kg or 4.93 lbs. Hence, one 'margarine cup' of shelled peanut would approximately weigh 0.37 kg or 0.82 lbs. The present survey adopted 'margarine cup' as the standard measure. See Nagai (2008) for details on local units of measurement for some cereal grains and legumes in Ghana.

Also, in most cases where two or more members of a particular household were present, females were unanimously chosen by the other members to participate on behalf of the household. Hence, the female dominance in the survey is due to their key roles in household decisions concerning food; namely market transactions, food handling and storage, meals preparation, among others.

Furthermore, the distribution of formal education levels shown in Table 3.4 indicates that three-quarters of the individuals interviewed have had at least 9 years of formal schooling at the ‘Middle School’ level (or junior high school level).

Table 3.4. Summary Statistics for the Discrete Variables

Variables	Categories	Frequency	Percent	Cumulative Frequency	Cumulative Percent
age_group	Young	423	64.88	423	64.88
	Old	229	35.12	652	100
edu_class	Primary sch	81	12.42	81	12.42
	Middle sch	269	41.26	350	53.68
	High sch	211	32.36	561	86.04
	Coll/Univ.	91	13.96	652	100
substitute	No	67	10.28	67	10.28
	Yes	585	89.72	652	100
sex	Female	406	62.27	406	62.27
	Male	246	37.73	652	100
mstatus2	Married	341	52.3	341	52.3
	Single	311	47.7	652	100
awareness	Aware	44	6.75	44	6.75
	Not Aware	608	93.25	652	100
frequency	Once a week	186	28.53	186	28.53
	2-3 times a week	240	36.81	426	65.34
	4-6 times a week	93	14.26	519	79.6
	Daily	88	13.5	607	93.1
	Other	45	6.9	652	100
aware_g	Aware	333	51.07	333	51.07
	Not Aware	319	48.93	652	100
wtp	In favor	512	78.53	512	78.53
	Against	106	16.26	618	94.79
	Undecided	34	5.21	652	100

Source: Survey Data

3.6 Results and Discussion

This section provides results from the survey data in addition to observations made on the field through interviewers' interactions with survey participants.

3.6.1 Awareness of Aflatoxin Contamination

The survey asked respondents if they had ever heard about the aflatoxin contamination problem in food products, particularly in peanuts. As revealed in Table 3.4, people's familiarity with the aflatoxin issue is low in that approximately 9 out of every 10 individuals were not aware of the aflatoxin problem. This low level of aflatoxin awareness is consistent with Jolly et al. (2006) who found substantial evidence of little awareness among study participants in Ghana in 2002. However, the interviewers observed that most participants consider visibly moldy foods (including peanut) as unwholesome for human consumption. Hence, the apparent low level of aflatoxin awareness may, in fact, be less troubling since the average person in Ghana considers moldy foods as unhealthy for consumption. Moreover, the survey attempted to find out about consumers' knowledge of food contamination in general (see Table 3.4). Slightly more than half of the respondents demonstrated some awareness of issues regarding food contamination. The dominant concern expressed by the consumers was about chemical residues in food crops owing to the excessive use of synthetic pesticides and inorganic fertilizers in farming.

3.6.2 Willingness to Pay for Aflatoxin-free Peanut

This subsection provides information on the key objective of the survey. Respondents were asked to cast their vote to reflect their willingness (or otherwise) to pay price premiums for aflatoxin-free peanuts. The referendum was conducted after survey participants had received concise information on the aflatoxin contamination issue and implications of its regulation, namely the availability of aflatoxin-free peanut in local markets but at higher retail prices.

By inspection, one can conclude that consumers in Ghana are willing to pay more for safer peanut (see Table 3.4). That is, approximately 79% of the survey participants voted in favor of aflatoxin regulation interventions that would ensure the availability of aflatoxin-free peanut, despite the attendant increase in prices. This result was obtained in the face of persistent reminders that consumers had the option to vote against the proposition (in favor of an alternative world where there would be different grades of peanut in retail markets, and the decision to buy sorted or unsorted peanut would rest entirely with the consumer). The participants who voted in favor of aflatoxin regulations expressed worries about the alternative scenario since, in their opinion, sellers of peanut paste (or butter), as well as food vendors (locally called "chop bars") are often suspected of using unwholesome peanut in processing food products.

Over the survey period, the average market price of shelled and uncooked peanut was 1.5 Ghana cedis per cup (see Table 3.3). The survey shows that given the reference price of 1.5 Ghana cedis per cup, consumers are willing to pay 2.5 Ghana cedis per cup for aflatoxin-free peanut. This implies that consumers in Ghana are willing to pay a price premium of about 66% relative to existing peanut prices (see Table 3.3). However, mean WTP estimates obtained from the logistic regression are substantially less than the median value shown in the Descriptive Analysis (see the next subsection and Table 3.5). Specifically, the polytomous logit model indicates that respondents in the 'Yes-Yes' category are willing to pay a premium of 27% as opposed to those in the 'Yes-No' category who would pay a 20% premium. Similarly, according to the binary logit regression results, participants who demonstrated some willingness to pay (i.e. the 'Yes' category) offered to pay 13% more than existing prices (see Table 3.5). It must be mentioned that some traditional markets in Ghana actually offer two grades of peanut for sale, where one is sorted thereby attracting higher prices compared to the unsorted counterpart. A few of the respondents also pointed out that superior-quality peanut (i.e. well sorted) are also sold in modernized grocery stores locally referred to as "supermarkets".

3.6.3 Factors Influencing Consumers' Willingness to Pay for Aflatoxin-free Peanut

Table 3.5 shows estimation results obtained from cumulative (i.e. ordered) logistic regression models. Although the Score Test rejected the proportional odds assumption (i.e. equal slopes for all response-category functions but with different intercepts), we maintain the cumulative logistic regression results since the latent WTP-variable is ordinal. Furthermore, the Score Test is known to be non-conservative in that it has the tendency to reject the proportional odds assumption more frequently in favor of the alternative (Derr, 2013).[29] Also, the alternative Generalized Logistic Regression yields potentially unstable results for the polytomous model due to small and empty cell entries revealed in preliminary analyses using bivariate contingency tables. The crosstabs were constructed for the response variable versus each of the categorical covariates (results from the contingency tables are not reported). Owing to the presence of low cell entries, the three-level WTP variable was collapsed to two

[29]Stokes, Davis, and Koch (2012) argue that small samples and/or cell frequencies often inflate the Score Test statistic.

categories. Therefore, binary ordered logistic regressions were also run with the response levels 'Yes-Yes' and 'Yes-No' combined as one category called 'Yes'. The purpose of the binary ordered logistic regression was to ascertain the robustness of results from the polytomous counterpart. The response variables in all models represent increasing levels of consumers' WTP for peanut with reduced aflatoxin contamination. Also, willingness-to-pay probabilities are cumulated over lower-ordered response values. In general, the concordance index indicates that the models perform well on the data in that observed probabilities for the outcome variable are correctly predicted in most cases. For ease of interpretation, discussion of results focuses on odds ratio estimates derived by taking exponents of the estimated regression parameters (see Appendix 3A for corresponding odds ratios computed from the cumulative logit models in Table 3.5).

Table 3.5. Model Estimation Results

Variables	Category	Polytomous Models (Dep. Var=wtp_order) Model (1)	Model (2)	Binary Models (Dep. Var=wtp_order2) Model (3)	Model (4)
Intercept11	yes-yes	-10.3126***	-10.9289***	----	----
		(0.9184)	(1.1032)	----	----
Intercept12	yes-no	-9.7769***	-10.3267***	----	----
		(0.8933)	(1.0772)	----	----
Intercept2	yes	----	----	-21.4009***	-30.1066***
		----	----	(2.2996)	(4.6309)
max_price	----	5.5525***	5.6350***	12.3507***	16.4519***
		(0.4963)	(0.5157)	(1.3513)	(2.4741)
income_gp	high	----	0.1690	----	1.1460***
		----	(0.1734)	----	(0.4275)
hhsize2	large	----	-0.2038	----	-1.0512**
		----	(0.1768)	----	(0.4748)
age_group	young	----	0.3424*	----	1.2600***
		----	(0.1769)	----	(0.4408)
edu_class	coll/univ	----	-0.9022**	----	-1.8458*
		----	(0.4466)	----	(1.0427)
	high sch	----	-0.0847	----	-0.5880
		----	(0.2749)	----	(0.6462)
	middle sch	----	0.5498**	----	1.0745*
		----	(0.2784)	----	(0.6122)
substitute	yes	----	0.0416	----	0.1946
		----	(0.2602)	----	(0.5653)
sex	female	----	-0.1273	----	-0.7193**
		----	(0.1638)	----	(0.3603)
region1	BA	----	-1.1730**	----	-0.0010
		----	(0.5438)	----	(1.6077)
	Central	----	0.3355	----	-0.4382
		----	(0.3858)	----	(0.9363)
	Eastern	----	-0.6988	----	-1.2725
		----	(0.4281)	----	(0.9257)
	Western	----	0.3382	----	-0.1996
		----	(0.3614)	----	(0.8816)
awareness	aware	----	0.3298	----	-0.7889
		----	(0.3564)	----	(0.6620)
frequency	high	----	-0.1942	----	-0.1984
		----	(0.1773)	----	(0.3844)
Likelihood Ratio		474.344***	508.426***	571.723***	609.042***
Concordance Index(c)		0.955	0.963	0.992	0.998
Number of observat'ns		652	652	652	652

Notes: 1. *** Significant at 1% ; ** Significant at 5%; and * Significant at 10% .
2. Standard errors are shown in parentheses.
3. Probabilities modeled are cumulated over lower-ordered response values.

Comparing the full polytomous and binary models — Models (2) and (4), respectively — we observe that the results are largely similar with expected signs even though household size and income appear important in Model (4), whereas region of residence matters in Model (2). Thus, results obtained from the polytomous logistic regression appear considerably stable. Nonetheless, the binary logistic model is preferred, especially in connection with the socioeconomic characteristics, given the relatively small sample size of the survey data. Hence, results from Model (4) are the main focus in this subsection although references are made to Model (1) in discussions regarding mean WTP estimates for the upper categories of the dependent variable.

Applying Equation (11), the estimated median WTP derived from the simple polytomous model (i.e. Model (1)) are 1.9 and 1.8 Ghana cedis, respectively for the 'Yes-Yes' and 'Yes-No' categories of the outcome variable. The simple binary regression (i.e. Model (3)) also produces a median WTP value of 1.7 Ghana cedis for the 'Yes' group of respondents.[30] These WTP estimates suggest that consumers are willing to pay median price premiums ranging from 20% to 27%, according to the polytomous model; whereas the binary logistic model shows the median WTP as 13% more than prevailing market prices. These price premiums are derived relative to the median market price of 1.5 Ghana cedis displayed in Table 3.3.

On impact of socioeconomic characteristics, as far as consumers' WTP are concerned, Table 3.5 shows that household income, number of individuals in households, age of respondents, and gender are relevant factors that affect people's

[30] Notice that absolute values of the intercepts are used in computing the mean WTP estimates. Also, the price parameter (ρ) is positive, hence, a downward-sloping WTP curve can be derived after plugging the estimated slope into the index function shown in Equation (9) above.

behavior. In addition, the level of respondents' formal education appears to influence their WTP although the evidence is statistically weak. Conversely, the remaining consumer characteristics, namely the availability of peanut substitutes, region of residence, participants' awareness about aflatoxin contamination, as well as the frequency of peanut consumption have no impact at all on the variation in WTP.

Specifically, compared to lower income households, participants belonging to the higher income group (i.e. with monthly household incomes exceeding 500 Ghana cedis) are about 10 times more willing to pay premiums, holding all other variables in the model constant. The preceding result is statistically significant at the 1% level. Furthermore, the odds of larger households paying price premiums are approximately 88% less than those of smaller households (i.e. with at most four individuals), for given levels of the remaining regressors. In other words, people from smaller households are more willing to pay higher prices for aflatoxin-free peanuts compared to participants from larger households, and this result is statistically significant at the 5% level. Also, at the 1% level of significance, the odds of younger respondents' WTP are 12 times greater than older survey participants. Precisely, respondents who were 35 years and below at the time of the survey were more likely to offer price premiums compared to older respondents. In addition, males are more likely to offer price premiums than females in the sense that the odds of female's WTP is only 24% that of their male counterparts. Interestingly, individuals who have had at least college education are less likely to pay more for aflatoxin-free peanut compared to people who had a maximum of elementary schooling even though this result is only significant at the 10% level.

Finally, socioeconomic characteristics such as participants' access to peanut substitutes, geographical location of the survey, whether individuals are familiar with the aflatoxin problem or not, and the frequency at which households consume peanut do not influence WTP (even at the 10% level of statistical significance).

3.7 Summary and Conclusions

The central goal of this chapter was to study consumer preference for peanut with reduced aflatoxin contamination, following concerns over negative effects of aflatoxin policy interventions on the economic welfare of food market participants. This topic shows empirical evidence of consumer willingness to pay (WTP) for safer peanut guaranteed through regulations; a subject that has been ignored in assessments of aflatoxin policy interventions. In addition, the study sought to determine some important socioeconomic factors that may affect people's WTP for quality peanut. To achieve these objectives, a Contingent Valuation (CV) survey was conducted in the year 2012 on 652 individuals sampled from households in Ghana. The resulting survey data were analyzed using a semi-double-bounded dichotomous choice method based on the random utility theory. Consequently, cumulative (ordered) logistic regression models were estimated.

Findings reveal that efforts at disseminating information on aflatoxins contamination must be intensified in order to improve on the existing level of awareness among people living in Ghana. Education campaigns to effectively raise awareness are required since most people consider conspicuously moldy foods as unhealthy but do not necessarily understand the adverse impacts of high levels of dietary aflatoxins exposure.

Another revelation from the survey data is that a majority of consumers in Ghana are willing to pay price premiums for peanut with reduced aflatoxin contamination. Specifically, the survey participants offered modest to high WTP values ranging from 13% to 66% greater than existing market prices.

Furthermore, the study shows that socioeconomic characteristics such as income, family size, age, and gender actually influence consumers' willingness to pay premiums for quality/safer peanut. Particularly, improving income levels substantially affects people's willingness to pay for aflatoxin-free peanut. Moreover, individuals associated with smaller households are more inclined to demand quality food by offering price premiums for safer peanut. The younger segment of the population in Ghana are relatively conscious about food safety, and are more willing to pay higher prices in order to consume peanut with reduced aflatoxin contamination. According to the 2010 Population Census, Ghana's population is predominantly young with mean (median) age of 24 (20) years (Ghana Statistical Service, 2012). This means that the introduction of regulations would largely receive approval from the populace. Females in Ghana have been shown to be less willing to pay price premiums for aflatoxin-free peanut unlike the males. Given the integral role of women in the Ghanaian society — in terms of planning, purchasing, and preparation of meals at the commercial and household levels — it would be crucial for policymakers to target women in aflatoxin awareness campaigns and economic empowerment schemes.

Another interesting finding was that consumer characteristics such as the availability of peanut substitutes, region of Ghana where the respondent lives, participants' awareness of aflatoxin contamination, the frequency at which households consume peanut, as well as formal education level have no effect on people's WTP for safer peanut.

To conclude, field observations together with analyses performed on the survey data show that consumers in Ghana are strongly in support of aflatoxin regulation enforcement and are willing to pay price premiums for aflatoxin-free peanut. The findings provide encouraging signals to the research community and regulatory bodies regarding factual assessments of aflatoxin policy implications on food market participants — producers and consumers. Specifically, it has been shown empirically that the introduction of aflatoxin standards with the attendant price increases may not be harmful to consumers' economic welfare as it is widely believed. Knowing that consumers are willing to pay more for aflatoxin-free peanut also serves as incentive to stakeholders in the supply chain. Particularly, peanut producers would strive to comply with aflatoxin standards if there is substantial demand for food products with reduced aflatoxin content.

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Appendix 1: Additional Information for Chapter 1

1A. Peanut Import Quantity (or Market) Shares for Exporters in the EU Market

Exporters	1995-1998	1999-2002	2003-2007	1995-2007
China	0.2115	0.3115	0.267	0.2636
USA	0.2341	0.1918	0.1018	0.1702
ROW	0.5544	0.4967	0.6312	0.5662

Source: Computed from FAO Statistics (2010).

Note: EU's annual edible peanut import from each exporter is divided by total EU annual edible peanut imports and results averaged over the stated periods.

1B. Computation of Compliance Tax Rates and Price Transmission Elasticities

In an attempt to model the EU regulation as a tax, the basic price equations are specified as below:

$$(4)-(6) \qquad P_i^D = P_i^S + T_i + C_i \quad for\ i = china, usa\ and\ row$$

where T_i is the per-unit transfer costs, and C_i is the per-unit compliance cost or "tax." Suppressing transfer costs, these equations are written in percentage changes as in equations (4')-(6') above, where $\alpha_i = \frac{P_i^D - T_i - C_i}{P_i^D}$ are the price transmission elasticities, $\beta_i = \frac{C_i}{P_i^D}$ are the compliance tax rates, and $R*$ is the uniform percentage increase in standards (compliance costs) caused by tighter regulation.

All source-specific import prices were obtained from the FAOSTAT (2010) database as unit prices. Shipping cost for the USA, according to a Nicaraguan peanut sector study conducted by Oosterman (2000), is 87 US$/MT. Except for Argentina and some African countries (with shipping costs of 105 US$/MT and 200 US$/MT respectively), there are no available direct shipping costs for the other peanut exporters who make up the ROW.

Therefore, Jaffee's (2003) research (cited by Hallam *et al.,* 2004) which provides the cost of freighting green beans from different origins to the EU market was consulted. Consequently, China and ROW are assigned shipping costs of 250 US$/MT each.

1C. Estimating Export Supply Elasticities

The export supply elasticities were computed from the equation:

$$(39-41) \qquad \varepsilon_i = \frac{e_S + (1 - kx_i)|e_D|}{kx_i} \quad for\ i = \ china, usa\ and\ row$$

where e_S and e_D are, respectively, supply and demand elasticities for peanut in the domestic markets of the exporting countries and assumed to be identical across all exporters. kx_i is the country-specific export share (i.e. share of total domestic production that is exported). Note that the demand elasticities substituted into the above formula are absolute values. Figures for exporters' domestic peanut supply and demand elasticities are from the elasticity database of the Food and Agricultural Policy Research Institute (FAPRI) cited by Beghin and Matthey (2003). Finally, values for export share of domestic production were computed from FAO Statistics. The table below provides details on parameters used to estimate the export supply elasticities shown in Table 1.2 above:

1C. Parameters Used to Estimate Export Supply Elasticities

Parameter	Definition	Value
e_S	Domestic own-price supply elasticity[a]	0.350
e_D	Domestic own-price demand elasticity[a]	-0.200
kx_1	Export share of China's domestic peanut production	0.029
kx_2	Export share of USA's domestic peanut production	0.114
kx_3	Export share of ROW's domestic peanut production	0.050

Notes: [a]The elasticities are assumed to be identical across all three exporters and all periods.

1D. Short-Run Effects with Export Supply Elasticities set to Zero (Perfectly Inelastic)

Results shown in the tables below are obtained when peanut supply elasticities are perfectly inelastic. This simulation is carried out to highlight short-run impacts of EU standards tightening on peanut exporters. In addition, this exercise shows the scenario where export supply is less elastic than import demand in order to clearly demonstrate the demand and supply principle that the less elastic side of a market bears the greater incidence of a given policy.

1D1. Reduced-Form Elasticities for Peanut Prices and Quantities in the EU Market

Variables	No Substitution Effects	Substitution Effects Included
$P_c^{S}*$	-0.1927	-0.1927
$P_{us}^{S}*$	-0.8431	-0.8431
$P_{rw}^{S}*$	-0.4174	-0.4174
$P_c^{D}*$	0	0
$P_{us}^{D}*$	0	0
$P_{rw}^{D}*$	0	0
Q_c*	0	0
$Q_{us}*$	0	0
$Q_{rw}*$	0	0

Note: The effects on import demand prices are so small that they have been approximated to zeros. Thus, the actual results are -0.0000009, -0.0000008 and -0.000002 for demand prices paid to China, USA and ROW, respectively.

1D2. Exporter Welfare Changes (US$) Induced by 10% Regulation Costs Increase

Exporters	No Substitution Effects
China	-1487513
USA	-4639729
ROW	-5869964

1E. Exporter Welfare Changes (1,000 US$) Induced by 10% Tax Increase: No Substitution Effects Case

Exporters	1995-2007[a]	1995-1998[b]	1999-2002[c]	2003-2007[d]
China	-74.85	-83.43	-24.09	-98.25
USA	-750.37	-767.09	-795.88	-510.29
ROW	-71.27	-64.8	-115.61	-53.29
Total	-896.49	-915.32	-935.58	-661.83

[a]Baseline period. [b]First sub-period. [c]Second sub-period. [d]Third sub-period.

1F. Price Transmission Elasticities, Compliance Tax Rates and Export Quantity Share Values for Sub-periods

1F1. Price Transmission Elasticities (alpha parameters)

Exporters	1995-1998	1999-2002	2003-2007
China	0.5498	0.5899	0.5877
USA	0.6502	0.5041	0.3808
ROW	0.5021	0.2788	0.5618

1F2. Compliance Tax Rates (beta parameters)

Exporters	1995-1998	1999-2002	2003-2007
China	0.1543	0.037	0.1235
USA	0.2606	0.4116	0.539
ROW	0.1835	0.498	0.114

1F3. Export Quantity Share Values

Exporters	1995-1998	1999-2002	2003-2007
China	0.0269	0.0309	0.0287
USA	0.141	0.1207	0.0878
ROW	0.0506	0.0508	0.0491

1F. Vertical Shift in the Import Demand Curve Due to Regulations

Using the model scenario where demand interrelationships are ignored, we compute the vertical (i.e. proportionate) shift in demand due to the regulation tax as follows:

A vertical shift in import demand implies that the supply curve or quantity is fixed (i.e. vertical supply curve) at the initial equilibrium value (for more on vertical shifts in curves, see Muth, 1965; Kinnucan, Xiao, and Yu, 2000). Hence, there is no relative change at all in the quantity supplied i.e. $X_i^* = 0$.

However, in equilibrium, $X_i^* = M_i^* = Q_i^*$ as shown in equations (10')-(12'). This means that the demand relation in equations (16)-(18) can be rewritten as follows:

$$0 = \alpha_i \eta_{ii} P_i^{S*} + \beta_i \eta_{ii} R^*$$

Solving for P_i^{S*} yields the following price relation, representing the proportional demand shift on the price axis:

$$P_i^{S*} = \frac{\beta_i}{-\alpha_i} R^* < 0$$

Therefore, the vertical shift in demand is denoted as shown below:

$$V_i^D = \frac{\beta_i}{-\alpha_i} R^* < 0$$

Appendix 2: Additional Information for Chapter 2

2A. Alternative forms of equations (19), (20), (21), and (22) in the text

$$(19') \quad \frac{P_S^*}{R^*} = \frac{\beta}{\alpha}\left[\frac{\varepsilon_S}{\alpha K_X(\varepsilon_X - \eta_X)} - 1\right] < 0$$

$$(20') \quad \frac{Q_D^*}{R^*} = \frac{\varepsilon_S \beta \eta_D}{\alpha K_X(\varepsilon_X - \eta_X)} < 0$$

$$(21') \quad \frac{Q_X^*}{R^*} = \frac{\varepsilon_S \beta \eta_X}{\alpha K_X(\varepsilon_X - \eta_X)} < 0$$

$$(22') \quad \frac{Q_S^*}{R^*} = \frac{\varepsilon_S \beta}{\alpha}\left[\frac{\varepsilon_S}{\alpha K_X(\varepsilon_X - \eta_X)} - 1\right] < 0$$

2B. Vertical Shift in the Tax-Burdened Domestic Supply Curve

The vertical (i.e. proportionate) shift in domestic supply caused by regulation costs is computed as follows:

A vertical shift in supply implies that the demand curve or quantity is held constant (i.e. vertical demand) at the initial equilibrium value (for more on vertical shifts, see Muth, 1965; Kinnucan, Xiao, and Yu, 2000). Thus, there is no relative change in the quantity demanded; $Q^* = 0$. From Model One, equilibrium in the domestic market requires the following identity: $Q_S^* = Q_D^* = Q^*$

Therefore, the tax-burdened domestic supply shown in equation (6) can be set to zero as follows:

$$0 = \frac{\varepsilon_S}{\alpha} P_D^* - \frac{\varepsilon_S \beta}{\alpha} R^*$$

Solving for P_D^* yields the following price relation, representing the proportional supply shift on the price axis:

$$P_D^* = \beta R^*$$

Hence, vertical shift in the supply curve is denoted as follows:

$$V_S = \beta R^*$$

Appendix 3: Additional Information for Chapter 3

3A. Corresponding Odds Ratio Estimates from Model Parameters

Table 3.5.1. Odds Ratio Estimates

		Polytomous Model (Dep. Var=wtp_order) Model (2)			Binary Model (Dep. Var=wtp_order2) Model (4)		
Variables	Category	Estimate	Lower CL	Upper CL	Estimate	Lower CL	Upper CL
max_price	----	280.063	101.924	769.545	>999.999	>999.999	>999.999
income_gp	high	1.402	0.711	2.767	9.895	1.852	52.865
hhsize2	large	0.665	0.333	1.330	0.122	0.019	0.786
age_group	young	1.983	0.991	3.968	12.429	2.208	69.957
edu_class	coll/univ	0.262	0.063	1.084	0.041	0.002	1.070
	high sch	0.593	0.209	1.685	0.143	0.013	1.557
	middle sch	1.119	0.411	3.051	0.752	0.083	6.849
substitute	yes	1.087	0.392	3.013	1.476	0.161	13.535
sex	female	0.775	0.408	1.473	0.237	0.058	0.974
region1	BA	0.093	0.024	0.360	0.148	0.003	8.028
	Central	0.422	0.166	1.072	0.095	0.010	0.921
	Eastern	0.150	0.052	0.430	0.041	0.004	0.391
	Western	0.423	0.176	1.016	0.121	0.015	0.959
awareness	aware	1.934	0.478	7.821	0.206	0.015	2.765
frequency	high	0.678	0.338	1.359	0.672	0.149	3.034
Likelihood Ratio		508.426			609.042		
Concordance Index(c)		0.963			0.998		
Number of observations		652			652		

Notes: 1. "CL" means Confidence Limit i.e. 95% Wald Confidence Limits.

2. Probabilities modeled are cumulated over lower-ordered response values.

3B. Survey Questionnaire for Studying Consumers' Willingness to Pay for Aflatoxin-free Peanuts in Ghana

Date of interview………………………………………………………………………………….

Name of interviewer…………………………………………………………………………...

Region……………………........….. Capital…………………....

Suburb…………………….

Interviewee Number /___/___/___/

Introduction

Auburn University and KNUST, as members of USAID-sponsored Peanut CRSP team of investigators, are conducting this survey to assess Ghanaian consumers' demand/preferences for quality (or safe) peanuts in domestic markets. We will therefore be glad if you could grant us a few minutes of your time and objectively respond to questions we have for you. We assure you that opinions expressed will be strictly treated as confidential.

A. Screening

A1. Have you ever eaten peanuts and other peanut products before?

1.) Yes/___/
2.) No/___/ (Terminate interview)

A2. How often do you eat peanuts and peanut products?

1.) Once per week /___/
2.) Two to three times per week /___/
3.) Four to six times per week /___/
4.) Daily /___/
5.) Other/___/ (please specify)……………………………………………………………….

A3. Based on the above codes (A2) please indicate the frequency at which you consume the following peanut products (<u>Multiple Response Allowed</u>).

1.) Soup, butter or paste /___/
2.) Raw/uncooked kernels/___/
3.) Boiled kernels/pods/___/
4.) Roasted kernels/pods/___/
5.) Peanut oil/___/
6.) Peanut products like candies, cookies/pastry, fried peanut bars and kernels/___/

A4. What is your main source of peanut supply (Over 50%)?

1.) Own farm/producer/gifts/___/ (Terminate interview)
2.) Buys from market/___/

A5. About how many cups of shelled peanuts do you purchase weekly for your family needs?
………………………………………………… cups per week.

B. Awareness of Aflatoxin Contamination

B1. Have you heard about any food contaminants that pose health problems to consumers?
1.) Yes/___/
2.) No/___/ (Skip to B2)

B1.1 If yes, please list………………………………………………………………………..

B2. Are you familiar with the problem of aflatoxin contamination in peanuts?
1.) Yes/___/
2.) No/___/ (Skip to Section C)

B2.1. (If 'yes' to question B2): How did you become aware of peanut aflatoxin contamination? For each of the sources below, please answer by indicating 1). Yes or 2). No:
1.) Through print/electronic media (e.g. TV, radio, newspapers) /___/
2.) Through individuals like friends and other relations/___/
3.) Through bodies like religious groups, NGOs/___/
4.) Through workshops by universities and other government research institutions/___/
5.) Others /___/ (please specify)……………………………………………………………

C. Market Description

At this point, the interviewer MUST clearly and accurately explain the text below to all respondents before proceeding to Section D. This part is crucial since consumers must make informed decisions in the subsequent sections of the questionnaire.

Market Description

"Given the warm and humid weather conditions in Ghana, peanuts are often contaminated with aflatoxins particularly during post-harvest handling and marketing. Aflatoxins are substances produced by molds (fungi) that cause people to fall sick when highly contaminated peanuts are consumed over time. Researchers have found associations between aflatoxins exposure and health problems such as aflatoxicosis, fever, jaundice, and liver cancer. Although environmental conditions make the elimination of aflatoxins nearly impossible, there are scientifically proven measures that could be adopted by peanut producers through retailers to minimize contamination. Activities that effectively reduce aflatoxins include proper drying, sorting, and hygienic practices. However, the procedures that achieve no/low aflatoxin contamination involve additional costs (in terms of more labor and the discarding of contaminated peanuts) which could lead to higher retail prices. To protect the consuming public, government regulators in Ghana will have to enforce aflatoxin standards in the near future. In view of the above, we would want you to candidly answer the questions below by taking decisions in the context of your preferences, income, and regular food expenditure patterns."

D. Willingness to Pay, Demand and Preferences

"Please observe these three peanut samples – A, B, and C – for a moment. Note that sample A is *unsorted* and has the highest possibility of aflatoxin contamination. Sample B is fairly sorted (i.e. still contains broken and shriveled kernels) and has a lower possibility of aflatoxin contamination compared to A. Sample C has the least possibility of aflatoxin contamination since it is *well-sorted* and thoroughly cleaned. We would want you to answer a few questions shortly."

D1. If we asked you to make a choice, which of the samples will you first pick for consumption?

1.) Sample A i.e. unsorted peanuts/___/
2.) Sample B i.e. moderately-sorted peanuts/___/
3.) Sample C i.e. thoroughly-sorted peanuts/___/

D2. Based on the quantities of peanuts you buy per week for your family, if you were to buy the same number of cups indicate how many cups you would buy of each category (sample) at each of the prices below.

Prices (GHC/cup) / Peanut samples	Less than 1.0	1.0	1.5	2.0	2.5	3.0	Above
Sample A i.e. unsorted peanuts							
Sample B i.e. moderately-sorted peanuts							
Sample C i.e. thoroughly-sorted peanuts							

D3. What is the approximate price of peanuts in your preferred market? (Please specify unit of measurement and whether shelled or unshelled)…………………………………………………...

D4. In preparing your meals that typically include peanuts, do you have other substitutes/ingredients that you can use instead of peanuts?

1.) Yes/___/
2.) No/___/ (Skip to D5)

D4.1. If 'yes' to question D.4, please specify your peanut substitutes…………………………….

D4.2. What do you think can strongly influence you to switch away from peanuts to the substitutes you have listed?

1.) Prices/___/
2.) Food safety reasons/___/
3.) Others/___/ (please specify)……………………………………………………………….

D5. If the Government of Ghana organized a referendum calling on Ghanaians to express their opinions on a proposition to enforce peanut aflatoxin standards, what will your vote be? Please remember that the regulations will ensure the availability of aflatoxin-free (safer) peanuts in markets but could also mean that consumers will have to pay more than existing peanut prices. Please cast your vote.

1.) In favor/___/
2.) Against/___/ (Skip to Section E)
3.) Undecided/___/ (Skip to Section E)

D5.1. If vote is 'in favor' how much will you be willing to pay for a unit of aflatoxin-free peanuts?……………………………………………...
.

D5.2. Would you be willing to pay more if the true price of aflatoxin-free peanut turns out to be a little higher than you have stated above?

1.) Yes/___/
2.) No/___/ (Skip to Section E)
3.) Not sure/___/ (Skip to Section E)

D5.3. If 'yes' please specify the maximum price for aflatoxin-free peanuts beyond which you will no longer be willing to pay………………...

E. Attitudes and Behaviors Suggesting Food Safety Consciousness

E1. Please rank the peanut forms below according to your intensity or frequency of consumption using alphabets A to F where A is the highest rank and F is the lowest rank.

1.) Peanut butter/soup /___/
2.) Uncooked peanut kernels /___/
3.) Boiled peanut kernels/pods /___/
4.) Dry-fried or roasted kernels/pods /___/
5.) Peanut oil /___/
6.) Peanut products like candies, cookies/pastry, fried peanut bars and kernels /___/

E2. Which of the following best describes your habit regarding peanut purchases?

1.) Buys in bulk and use in bits over a period/___/
2.) Buys in bits for one-time use only/___/ (Skip to E3)

E2.1. If you buy in bulk, how do you typically store your peanuts? (Multiple Response Allowed)

1.) In a refrigerator/___/
2.) Kitchen shelves/cupboard/___/

3.) In a storage room with other food items/___/
4.) Others/___/ (please specify)…………………………………………………………

E3. Which of the factors below do you normally give priority to before you decide to buy peanuts from a particular seller or group of sellers? (Multiple Response Allowed)
1.) Prices/Affordability/___/
2.) Cleanliness/neatness of products/___/
3.) Food safety concerns/health considerations/___/
4.) Others/___/ (please specify)…………………………………………………………

E3.1. Out of the factors you have picked in E3, which one do you consider as the most important?
1.) Prices/Affordability/___/
2.) Cleanliness/neatness of products/___/
3.) Food safety concerns/health considerations/___/
4.) Others/___/ (please specify)…………………………………………………………

F. Socioeconomic Characteristics

F1. Gender
1.) Male/___/
2.) Female/___/

F2. Marital Status
1.) Married/___/
2.) Single/divorced/separated/widowed/___/

F3. Type of occupation
1.) Unemployed/___/ (Skip to F4)
2.) Self-employed/___/
3.) Public servant or works for a private entity/___/

F3.1. Please specify your occupation……………………………………………………………….
F4. Highest level of formal education
1.) No formal education or zero years of schooling/___/
2.) Primary or 6 years of schooling/___/
3.) JHS/Middle School or 9 years of schooling/___/
4.) SHS or 12 years of schooling/___/
5.) Training College/Polytechnic or 15 years of schooling/___/
6.) University or 16+ years of schooling/___/

F5. Age of respondent………………………………………years old.

F6. Number of people in your household………………………………………………
F7. What is your household's monthly income (including wages, salaries, remittances)……………………………………………………………………………….

1.) Below 300 Gh cedis/___/
2.) From 300- 600 Gh cedis/___/
3.) 601- 900 Gh cedis/___/
4.) 900 and above Gh cedis

F8. Have you had any health problems after you have eaten peanuts or peanut products?

1. Yes/___/
2. No/___/ (Skip to F9)
3. Never noticed/___/ (Skip to F9)

F8.1 If yes, please list……………………………………………………………………………..
F9. Has any other members of your immediate family had health problems after eating peanuts or peanut product?

1. Yes/___/
2. No/___/
3. Don't know /___/

F9.1 If yes, please list……………………………………………………………………………

3C. Survey Questionnaire Guide for Enumerators

Interviewers are required to pay particular attention to instructions provided below regarding specific sections in the questionnaire.

A. Screening

For question **A1;** if a respondent's answer is "NO," politely terminate the interview and thank him for his time.
For question **A3;** if a respondent indicates that he consumes ONLY peanut oil (i.e. option 5 of question A3) and no other forms of peanut then politely end the interview.
For question **A4;** if a respondent obtains his peanut mainly (i.e. over 50%) from his own harvest and/or as gifts then politely terminate the interview. This study focuses on peanut consumers who buy from markets; 'out-of-pocket' consumers.

C. Market Description

Please endeavor to communicate the content of this section to respondents in very clear terms. The reliability of responses strongly hinges on how well the content of this particular section is conveyed.

SECTION C

<u>Interviewers MUST clearly and accurately explain the text below to all</u>

respondents. This part is crucial since consumers must take informed decisions in the subsequent sections of the questionnaire.

Market Description

"Given the warm and humid weather conditions in Ghana, peanuts are often contaminated with aflatoxins particularly during post-harvest handling and marketing. Aflatoxins are substances produced by molds (fungi) that cause people to fall sick when highly contaminated peanuts are consumed over time. Researchers have found associations between aflatoxins exposure and health problems such as aflatoxicosis, fever, jaundice, and liver cancer. Although environmental conditions make the elimination of aflatoxins nearly impossible, there are scientifically proven measures that could be adopted by peanut producers through retailers to minimize contamination. Activities that effectively reduce aflatoxins include proper drying, sorting, and hygienic practices. However, the procedures that achieve no/low aflatoxin contamination involve additional costs (in terms of more labor and the discarding of contaminated peanuts) which could lead to higher retail prices. To protect the consuming public, government regulators in Ghana will have to enforce aflatoxin standards in the near future. In view of the above, we would want you to candidly answer the questions below by taking decisions in the context of your preferences, income, and regular food expenditure patterns."

D. Willingness to Pay, Demand and Preferences

At this point, the interviewer must show all three peanut samples to the respondent for careful observation. Emphasize that although all peanut samples may be contaminated, the unsorted one (A) and the moderately sorted (B) are more likely to have higher aflatoxin levels than the sorted sample (C). Also stress that samples A and B are peanuts typically sold in Ghanaian markets.
For question **D3**; find out about the price he normally pays for his peanuts in the appropriate quantity (i.e. whether per margarine can, 'olonka', etc.).
For question **D5**; again, remind the respondent to take decisions in the context of his preferences, income, and regular food expenditure patterns.

F. Socioeconomic Characteristics

For question **F7**; Actual household monthly incomes are preferred so please attempt to get precise income levels in addition to intervals.
For question **F7**; Household should comprise of all individuals in a home that share meals and other basic necessities.

Please Note: "Multiple Response" at the end of a question indicates that respondents can choose one or more options.