ECONOMIC RISKS OF AFLATOXIN CONTAMINATION IN THE PRODUCTION AND MARKETING OF PEANUT IN BENIN

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Cynthia Bley N'Dede

Certificate of Approval:

Patricia A. Duffy Professor Agricultural Economics and Rural Sociology	Curtis M. Jolly, Chair Professor Agricultural Economics and Rural Sociology
Norbert L. Wilson Associate Professor Agricultural Economics and Rural Sociology	George T. Flowers Dean Graduate School

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Cynthia Bley N'Dede

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ECONOMIC RISKS OF AFLATOXIN CONTAMINATION IN THE PRODUCTION

AND MARKETING OF PEANUT IN BENIN

Cynthia Bley N'DEDE

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Signature of Author

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Date of Graduation

VITA

Cynthia Bley N'DEDE, daughter of Roger N'DEDE and Marie (Magnin) N'DEDE, was born August 22, 1981, in Abidjan, Cote D'Ivoire. She graduated from Université de Cocody, Abidjan in December 2005. She worked in an Audit Company in Abidjan, Cote d'Ivoire before she entered the United States. She entered Graduate School at Auburn University in August 2006 in the Department of Agricultural Economics and Rural Sociology. She is a sister of seven and a mother of one (Ivanah love H.).

THESIS ABSTRACT

ECONOMIC RISKS OF AFLATOXIN CONTAMINATION IN THE PRODUCTION AND MARKETING OF PEANUT IN BENIN

Cynthia B. N'DEDE

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Aflatoxins are naturally occurring mycotoxins that are produced by species of fungus: *Aspergillus flavus* and *parasiticus*. Aflatoxins occur in many agricultural products, in particular peanut (Arachis Hypogea L.). Many developing countries are affected by aflatoxin problem. The focus of this thesis is on farmers and market participants of peanut in Benin. We examine the risk of aflatoxin contamination on producing and marketing peanut in Benin. We, therefore, use enterprise budget and risk analysis to evaluate the effects of aflatoxin contamination on production and marketing of peanut. Data were collected in 2007 through a personal survey in three agro-ecological zones. A total of 90 farmers, 45 traders, 90 processors and 45 stockers were interviewed. Laboratory analyses show that samples collected from processors had high levels of

aflatoxin of up to 980 ppb, followed by the stockers with a maximum level of 610 ppb. Highest level for farmers was 230 ppb while for the traders, it was lower (7.3 ppb); these levels exceed the regulatory limits set by the WHO. Further, results show a decrease in net returns when farmers and market participants sort their products in an attempt to reduce aflatoxin levels. It is more profitable for producers and market participants to sell unsorted peanut immediately after harvest than to sort it before selling. Sorting peanut affects both labor cost and net returns. Unless they sell sorted peanut at a higher price there is no incentive to sort the peanut. In addition, findings indicate that aflatoxin production increases with storage length and this affects product quality and market prices. After 6 months of storage, net revenues from sale of peanut decrease due to lower peanut quality. Unless there is a policy in place for price increases for a better quality and safe product, market participants are likely to engage in cost shifting. Overall, results from enterprise budgets and risk analysis describe drying, sorting, and storage as the most important factors affecting costs and net returns. The results also show that the sorting of peanut may increase market risks of participants. Understanding the economic impacts of aflatoxin contamination may help farmers and market participants to improve product quality in the peanut sector in Benin.

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INTRODUCTION

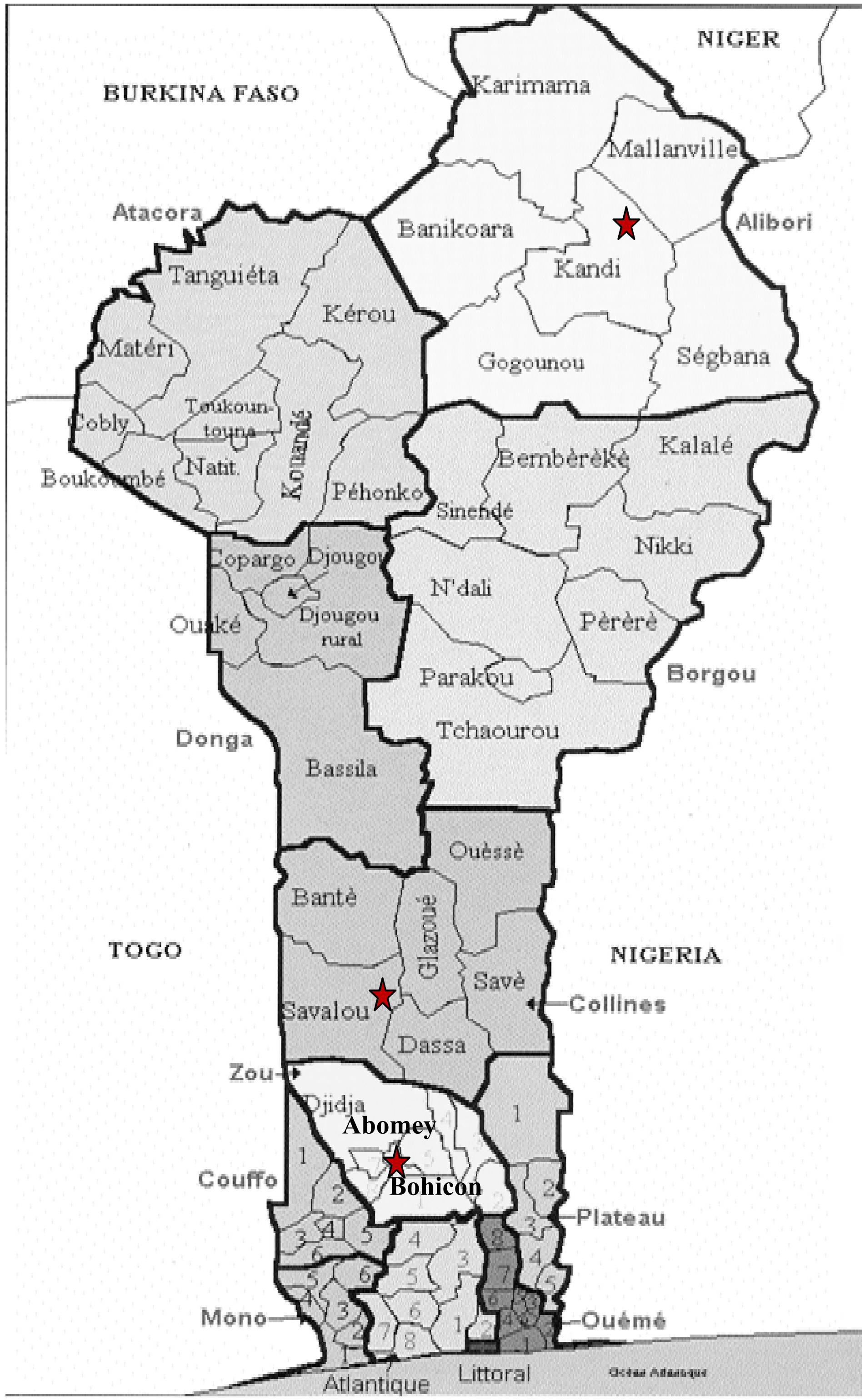
Aflatoxins are naturally occurring mycotoxins that are produced by species of fungus: *Aspergillus flavus* and *parasiticus*. Aflatoxins are some of the most potent toxic substances found in foods and feeds (Salunkhe et al., 1992). Since the 1960s, when they were first discovered as responsible for the death of 100,000 turkeys in England, aflatoxins have been a subject of concern of many studies (Atawodi et al., 1994). Aflatoxins are highly toxic and can cause serious harm to human and animal health. Numerous studies have linked aflatoxins to various diseases, such as cancer of liver and hepatitis B and C. High levels of aflatoxin were detected in children with *kwashiorkor* (Childhood malnutrition from protein insufficiency) in Sudan (Hendrickse et al., 1982), in Durban, South Africa (Ramjee et al. 1992) and in Nigeria (Lamplugh and Hendrickse,1982). In Gambia, ninety-three percent of sampled children (6-9 years) tested positive for aflatoxin albumin adducts (Turner et al. 2003). Aflatoxins are ubiquitous but are commonly found in warm and humid climates (Dohlman, 2003). Hence most commodities from tropical countries, especially peanut and maize, are easily contaminated with aflatoxin.

Aflatoxin contamination of human and animal feeds poses serious health and economic risks worldwide. FAO estimates that 25% of the world food crops are affected by mycotoxins each year and constitute a loss at post-harvest (FAO 1997). According to Cardwell et al. (2004), aflatoxin contamination of agricultural crops causes annual losses of more than $750 million in Africa. Jolly et al. (2009) also reveal that post-harvest losses of crops are greater than the improvements made in primary production. In the US, it was reported that income losses due to AF contamination cost an average of more than US$100 million per year to US producers (Coulibaly et al., 2008). Dohlman (2003) defined mycotoxin as toxic by-products of mould infestations affecting about one-quarter of global food and feed crop output.

Aflatoxin due to the invasion of *Aspergillus flavus* of the peanut (groundnut) pod is a serious problem in the international peanut market and has seriously hampered the export business of the developing countries, including Benin (FAO, 2002). In order to restrict exposure to this substance, many countries and governmental agencies set safety regulations, limiting the average concentration of aflatoxin on peanut and peanut products. For instance, in 1974 the Food and Drug Administration (FDA) proposed a tolerance level for aflatoxin of 15 parts per billion (ppb) in peanut products (Dichter, 1984). These regulations on food crops due to aflatoxin toxicity have a considerable economic impact on crop production and consequently on farm organisation. According to FAO (2002), developing countries account for approximately 95 percent of world peanut production, but are unable to sell large quantities of peanut on the international market because of aflatoxin contamination. Benin, a country in West Africa has lost its peanut export market because it is unable to meet international market standards of selling peanut and peanut products. The country of Benin provides a good care for evaluating the financial risks of aflatoxin contaminated peanut.

Peanut (Arachis Hypogea L.) is one the most important crops in West Africa because it is not only a useful crop for rotation with corn and other cereals but also a cash crop. Benin is a West African nation with a hot and humid climate. About 70% of the economically active population is engaged in the agricultural sector. Food crops include cassava, yams, corn, sorghum, beans, rice, sweet potatoes, pawpaws, guavas, bananas, coconuts and peanut. Peanut is grown as a protein source and consumed throughout the country. The northern area (Kandi) is the most productive region because it is dryer compared to the southern regions where it rains a lot and it is relatively humid. National production in 2004 was estimated at 130,000 tons (FAO, 2007). In the southern part of Benin, the climate is constituted by two dry and two rainy seasons, while in the north there is only one dry season and one rainy season. Overall, the dry season runs from November to April, and a rainy season from the end of April through September. The mean temperature is near 80 degrees Fahrenheit (27.7°C). Rainfall and humidity decrease from the south to the north. The southern zones have two growing seasons each year, while the northern area has only one season. Harvesting period differs by zone. The various zones and the areas of this study are seen in the map of Benin in figure 1.1.

Figure 1.1. Map of Benin



Recent studies have linked aflatoxin production in foods to environmental conditions, poor processing and lack of proper storage facilities in developing countries (Farombi, 2006). The same conclusion was reported by Hell et al. (2000) and Kaaya and Kyamuhangire (2006). In a study carried out in Uganda, Kaaya and Kyamuhangire (2006) revealed that aflatoxin levels increased with storage time such that the mean level of aflatoxin found in maize samples stored for more than six months exceeded regulatory limits fixed by FDA/WHO (15/20 ppb).

Hell et al. (2003) investigated the relationship between aflatoxin in stored maize and the management practices of fungal infection in Benin. They reported that high levels of aflatoxin (mean, 105 ppb) were associated to pre- and post-harvest practices (planting local varieties in the southern Benin, use of urea fertilizer, prolonged harvesting) and post-harvest factors (long drying period in the field). Other results also indicated that aflatoxin contamination was reduced by pre-harvest and post-harvest factors such as planting of improved varieties in the northern part, drying of harvested cobs for a period of 60 to 90 days and sorting out of poor quality ears.

Aflatoxin is common in warm and humid climates and occurs either in the field, during post-harvest transportation or storage (Dohlman, 2003). Similar results were found by Cotty and Jaime-Garcia (2007) who examined the influence of climate on aflatoxin contamination. The authors used geostatistics and multiple regression analyses to highlight the impact of climate on contamination. The findings indicated that aflatoxin contamination is prevalent both in warm humid climates and in irrigated hot desserts.

They also point out that a delay in harvest time could favor aflatoxin contamination (Jaime-Garcia and Cotty, 2003).

Pre-harvest and post-harvest management strategies employed to reduce aflatoxin in food result in lower productivity, but better quality. This is confirmed by Hell et al. (2008), who state that commodities contaminated with aflatoxin have a lower market value and cannot be exported. The authors also reveal that animal fed with grain contaminated with aflatoxin have lower productivity and slower growth. Likewise, Magan et al. (2003) conclude that poor post-harvest management can result immediately in rapid loss of quality and encourage mycotoxin growth. Research on aflatoxin problem has linked aflatoxin production to poor farming practices. In a survey of 300 samples collected from Benin's farmers, Hell et al. (2000) analyzed the relationship between the level of aflatoxin and storage practices. It was reported that aflatoxin levels at the beginning of storage were less than the ones found on maize stored during 6 months.

Dohlman (2003) proposed a strategy to reduce both health risks and the economic costs associated with mycotoxins. Food producers must be more aware of mycotoxin effect, and therefore, handling practices that would minimize mycotoxin contamination. Moreover, another solution would be to encourage the adoption of process-based guidelines (good agricultural practices (GAPs) or good manufacturing practices (GMPs)).

In spite of the studies that have outlined the losses due to aflatoxin, and the recommended practices to reduce the losses, there is little written on the effects of aflatoxin on the financial returns of production and marketing of peanut. Hence these questions must be raised: What are the risks associated to peanut aflatoxin contamination of production and marketing in Benin? How does aflatoxin contamination affect production, marketing costs, and returns? How does peanut aflatoxin contamination affect production and marketing risks? This study will provide valuable answers to these questions.

This study is divided into two parts. In part I, we examine the effects of aflatoxin on the production profitability and financial feasibility, and in part II we evaluate the effects on marketing profitability and risks.

Specific objective 1: examine the effects of aflatoxin on the production profitability and financial feasibility. (a) We hypothesize that aflatoxin contamination of peanut affects quality and quantity marketed. Based on survey answers and visuals judgments, we examine peanut quality by sorting the nuts. (b) We also hypothesize that aflatoxin contamination of peanut influences selling price; we examine buyers' responses to test the influence of aflatoxin on selling price. Finally, (c) we hypothesize that aflatoxin contamination influence labor costs and reduces net returns from peanut. We examine sorting, labor requirement, labor costs from survey data, and enterprise budget. We also examine how sorting affects financial and marketing risks and capital budget risks.

Specific objective 2: evaluate the effects on marketing profitability and risks. (a) We hypothesize that the returns and risks from selling of peanut are influenced on who bears the costs of sorting peanut. (b) We hypothesize that the purchase of sorted peanut influences the variation in net returns and risk from peanut selling and processing. (c) We hypothesize that the condition and length of storage influence net returns and risk from price variation.

CHAPTER 1: RISK OF AFLATOXIN ON PRODUCTION OF PEANUT IN BENIN

1. Introduction

Aflatoxin contamination of peanut affects the quantity and quality produced and marketed. The aflatoxin contaminated peanut is tainted and cannot be marketed and must be thrown away. Awuah et al. (2009) stated that about 5 to 15 percent of peanut in Ghana were discarded during sorting. This reduces the supply of peanut marketed at the farm level. Lower quality peanut is less attractive to buyers who offer a lower price for aflatoxin contaminated peanut. Hence it is expected that aflatoxin will lower farmer revenue and increase production and marketing risks.

Figure 1.2 represents a partial equilibrium model for peanut in which food regulation to improve food safety is observed. The model has a demand curve (D_o) and a supply curve (S_o) where the equilibrium price and quantity are P_E and Q_E. In this market, we assume near perfect competition, and farmers sort their peanut to improve quality. Hence, we use a highly elastic demand curve for our illustration. The sorting of peanut results in a reduction of the quantity supplied to the market which results in the supply curve (S_o) shift to the left to S_1. The demand curve D_o remaining constant, the new price is P_1 and the new quantity is Q_1. The higher price P_1 is an indication that consumers are willing to pay a higher price for a lower quantity. However, if consumers perceive that the sorting of nuts is an indication that the peanut is contaminated with aflatoxin, the demand curve (D_o) may shift to the left to D_1 resulting in price P_2 and quantity Q_2 will be marketed. Hence perceived lower quality results in a lower price and smaller quantity marketed. Consequently, total revenue measured by the area $0P_1AQ_1$ is reduced to "$0P_2BQ_2$".

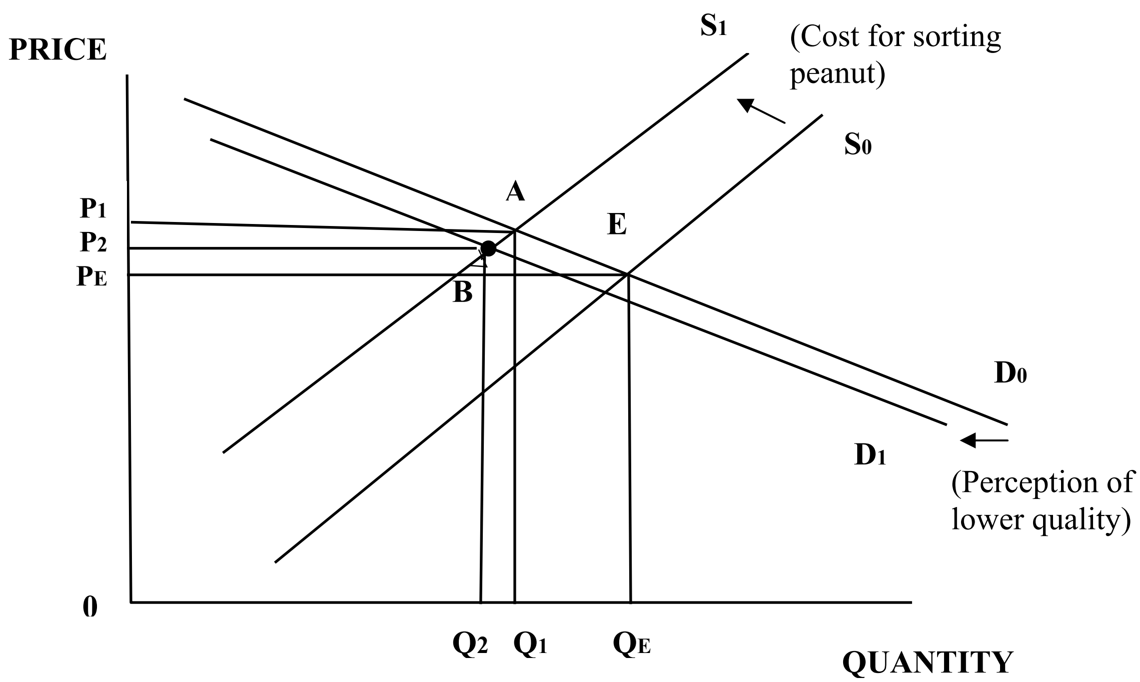


Figure 1.2: Market impact of food safety regulation

We can further represent the market equilibrium by these equations:

$$S_1 = \alpha + \beta_1 P - \theta_1 \quad (1)$$

$$D_1 = \alpha - \beta_1 P - \theta_2 \quad (2)$$

S_1 and D_1 are supply and demand respectively,

P represents the market price,

$\boldsymbol{\theta_1}$ and $\boldsymbol{\theta_2}$ represents both risk factors of aflatoxin.

The toxic effects of aflatoxin on human and animal health constitute one of the major factors for establishing acceptable evels of aflatoxins in food. These regulations require pre-harvest and post-harvest control such as appropriate drying, sorting and storage structures. However, implementing food safety standards can be costly to supply. According to Mitchell (2003), government regulations increase production costs which generally cause the supply curve of a firm to shift to the left. Hence, as shown in the figure above, if consumers are aware of aflatoxin problem and its consequences, they will be willing to pay a higher price for a safer food supply. Thus, the supply curve will shift to the left (Desire for safer food). We can conclude that supply is negatively associated to risk (θ_1).

Although, consumers throughout the world desire a safe food supply, not all consumers will be willing to pay a higher price for this food. Furthermore, if they perceive the product as unsafe they may be willing to buy less of the product. Demand curve will, therefore, shift downward. The net effect will be a fall in price and a fall in demand (figure 1.2: Perception of lower quality). This will lead to the following conclusion: Risk of aflatoxin (θ_2) negatively affects demand. Both cases (cost for sorting peanut and perception of lower quality) result in a decrease of the firm's revenue.

2. Factors affecting aflatoxin contamination

Since aflatoxin contamination of peanut is both a pre-harvest and a post-harvest problem, factors that affect production of the mycotoxin will also be discussed along these lines.

2.1. Pre-harvest

Aflatoxin production may occur during pre-harvest. In tropical countries, humidity, high temperature and rains are some factors encouraging fungal growth and aflatoxin production. Moisture content exceeding a safe range of 8 to 12% in the feed grains may contribute to fungal growth (Schatzki and Haddon, 2002, Diener and Davis, 1967).

2.2. Post-harvest

Drying: At harvest, moisture content in peanut is generally high and can lead to development of aflatoxigenic fungi. ICRISAT (2008) recommended drying of peanut immediately after harvest down to 8% moisture in order to avoid the production of aflatoxin when the crop is stored. In Benin, the most commonly used drying method for peanut is sun drying. Farmers spread out the nuts on a wooden or concrete floor usually for one to three days. Paz et al. (1989) reported that delayed drying could lead to a rapid increase in aflatoxin from 14.0 ppb at harvest to 93.8 ppb, if maize is not dried for 5 days after harvest. This was confirmed by Hell et al. (2003) who found that post-harvest contamination with aflatoxin in Benin increased when harvesting took more than 5 days and drying was delayed.

Storage: Another important post-harvest factor affecting aflatoxin contamination is storage condition. Grain crops may be attacked by fungi in the field which can then develop rapidly during storage when conditions are suitable for producing mycotoxins (Turner et al., 2005). During the survey, it was reported that the most common storage system used by farmers across all regions was unshelled peanut in polyester bags in storage houses or rooms. In addition, farmers were questioned about the time of storage of their products. Most of them reported that they can store peanut up to six months depending on market conditions. However, this time can be expanded to 8 to 12 months for other market participants. The relationship between the length of storage and the level of aflatoxin was, therefore, examined to assess the risk associated with storage time.

Sorting: Aflatoxin production is optimal in regions at high temperatures. Contamination is more acute in warm, humid climate. In order to eliminate those with possible contamination, peanut should be sorted to remove defective or contaminated grain.

3. Food policy on peanut

The risk of contamination by aflatoxins is an important food safety hazard for field crops (Dolman, 2003). In order to protect consumers from health risks, regulatory limits have been imposed on field crops intended for use as food and feed, and have significant impact on world export market. The World Health Organization (W.H.O) has set a maximum level for aflatoxin at 20 ppb in human foods and 100 ppb in animal feed. Likewise, the Food and Drug Administration (F.D.A) set a tolerance limit for peanut at 15 ppb for human. The European Union (E.U) has set stricter standards: any food products for human consumption with a concentration of aflatoxin greater than 4 ppb cannot be marketed.

4. Specific objective

The main objective in this part is to examine the effects of aflatoxin on peanut production in Benin.

Hypothesis 1: Aflatoxin contamination of peanut affects quality and quantity marketed. Based on survey answers and visuals observations peanut were sorted. We examined the peanut that are discolored, broken, punctured and discard them. The removal of bad peanut from the lot leaves us with less marketable peanut.

Hypothesis 2: Aflatoxin contamination of peanut influences selling price; we examine buyers' responses to test the influence of aflatoxin on selling price.

Hypothesis 3: Aflatoxin contamination influences labor costs and reduces net returns from peanut. We examine sorting, labor requirement, labor costs from survey data, and enterprise budgets. We also examine how sorting affects financial and marketing risks with capital budgets and risk analysis.

5. Materials and methods

Market participant identification, data and sample collection

We conducted surveys on aflatoxin contamination in peanut in three agro-ecological zones of Benin. Kandi (North), Savalou (South-east) and Abomey-Bohicon (South) were selected on the basis of their climatic conditions and levels of peanut production. A total of 30 farmers were selected in each of the three peanut producing regions of Benin during the period of May to July 2007. Peanut farmers and market participants were identified through the assistance of agricultural officers in the Ministry of Food and Agriculture (MoFA) and through the help of personnel from the University of Abomey-Calavi, Republic of Benin.

During the visits of each farm household, farming practices related to grain storage and handling were observed and documented using information on the survey instrument. Questionnaires were administrated to farmers by trained interviewers. Primary data collected included information on demographic and socioeconomic status, farming, post-harvest handling, storing and sorting practices, scheduled production activities, production level, household revenues and consumption frequency of peanut.

Data (produce samples) were collected at different post-harvest points and under different storage conditions. The levels of infestation of aflatoxin contaminated peanut under farmers' storage and marketing conditions were determined. It has been noted that aflatoxin levels vary along the marketing chain and the level of aflatoxin is more pronounced during storage and processing (Awuah et al., 2009).

Samples of 0.800 kg (= 1.764 pounds) of peanut were taken in the fields and markets from each farmer. These samples were divided into two groups: sorted clean and rejected (bad) nuts. Bad nuts were the ones with discoloration and holes.

Determination of aflatoxin (AF) level

Assessment of AF levels was undertaken using the VICAM technique. VICAM is an aflatoxin test that produces numerical results using monoclonal antibody-based affinity chromatography. The test can isolate aflatoxin β1, β2, ğ1, and ğ2 from feeds, foods, grains, and nuts, and from dairy products.

This test involved observation of post-harvest and handling of peanut, collection of data on management issues related to grain storage and handling, collection of peanut samples, and testing them to detect aflatoxin levels. Each farmer's farm or business selected for the study was visited. The frequency of levels of aflatoxin found in peanut was used to estimate the probabilities of occurrence of aflatoxin.

Statistical analysis

Data collected during the survey were entered into an EXCEL spreadsheet and analyzed using SAS software package version 9.1. These data were used to develop enterprise budgets for producing peanut. The costs of each business activity were estimated based on the data collected in the survey. Furthermore, a simulation of the risk of aflatoxin contamination on farmers' income from the production, storage and trading of peanut was done using the @RISK software.

6. General Assumptions

6.1. Regional effects

The survey was carried out in three different agro-ecological zones: Kandi, the northern region has one growing season starting at the end of May to September, with a temperature ranging from 28 to 45°C and a low rainfall averaging 800 to 900 mm. However, Savalou and Abomey-Bohicon have both two growing seasons (April to July and September to November) with a higher rainfall between 1,300 and 1,500 mm, and a temperature from 25 to 35°C (Setamou et al. 1997). Because of its climate (dry), Kandi is the most productive region and is also the least prone to aflatoxin production.

In the southern regions, aflatoxin production is due to the area high rainfall, and temperature. Under these tropical conditions, development of fungi and aflatoxin proliferation are facilitated. It is expected to have higher concentration of aflatoxin in Abomey-Bohicon than in Savalou and Kandi.

6.2. Decision on drying, sorting and storing peanut

Based on previous studies, variables drying, sorting and storing are reported as the most important factors that encourage aflatoxin production. Farmers are recommended to dry peanut immediately after harvest, and most important, down to a moisture level of less than 8 percent (ICRISAT, 2008).

Another important element is the decision on sorting. Sorting is considered as one of the ultimate solutions for aflatoxin problem. This method has been reported as a post harvest intervention strategy successful in reducing aflatoxin levels in peanut. An essential question was how much farmers or market participants will lose if they decide to sort peanut. In case the decision was “no sorting”, not only quantity is affected but also labor cost. Hence, based on the answers obtained during the survey, the probability to throw away some nuts was estimated at one to five percent of quantity produced if farmers decide to sort them. However, if not, the risk of fungal growth and from nuts (molded or contaminated with aflatoxin) will increase.

Long-term storage in warm environment results in *aspergillus* formation and increased aflatoxin contamination. No previous paper has suggested a safe period in which peanut can be stored. We assumed, therefore, that after two months, with a risk of having bad nuts (mold, insect damage, and aflatoxin contamination), percentage of rejection will be one percent and will increase by one percent more after each two months. This percentage is applied on the quantity harvested as the percentage representing the quantity loss if the storage length exceeds two months. This period (two months) was chosen based on survey reports.

6.3. Enterprise budgets

Budget analyses are used to evaluate the profitability of peanut enterprises in the short-run. Costs and returns were estimated for each region. Most information used to develop each enterprise budget was obtained during survey. Data such as seed quantity, seed price, quantity of peanut harvested, peanut selling price, material and equipment, labor hours and labor costs are obtained from the survey. They are the averages for the various size farms. All lands in the budgets are treated as owned by farmers. Material and equipment are the same in each region (Appendix 1.1) and are depreciated according to the useful life, using the straight-line method (Appendix 1.2). Costs for repairs and maintenance are assumed to be $1.00 for a one-hectare farm. Labor costs include land preparation, planting, harvest, drying, sorting, bagging, and transport costs. Labor costs and hour of use vary depending on the farm size.

6.4. Financial and economic analysis

Capital budgeting analyses are performed to evaluate the long term feasibility of producing peanut. Cash flows (appendix 1.3), net present values (NPV), internal rate of return (IRR) and profitability index (PI) are calculated (Appendix 1.4). The discount rates used are 6%, 10%, 13% and 15%. Since interest rate in Benin was 6% in 2007, 6% was retained for the NPV values in each table. In addition, the planning horizon is 10 years.

6.5. Risk analysis

Parameters such as price of output, inputs and quantity are manipulated to examine how changes in parameters affect peanut production and revenues. A total of 5,000 iterations of the model are executed to generate all probability distributions that are used to establish stochastic dominance. All the parameters used to develop the risks models are presented in Appendix 1.5.

Here we assume that net returns from peanut sales are affected by the costs of production and post-harvest handling. Hence, we use the formula:

$p_i*N.R = [p_i*(P_p*Q_p) – (p_i*Cost)]$

where,

p_i is the probability of the occurrence,

N.R is net return,

P_p is the price for peanut,

Q_p is the quantity for peanut and,

Cost is the cost of production; cost includes seed quantity and price, equipment, cost of pre-harvest, harvest, sorting, storage, bagging, winnowing…

Cost = $p_1*\beta_1$ drying cost + $p_2*\beta_2$ drying cost + $p_3*\beta_3$ sorting cost +…+ $p_n*\beta_n$ costs of n

Stepwise least squares regression is conducted between the collected input distribution values and the selected output values. The assumption is that there is a relationship between each input and output. The output of the stepwise regression is expressed in the form of a tornado chart.

Tornado chart is used to show the influence an input distribution has on the change in value of the output. Its main use is to enable the researcher to determine which variable contributes more to the output. It is also used for model diagnostic.

Therefore, the coefficient for any of the variables will vary from -1.0 to +1.0. Variables contributing zero to the cost will be eliminated. Variation in cost, each year will be kept and their importance to cost will be explained.

7. Results

7.1. Demographics and socio-economic results

7.1.1. Age and gender

Age is divided into three different groups. The majority of the respondents were between 36 and 55 years in each region (Table 1.1). About forty percent of the people interviewed in Kandi are under 35 years old, with 7.8% being over 55 years old. In

Savalou, 20% of the respondents are less than 35 years old and 35.6% more than 55 years. In Abomey-Bohicon, the portion of the people with age below 35 years old is 23.3%, and 15.6% are being over 55 years old.

Most of the peanut producers in Kandi (63.3%) and Abomey-Bohicon (54.4%) are male while in Savalou all farmers are male (Table 1.1).

7.1.2. Education and Experience

Most respondents have no formal education, with 56.7% (17) in Kandi, 76.7% (23) in Savalou and 63.3% (19) in Abomey-Bohicon. A large number is found in Kandi with 43.3% (13) literates, and only 16.7% (5) attending secondary school. Of those respondents who received a formal education, only 3.3% (1) in Savalou continued to secondary school, and in Abomey-Bohicon, 36.7% (11) had primary education and only 6.7% (2) attended secondary school (Table 1.1).

Years of experience are divided into 3 groups: less than 15 years (group one), between 15 and 30 years (group two) and over 30 years (group three). In Kandi, most farmers belong to the second group (46.7%); about 23.3% have been farming for more than 30 years and 30%, less than 15 years. In Savalou, the majority (53.3%) is in group 1, 20.0% in the second group and 26.7% in group 3. More than half of the respondents in Abomey (53.3%) have been farming for at least 30 years. However, 23.3% have started the activity less than 15 years ago and the remaining 23.3% is between 16 and 30 years (Table 1.1).

7.1.3. Land ownership

The majority of the respondents own their land in Kandi and Savalou, but in Abomey a large percent (83.3%) rent land to grow peanut and 16.7% are land owners (Table 1.1). About 86.7% farmers in Kandi and 60.0% in Savalou own their land while the others rent their land.

7.1.4. Level of income

Income level per ha for each region range from $0 to $350.14, $350.14 to $700.28 and $700.28 to $1,400.56 (Table 1.1). Of 90 farmers in Kandi, about 33.3% have an income less than $350.14, with 10% between $350.14 and $700.28, 33.3% between $700.28 and $1,400.56, and 23.3% greater than $1,400.56. For the producers in Savalou, half of them generate an income level between $350.14 and $700.28; approximately, 43.3% have revenues less than $350.14 and only 6.7% range between $700.28 and $1,400.56.

In Abomey-Bohicon, the majority of peanut farmers (60.0%) generate income under $350.14, 30% between $350.14 and $700.28, 6.7% between $700.28 and $1,400.56, and only 3.3% above $1,400.56.

7.1.5. Aflatoxin Knowledge and identification

Very few respondents know about aflatoxin contamination of food. As Kaaya and Warren (2005) reported, a large number of producers, traders and even consumers are not aware of food contamination with aflatoxin. When they were asked about the criteria used to identify aflatoxin contaminated peanut, some of them reported that they could identify spoiled or contaminated crops by the color or the shape; common colors are black, brown, white dust and greenish. Respondents suspect also any nut that are broken or attacked by insects to be contaminated with aflatoxin.

7.1.6. Illness related to aflatoxin

There is no report of diseases related to aflatoxin; however, it was reported that important consumption of peanut could affect consumers' health. Table 1.2 shows that 27.78% (Kandi), 43.33% (Savalou) and 47.78% (Abomey) respondents reported that they were affected by diseases such as malaria, diarrhea and coughing, due to a large and frequent consumption of peanut.

7.1.7. Decision on drying, storing and storing

About 95.6% of the farmers say that they dry their peanut immediately after harvest (Table 1.3). Of 90 farmers interviewed, only 10% sort their peanut. They mentioned that sorting is made immediately in the field while assembling the product for sale. Most of them (90%) refuse to do so because they do not want to discard the nuts and lower their sale. Another reason is that sorting is time consuming. However, for those who sort their peanut before selling, the discarded nuts are used as animal feed. Average quantity rejected after sorting range from zero to five percent.

During the survey, the majority of the respondent (78%) stated that they store their production for approximately 2 to 6 months or longer if market price is not favorable. In the northern region (Kandi), this period can exceed 6 months (up to 12 months) because there is only one growing season each year.

7.2 Aflatoxin level

Distribution of aflatoxin level for farmers samples are shown in table 1.4. Based on European standards, we observe that a large number of the samples tested (91.5%) have a concentration level of less than 4 ppb and only 8.5% are greater than 4 parts per billion. About 93.2% of the samples have a level less than the tolerance limit (15 ppb) set by the Food and Drug Administration (FDA). Only 6.8% have a level superior to 15 ppb. Based on WHO standards, the majority of the samples (96.6%) are safe for consumption, while 3.4% exceed 20 ppb. In addition, most of the samples (98.3%) are less than the permissible level in animal feed (100 ppb), while only 1.7% of the samples are greater.

7.3 Enterprise Budget

Enterprise budgets for each type of farm for each zone studied are shown in tables 1.5.1, 1.5.2 and 1.5.3. Peanut production is more profitable in Kandi than in the other regions. Net returns above total expenses are $270.50 for the small farms, $812.98 for the medium and $2,710.04 for the large farms (Table 1.5.1). In Savalou, the gross revenue for small farms was $756.30 with net returns of $ 647.37 (Table 1.5.2) while large farms generated net returns of $2,156.83 (Table 1.5.2). Results in table 1.5.3 show that large, medium and smallholder farms in Abomey-Bohicon generate net returns of $1,337.56, $320.97 and $133.45, respectively. Furthermore, break-even price calculated in each enterprise budget is $0.058 in Kandi, $0.059 in Savalou and $0.084 in Abomey-Bohicon. Comparing these results to that from budgets displayed in table 1.6, we observe that there is a decrease in revenue and returns, when farmers decide to sort peanut to improve quality. Since farmers have to sort to improve peanut quality, they end up throwing up to 5% of the quantity harvested; consequently revenue is reduced, resulting in lower net returns. The estimated costs and returns for one hectare peanut production are displayed in appendix 1.6.1 and appendix 1.6.2 for Kandi, appendix 1.7.1 and 1.7.2 for Savalou and appendix 1.8.1 and 1.8.2 for Abomey-Bohicon. Net revenues per hectare generated by farmers who do not sort peanut are respectively $630.25 (Kandi), $504.20 (Savalou) and $336.13 (Abomey-Bohicon).

In Kandi, quantity drops from 1,500 kg to 1,485 kg per hectare, which results in decreased revenue of $623.95 per hectare (Appendix 1.6-2). In addition, labor cost increases to $61.38. Table 1.6 summarizes and compares the costs and returns generated by the farmers when they decide to sort peanut before selling. Net returns are reduced to $532.72 in Kandi, $423.23 in Savalou and $261.03 in Abomey-Bohicon. Based on the assumptions shown in Table 1.6, this comparison demonstrates that improving quality, to meet food regulation standards, results in an increase in labor costs and a reduction in returns of $9.46 per hectare in Kandi, $8.19 per hectare in Savalou and $6.51 per hectare in Abomey-Bohicon (Appendix 1.9).

Storage impact

Based on Hell et al. (2000) and Kaaya and Kyamuhangire (2006) results, which indicate that duration of storage positively influences fungal growth and aflatoxin production in food crops, it is expected that peanut stored for more than 6 months have a negative effect on farmers net returns.

Since consumers may perceive that peanut quality will deteriorate during storage, due to aflatoxin contamination, they might lower price. Table 1.7 shows the results of peanut stored by farmers for more than six months in each agro-ecological zone. The assumption in this table is that there is a decrease in price by five percent. After 6 months of storage, significant differences are observed in product quality and on farmers' income. Revenues decrease to $853.20 in Kandi, $1,137.61 in Savalou and $364.03 in Abomey-Bohicon (Table 1.7). Hence, net returns per hectare above all expenses are reduced.

Desire for a better quality

Sorting has been reported as one of the most efficient methods to reduce aflatoxin contamination. As farmers sort their stored product, we assume that an increase in peanut price of 5, 10 and 15 per cent is offered over the storage period. Table 1.8 shows the simulated effects of change in price and storage duration on farmers' costs and returns. Assumptions are shown in table 1.8.1, table 18.2 and table 1.8.3. The longer peanut is stored, the smaller is the final quantity due to fungal and aflatoxin production; however, for each region, as price is increasing by 5, 10, and 15 per cent, revenue, net returns and

NPV also increase (Table 1.8). Overall, to improve quality of stored peanut, farmers sort peanut which results in an increase in labor cost, a decrease in yield and higher net returns. In Savalou for example, final quantity of peanut after 6 months of storage drops from 3,000.0 kg to 2,850.0 kg (Table 1.8) and net returns decrease to $948.9. Nevertheless, as storage period exceeds 6 months, the enterprise becomes less profitable.

Although, farmers sort peanut, it is still perceived as a lower quality product after 6 months. Hence, from that period peanut is sold at a lower price, resulting in lower returns; this means that a decrease in price by 5, 10 and 15 per cent reduces farmers' income ($945.8) by $92.18, $145.59 and $198.06 (Table 1.8). In addition the net present value is also reduced ($6,489.0).

7.4 Risk analysis

Results of risk analysis for only one type farm (one hectare) are examined. Figure 1.3 presents the tornado graphs for net returns for farmers who do not sort peanut. There is a positive and significant relationship between price and drying and net returns. Coefficients for these variables are respectively 0.98 and 0.21 in Kandi, 0.89 and 0.44 in Savalou and 0.88 and 0.46 in Abomey. For instance, net returns will increase by 0.98 standard deviation if price increases by one standard deviation. However, other labor costs such as cost of storage and cost of packaging negatively influence net returns if farmers have to pay more. In figure 1.4, farmers sort peanut before marketing. Likewise, the graphs show that price is the most important variable in the regression analysis, with a coefficient of 0.98 in Kandi, 0.90 in Savalou and 0.89 in Abomey-Bohicon. Drying has also a positive impact on farmers' revenue and net returns, which shows that farmers have to dry peanut efficiently before selling their products. Regression coefficients for variable drying are 0.21 in Kandi, 0.45 in both Savalou and Abomey-Bohicon. However, there is a negative relationship between sorting and net returns (Figure 1.4). It is evident that when farmers sort peanut, it negatively affects net returns. Similarly, coefficients for storage (-0.03) and other labor variables like harvesting (-0.001) have a negative influence on net returns for each region (Figure 1.4).

Figure 1.5 presents the cumulative probability distribution of the net present value for sorted peanut in the three regions. The distribution for each region indicates that most of the NPVs in Kandi range between $2,436.2 and $3,766.3, with a mean of $3,102.3. In Savalou, they range between $8,470.6 and $12,595, with a mean of $10,528.5 while in Abomey-Bohicon, the majority range between $2,444.5 and $3,773.8, with a mean of $3,102.4.

The assumptions applied in table 1.6 to determine the impact of sorting on farmers' income and net returns were used to generate the cumulative probability distributions for NPV presented in figure 1.6. It is observed that the NPV for farmers who sort peanut is more risky than for those who do not sort. At a probability of 0.4, the NPV for farmers who sort peanut is equal to $4,100 which is lower than that found for those who refused to sort peanut ($4,150). This comparison demonstrates that the improved quality of peanut is not profitable for farmers and the more they have to throw away, due to aflatoxin contamination, the less will be their net returns. After sorting peanut, farmers' net returns are reduced. It means that for farmers to sort their nuts, they must be compensated. From the budget analysis, farmers will have to receive at least $0.631 per kg more in Kandi, $0.682/kg in Savalou and $0.814/kg in Abomey-Bohicon, to entice them to sort their product for sale. Furthermore, based on the assumptions used to develop the sensitivity analysis of the NPVs in table 1.8, risk is incorporated in NPV at different price levels and at different storage times. Results in figure 1.7 shows that NPV for farmers who sort peanut and sell at the normal price is smaller than those who sell sorted peanut at a higher price (5%). It is, therefore, more profitable and less risky, to increase selling price to cover cost of sorting. Tornado graphs, in appendix 1.10, show that there is a significant relationship between price and NPV. As price goes up due to sorting, the NPV also increases; for instance, with a probability of 80%, NPV is 15.24% smaller when farmers sort immediately at harvest (Figure 1.8). Sorting 6 months after harvesting time is more risky than when farmers sort at harvest; we assume that price does not increase with improved quality. Price, drying, sorting and storage are likely to have a significant influence on the NPV (Appendix 1.11). Coefficient for sorting at harvest is -0.126 while after 6 months it equals -0.386. For variables storage and bagging, coefficients are respectively -0.036 and -0.002 at harvest and -0.099 (storage) 6 months later.

Discussion and conclusion

This study compares the costs and returns of peanut production in three agro-ecological zones of Benin. Socio-demographics information, knowledge of aflatoxin on peanut and farming practices were asked during the survey. Ages of the respondents range from 35 to 55 years old and over 55years old. Most of those (66.7%) interviewed in Kandi, and in Abomey-Bohicon (43.3%) are between 36 and 55 years old, while the majority (46.7%) in Savalou are less than 35 years old. Peanut production is done mostly by men in Kandi (63.3%), Savalou (100%), and in Abomey-Bohicon (54.4%). A large number of peanut producers in Benin have not received any formal education, and have never heard of aflatoxin contamination of peanut. When they were asked if they got sick by ingestion of aflatoxin contaminated peanut, most of the respondents' answers were negative. Of 90 farmers interviewed in Benin, about 95.6% dry peanut immediately after harvesting, and only 10% sort peanut before selling. However, 90% refuse to sort peanut because not only it is time consuming but also, it reduces peanut quantity by 5 percent on average. Nevertheless, when peanut samples were tested for aflatoxin, results indicated that 91.5% of the samples tested were below the European standard (4 ppb), and only 8.5% were above that limit. About 93.2% of the samples were less than 15 ppb and 6.8% were greater than 15 ppb. Very few samples (3.4%) exceeded the W.H.O standards (20 ppb).

Further, farming practices were observed. Like Hell et al. (2003) reveal, aflatoxin is reduced by pre-harvest and post-harvest factors. During the survey, most farmers stated that drying of peanut was done immediately after harvest. However, the decision to sorting peanut was taken by very few respondents. In many studies, sorting has been suggested as an efficient method to control aflatoxin development in peanut. In addition, another factor that needs to be highlighted is storage condition. Growth of storage fungi followed by aflatoxin production is also determined by storage structure and storage length. Plastic bags or other synthetic bags used mostly by farmers during storage promote increased humidity, and hence, increase in aflatoxin levels. Since aflatoxin contamination in storage is dependent on the storage system, the solution would be to sort peanut during storage.

Results from enterprise budgets show that aflatoxin reduces farmers 'net returns. Sorting of peanut results in higher labor costs and smaller net returns than the costs and returns generated when farmers do not sort peanut. Net returns per hectare after sorting peanut were reduced to $532.7 in Kandi, $423.2 in Savalou, and $261.03 in Abomey-Bohicon. Net returns were higher for Kandi which is the most productive region.

Results also demonstrate that aflatoxin, increasing with length of storage, lowers revenue from peanut production. After 6 months of storage, farmers' net revenues decrease due to lower peanut quality. This result confirms Hell (2000) study who found that aflatoxin was higher after 6 months of storage than at the beginning of storage. It is evident that storage conditions have a significant impact on aflatoxin development. Assuming consumers are aware of poorer peanut quality resulting from storage, they will ask for a lower price. Moreover, in the risk analysis results, we note a significant relation between net returns and price, and also a negative relationship between net returns and sorting when farmers sort peanut. This finding confirms that sorting causes economic losses to peanut producers who want to improve quality. Hence to compensate for their losses due to costs of sorting, producers have to increase price to cover at least their variable costs.

Although investigations in this study indicate that it is more profitable for farmers to sell peanut immediately after harvest than to sort it before, the solution would be to improve farming practices and management, storage conditions, increase price in order to improve peanut quality and minimize risk of losses from aflatoxin. Improvements of quality and higher prices are obtainable with government legislations, and consumer and producer education.

TABLES

Table 1.1. Socio-demographics characteristics of peanut producers in Kandi, Savalou and Abomey-Bohicon.

	Kandi		Savalou		Abomey-Bohicon	
	Number	%	Number	%	Number	%
Age groups						
Under 35	8	26.7	14	46.7	8	26.7
36-55	20	66.7	9	30.0	38	43.3
over 55	2	6.7	7	23.3	8	26.7
Gender						
Female	11	36.7	0	0	5	45.6
Male	19	63.3	30	100	25	54.4
Education						
No formal education	17	56.7	23	76.7	19	63.3
Primary school	13	43.3	7	23.3	11	36.7
Secondary school	5	16.7	1	3.3	2	6.7
Years of experience						
0-15	9	30.0	16	53.3	7	23.3
16-30	14	46.7	6	20.0	7	23.3
Over 30	7	23.3	8	26.7	16	53.3
Land tenure						
Owner	26	86.7	18	60.0	5	16.7
Renter	4	13.3	5	16.7	25	83.3
Income levels (month)						
$0-$350.14	10	33.3	13	43.3	18	60.0
$350.14 - $700.28	3	10.0	15	50.0	9	30.0
$700.28 - $1,400.56	10	33.3	2	6.7	2	6.7
Over $1,400.56	7	23.3	0	0.0	1	3.3

-Income level are monthly income per ha

Table 1.2. Producers report sickness related to aflatoxin in three regions of Benin, 2007.

Region	Yes		No	
	Number	%	Number	%
Kandi	25	27.8	65	72.2
Savalou	39	43.3	51	56.7
Abomey	43	47.8	47	52.2

Table 1.3. Farmers' characteristics

Item	Yes		No	
	Number	**%**	**Number**	**%**
Farmers (N = 90 per region)				
Agronomic practices				
Dry peanut after harvesting	86	95.6	4	4.4
Sort peanut	9	10.0	81	90.0
Consume bad* grains	0	0.0	90	100.0
Give bad* grains to your animal	10	10.0	80	90.0

*Bad : discolored or contaminated
-Source: survey data

Table 1.4. Distribution of aflatoxin level for farmers based on standards (%).

Aflatoxin limit	European standards 4 ppb	USA standards 15 ppb	WHO standards 20 ppb	Animal standards 100 ppb
Less than	91.5	93.2	96.6	98.3
Greater than	8.5	6.8	3.4	1.7

-source: analysis of marketed peanut

Table 1.5.1. Estimated annual costs and returns budget for each type of farm in Kandi, using the following peanut production practices

-Planting in May
-45 kg of seed per ha
-Harvesting in September
-Sell unshelled and by bag of 100 kg
-Sell in local markets
-Straight line method for depreciation

Farm type:	**Small**	**Medium**	**Large**
	Value	Value	Value
Revenue			
Sale of peanut (1 kg @ $0.42)	**$315.13**	**$945.38**	**$3,151.26**
Variable costs			
Seed (1 kg @ $0.45)	$10.16	$30.49	$101.63
Labor (hrs)	$29.11	$87.34	$291.14
Material and Equipment (each)	$4.20	$12.08	$39.39
Total variable costs	$43.48	$129.91	$432.16
Income above variable costs	$271.65	$815.47	$2,719.10
Fixed costs			
Repair and maintenance	$0.50	$1.50	$5.00
Depreciation equip.	$0.64	$0.99	$4.06
Total fixed costs	$1.14	$2.49	$9.06
Total costs	$44.62	$132.40	$441.22
Net returns above all expenses	**$270.50**	**$812.98**	**$2,710.04**
Break-even price (per kg sold)			
to cover variable expenses	$0.06	$0.06	$0.06
to cover total expenses	$0.06	$0.06	$0.06

-Yields and prices come from survey data.
-Costs and returns are based on per-hectare enterprise budgets displayed on appendix 1.6.1.
-Total area for small farms is 0.5 ha, 1.5 ha for medium farms and 3 ha for large farms.
-Material and Equipment is physical resource used in the farm operation (appendix 1.1). They are renewed every year.

Table 1.5.2. Estimated costs and returns budget for each type of farm in Savalou, using the following peanut production practices

-Planting in April	-Sell unshelled and by bag of 100 kg
-15 kg of seed per ha	-Sell in local markets
-Harvesting in August	-Straight line method for depreciation

Farm type:	**Small**	**Medium**	**Large**
	Value	Value	Value
Revenue			
Sale of peanut (1kg @ $0.42)	**$756.30**	**$1,260.50**	**$2,521.01**
Variable costs			
Seed (1 kg @ $0.45)	$10.16	$16.94	$33.88
Labor (hrs)	$87.34	$145.37	$291.14
Material and Equipment (each)	$9.45	$15.76	$31.51
Total variable costs	$106.96	$178.27	$356.53
Income above variable costs	$649.34	$1,082.24	$2,164.48
Fixed costs			
Repair and maintenance	$1.50	$2.50	$5.00
Depreciation equip.	$0.47	$0.58	$2.65
Total fixed costs	$1.97	$3.08	$7.65
Total costs	$108.93	$181.35	$364.18
Net returns above all expenses	**$647.37**	**$1,079.16**	**$2,156.83**
Break-even price (per kg sold)			
to cover variable expenses	$0.06	$0.06	$0.06
to cover total expenses	$0.06	$0.06	$0.06

-Yields and prices come from survey data.
-Costs and returns are based on per-hectare enterprise budgets displayed on appendix 1.6.2
-Total area for small farms is 1.5 ha, 2.5 ha for medium farms and 3 ha for large farms.
-Material and Equipment is physical resource used in the farm operation (appendix 1.1).

Table 1.5.3. Estimated costs and returns budget for each type of farm in Abomey-Bohicon, using the following peanut production practices

-Planting in March (end)
-10 kg of seed per ha
-Harvesting in July
-Sell unshelled and by bag of 100 kg
-Sell in local markets
-Straight line method for depreciation

Farm type:	**Small**	**Medium**	**Large**
	Value	Value	Value
Revenue			
Sale of peanut (1kg @ $0.42)	**$168.07**	**$403.36**	**$1,680.67**
Variable costs			
Seed (1 kg @ $0.45)	$2.26	$5.42	$22.58
Labor (hrs)	$29.11	$69.87	$291.14
Material and Equipment (each)	$2.10	$5.25	$21.01
Total variable costs	$33.47	$80.55	$334.73
Income above variable costs	$134.59	$322.82	$1,345.94
Fixed costs			
Repair and maintenance	$0.50	$1.20	$5.00
Depreciation equipment	$0.64	$0.64	$3.38
Total fixed costs	$1.14	$1.84	$8.38
Total costs	$34.62	$82.39	$343.11
Net returns above all expenses	**$133.45**	**$320.97**	**$1,337.56**
Break-even price (per kg sold)			
to cover variable expenses	$0.084	$0.084	$0.084
to cover total expenses	$0.09	$0.09	$0.09

-Yields and prices come from survey data.
-Costs and returns are based on per-hectare enterprise budgets displayed on appendix 1.6.3
-Total area for small farms is 0.5 ha, 1.2 ha for medium farms and 3 ha for large farms.
-Material and Equipment is physical resource used in the farm operation (appendix 1.1).

Table 1.6-Estimated cost and returns budget (average peanut farms) per region Assuming that there is no change in price when farmers sort peanut.

	Kandi		Savalou		Abomey	
	Not sorted	Sorted	Not sorted	Sorted	Not sorted	Sorted
Average farm size (ha)	1.50		2.50		1.20	
Yield (Kg)	2,250	2,227.50	3,000	2,970	960	950
Revenue ($)	945.38	935.92	1,260.50	1,247.90	403.36	399.33
Labor costs ($)	87.34	92.07	145.57	153.45	69.87	73.66
Total variable costs ($)	129.91	134.64	178.27	186.14	80.55	84.33
Total fixed costs ($)	2.49	2.49	3.08	3.08	1.84	1.84
Income above variable costs ($)	815.47	801.29	1,082.24	1,061.76	322.82	315.00
Net returns ($)	812.98	798.80	1,079.16	1,058.67	320.97	313.16
Break-even price ($/kg)	0.06	0.06	0.06	0.06	0.09	0.09
NPV (6%)	8,568	8,418	11,355	11,139	3,374	3,292
PI (6%)	1,050.25	1,031.97	2,513.78	2,465.98	626.91	611.65
IRR	94.17	92.53	22.33	21.89	56.24	54.87

-results per hectare are shown in appendix 1.9.

Table 1.7- Storage impact on average peanut farms in each agro-ecological region.

	Kandi (1.5 ha)	Savalou (2.5 ha)	Abomey (1.2 ha)
Revenue ($)	853.20	1,137.61	364.03
Income above variable costs ($)	719.09	951.99	279.71
Net returns ($)	716.60	948.90	277.86
NPV (6%)	7,568	9,992	2,923
IRR	83.20	19.62	48.74

-Assuming that after 6 months peanut quality worsen, resulting in a lower price P1
-Peanut price decrease from $0.42 to $0.40 per kg.
-Results in this table are compared to the results in table 1.6

Table 1.8. Sensitivity analysis for average peanut farms gross margins, assuming that price varies through sorting and storage.

Table 1.8.1 Sensitivity analysis for peanut budget by changing price and the effect on revenue, net returns, and NPV (1.5 ha farm in Kandi)

Storage time (months)	Change in price %	Price ($/kg)	Quantity (kg)	Revenue ($)	Net returns ($)	NPV ($ @ 6%)
0-2	15	0.48	2,227.5	1,076.31	939.19	9,851
2-4	10	0.46	2,205.0	1,019.12	881.99	9,264
4-6	5	0.44	2,182.5	962.87	826.27	8,693
6-8	-5	0.40	2,137.5	853.20	716.60	7,568
8-10	-10	0.38	2,115.0	799.79	663.19	7,021
10-12	-15	0.36	2,092.5	747.32	611.25	6,489

Table 1.8.2 Sensitivity analysis for peanut budget by changing price and the effect on revenue, net returns, and NPV (2.5 ha farm in Savalou)

Storage time (months)	Change in price %	Price ($/kg)	Quantity (kg)	Revenue ($)	Net returns ($)	NPV (4%)
0-2	15	0.48	2,970	1,435.08	1,245.86	13,084
2-4	10	0.46	2,940	1,358.82	1,169.60	12,290
4-6	5	0.44	2,910	1,283.82	1,094.60	11,509
6-8	-5	0.40	2,850	1,137.61	948.90	9,992
8-10	-10	0.38	2,820	1,066.39	877.69	9,250
10-12	-15	0.36	2,790	966.43	808.25	8,528

Table 1.8.3 Sensitivity analysis for peanut budget by changing price and the effect on revenue, net returns, and NPV (1.2 ha farm in Abomey)

Storage time (months)	Change in price %	Price ($/kg)	Quantity (kg)	Revenue ($)	Net returns ($)	NPV (4%)
0-2	15	0.48	950.40	459.23	373.05	3,915
2-4	10	0.46	940.80	434.82	348.65	3,660
4-6	5	0.44	931.20	449.95	363.78	3,817
6-8	-5	0.40	912.00	364.03	277.86	2,923
8-10	-10	0.38	902.40	341.24	255.07	2,686
10-12	-15	0.36	892.80	318.86	233.22	2,458

Figures

Figure 1.3. Tornado graphs of the net returns of peanut production in each region, assuming that peanut is not sorted before marketing.

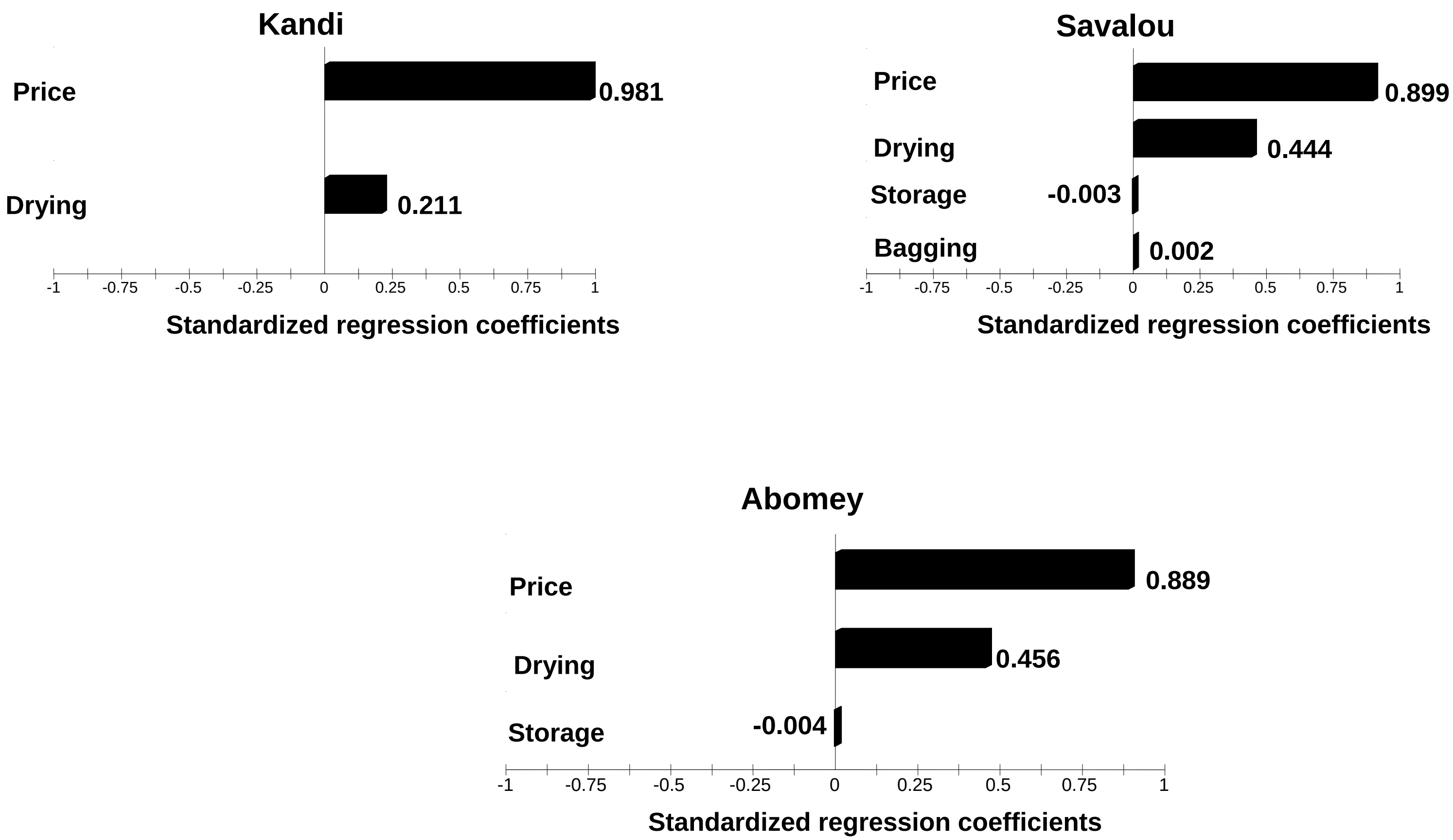


Figure 1.4. Tornado graphs of the net returns of peanut production in each region, assuming that peanut is sorted before marketing.

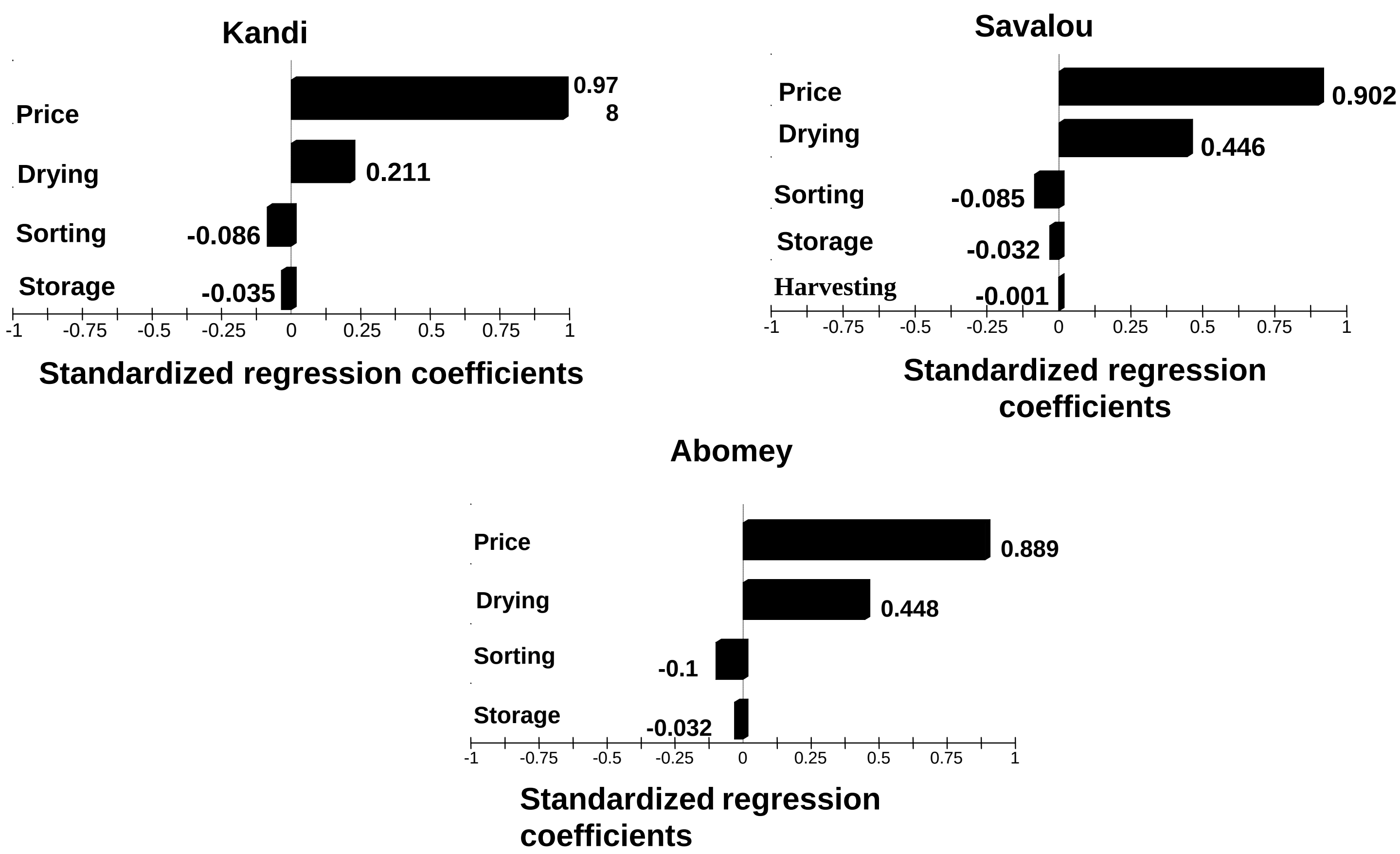


Figure 1.5. Cumulative probability distribution of the net present value discounted at 6%, for sorted peanut in Kandi, Savalou and Abomey-bohicon.

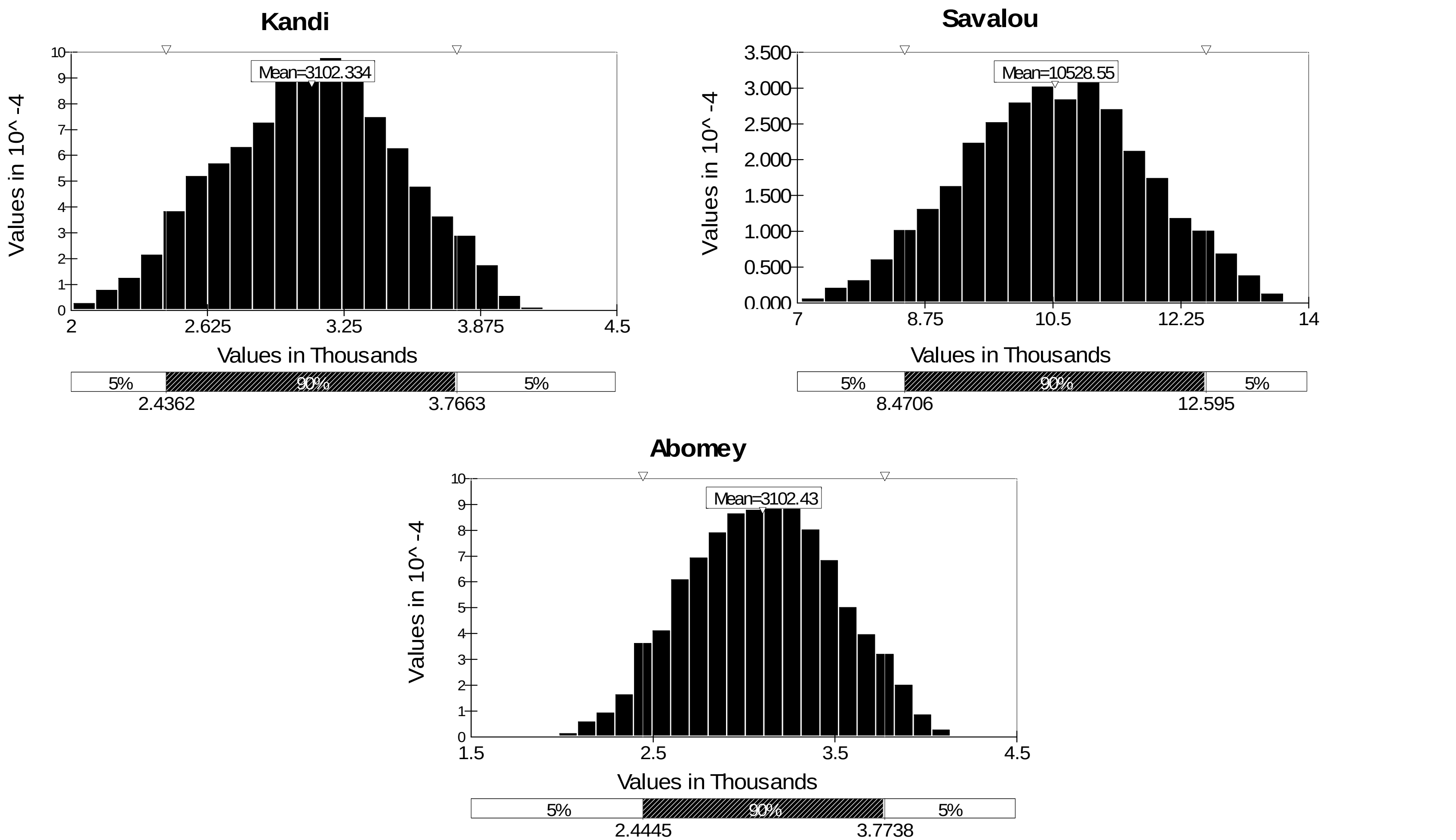


Figure 1.6. Cumulative probability distribution of the net present value for non-sorted and sorted peanut.

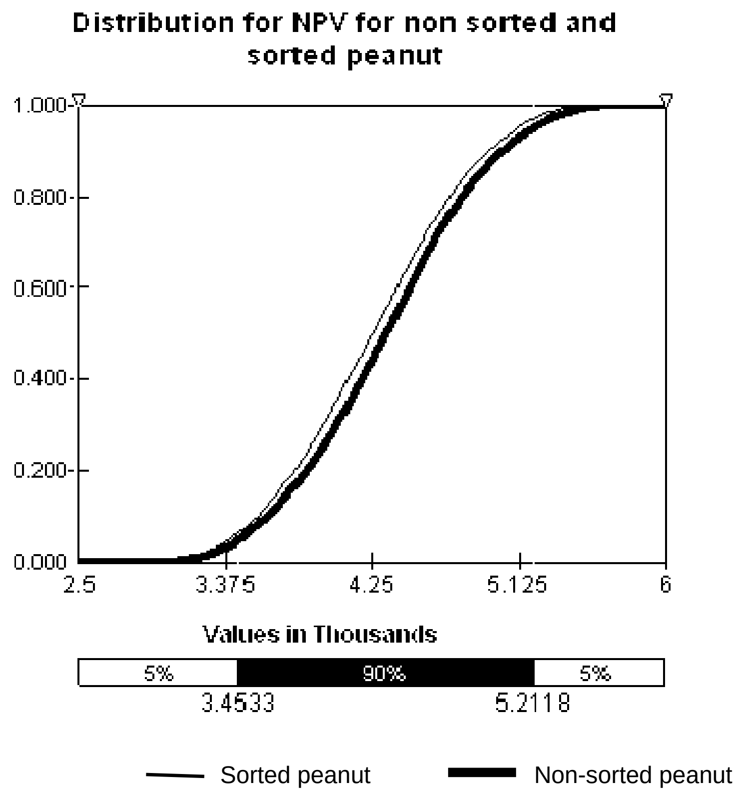


Figure 1.7. Cumulative probability distribution of the net present value for sorted and non-sorted peanut at varying prices according storage time (no change, 5% increase).

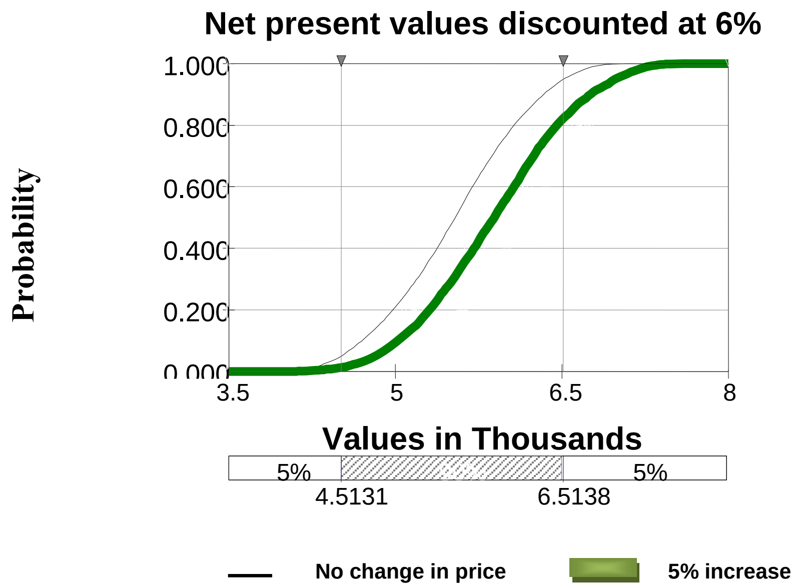
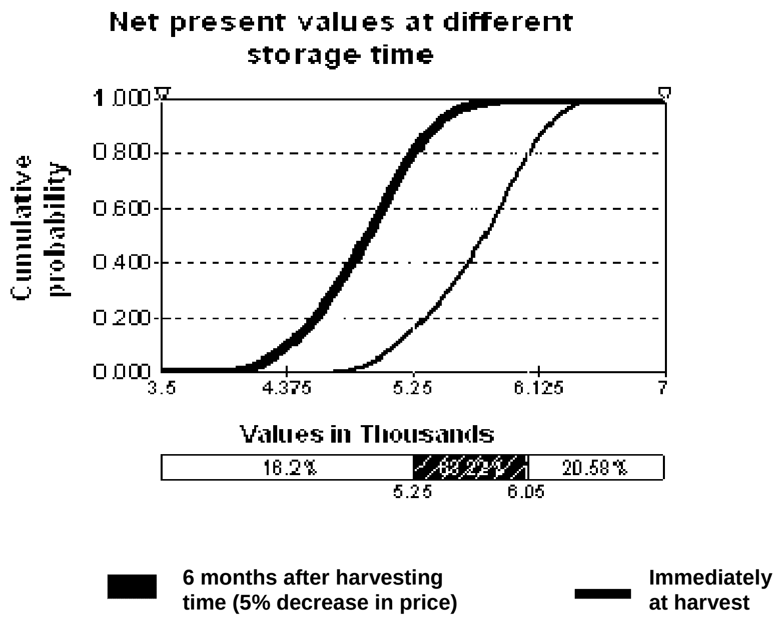


Figure 1.8. Cumulative probability distribution of the net present value for stored peanut at harvest and six months later.



APPENDIX

Appendix 1.1: Material and equipment used for peanut production for a one-hectare farm in Benin (Kandi)

	Unit	Quantity	Price/unit	Useful life
Animal for traction	Head	0	$8.40	10
Bags	Each	15	$0.53	1
Cutlass	Each	2	$1.05	7
Hoe	Each	2	$0.55	5
Plow	Each	2	$0.42	20
Storage buildings	Each	1	$1.68	20
Tractor	Each	0	$0.42	10

Source: survey data

Appendix 1.2: Depreciation of material and equipment using the straight line method

Year	1	2	3	4	5	6	7	8	9	10
Animal for traction	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Cutlass	$0.30	$0.30	$0.30	$0.30	$0.30	$0.30	$0.30	$0.30	$0.30	$0.30
Hoe	$0.22	$0.22	$0.22	$0.22	$0.22	$0.22	$0.22	$0.22	$0.22	$0.22
Plow	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04	$0.04
Storage buildings	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08
Tractor	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total	**$0.64**	**$0.64**	**$0.64**	**$0.64**	**$0.64**	**$0.64**	**$0.64**	**$0.64**	**$0.64**	**$0.64**

-Measures for equipment are per hectare
-Bags are considered as variable costs because farmers reported that they renew their bags every year.

Appendix 1.3: Cash flow budget for peanut production (10 years)

	Year →	1	2	3	4	5	6	7	8	9	10
Cash Farm Income:											
Sale peanut		$630.25	$630.25	$630.25	$630.25	$630.25	$630.25	$630.25	$630.25	$630.25	$630.25
Total Cash Income		**$630.25**	**$630.25**	**$630.25**	**$630.25**	**$630.25**	**$630.25**	**$630.25**	**$630.25**	**$630.25**	**$630.25**
Cash Farm Expenses											
Operating Expenses		$86.66	$86.66	$86.66	$86.66	$86.66	$86.66	$86.66	$86.66	$86.66	$86.66
Borrowed Operating Expenses		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Interest on Borrowed Op Exp		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Interest on Operating Expenses (6%)		**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
Interest on Principal (6%)		**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
Total Cash Expenses		**$86.66**	**$86.66**	**$86.66**	**$86.66**	**$86.66**	**$86.66**	**$86.66**	**$86.66**	**$86.66**	**$86.66**
Net Cash Farm Income		**$543.59**	**$543.59**	**$543.59**	**$543.59**	**$543.59**	**$543.59**	**$543.59**	**$543.59**	**$543.59**	**$543.59**
Non-cash Adjustments:											
Depreciation		**$0.64**	**$0.64**	**$0.64**	**$0.64**	**$0.64**	**$0.64**	**$0.64**	**$0.64**	**$0.64**	**$0.64**
Net Farm Income		**$542.95**	**$542.95**	**$542.95**	**$542.95**	**$542.95**	**$542.95**	**$542.95**	**$542.95**	**$542.95**	**$542.95**

-Cash flow budget for peanut production (cont')

	Year →	1	2	3	4	5	6	7	8	9	10
Material and Equipment		$5.71	$0.00	$0.00	$0.00	$0.00	$1.09	$0.00	$2.10	$0.00	$0.00
Borrowed material and Equip		**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
Repayment		**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
Borrowed Capital (Principal)		**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
Cash Value (income-debt)		**$543.59**	**$543.59**	**$543.59**	**$543.59**	**$543.59**	**$543.59**	**$543.59**	**$543.59**	**$543.59**	**$543.59**
Assets		$5.07	$4.42	$3.78	$3.14	$2.49	$2.94	$2.29	$3.75	$3.11	$2.46
Net Value (cash value after liquidating assets)		**$548.66**	**$548.02**	**$547.37**	**$546.73**	**$546.08**	**$546.53**	**$545.89**	**$547.34**	**$546.70**	**$546.05**
Total Cash Outflow		**$92.37**	**$86.66**	**$86.66**	**$86.66**	**$86.66**	**$87.75**	**$86.66**	**$88.76**	**$86.66**	**$86.66**
Net Cash Flow		**$537.88**	**$543.59**	**$543.59**	**$543.59**	**$543.59**	**$542.50**	**$543.59**	**$541.49**	**$543.59**	**$543.59**

Appendix 1.4: Capital budget for peanut production over 10 years

	Rate	Kandi	Savalou	Abomey-Bohicon
NPV	15%	$2,923	$2,320	$1,437
PI	15%	589.33	629.61	290.24
NPV	13%	$3,331	$2,643	$1,638
PI	13%	659.65	704.83	324.87
NPV	10%	$4,126	$3,275	$2,030
PI	10%	795.32	849.95	391.68
NPV	6%	$5,714	$4,536	$2,811
PI	6%	1,060.88	1,134.02	522.46
IRR		9,513%	10,076%	4,688%

Appendix 1.5. Definition of parameters (inputs) used for risk models.

Parameters	Unit	Risk function
Price (selling)	$	RiskTriang (0.32,0.42, 0.51)
Drying: No (0), Yes (1)	-	RiskDiscrete ({0,1},{0.044,0.956})
Sorting : No (0), Yes (1)	-	RiskDiscrete ({0,1},{0.04,0.96})
Storage	Month	RiskTriang (0, 2, 4)
Pre-harvest cost	$	RiskTriang (50, 52.5, 55)
Harvest cost	$	RiskTriang (1, 2, 3.5)
Drying costs	$	RiskTriang (0, 1.58, 3)
Sorting cost	$	RiskTriang (0, 3.15, 6.5)
Bagging cost	$	RiskTriang (0.5, 1.4, 2.5)
Transportation cost	$	RiskTriang (0.1, 0.5, 1.5)

Appendix 1.6.1: Budget for producing peanut using one hectare land and 45 kg of seed per hectare, based on the decision that farmers do not sort peanut (Kandi).

* Planting in May
* 45 kg of seed per ha
* Harvesting in September
* Sell unshelled and by bag of 100 kg
* Sell in local markets
* Straight line method for depreciation

	Unit	Quantity	Price	Value
Revenue				
Peanut	kg	1,500.00	$0.42	**$630.25**
Variable costs				
Seed	kg	45.00	$0.45	$20.33
Labor	hrs	52.50		$58.23
Material and Equipment	Each			$7.88
Interest on oper. Cap	6%			$0.00
Total variable costs	$			**$86.43**
Income above variable costs	**$**			**$543.82**
Fixed costs				
Repair and maintenance	$			$1.00
Depreciation equip.	$			$0.64
Total fixed costs	$			**$1.64**
Total costs	**$**			**$88.08**
Net returns above all expenses	**S**			**$542.18**
Break-even price (per kg sold)				
to cover variable expenses	$			$0.06
to cover total expenses	$			$0.06

Quantities and prices come from survey data.

Appendix 1.6.2. Budget for producing peanut using one hectare land and 45 kg of seed per hectare, based on the decision that farmers do sort peanut (Kandi).

* Planting in May
* 45 kg of seed per ha
* Harvesting in September
* Sell unshelled and by bag of 100 kg
* Sell in local markets
* Straight line method for depreciation

	Unit	Quantity	Price	Value
Revenue				
Peanut	kg	1,485.00	$0.42	**$623.95**
Variable costs				
Seed	kg	45.00	$0.45	$20.33
Labor	hrs	55.00		$61.38
Material and Equipment	each			$7.88
Interest on oper. Cap	6%			$0.00
Total variable costs	**$**			**$89.58**
Income above variable costs				**$534.37**
Fixed costs	$			
	$			
Repair and maintenance				$1.00
Depreciation equip.	$			$0.64
Total fixed costs	**$**			**$1.64**
Total costs	**$**			**$91.23**
Net returns above all expenses	**$**			**$532.72**
Break-even price (per kg sold)				
to cover variable expenses	$			$0.06
to cover total expenses	$			$0.06

Quantities and prices come from survey data

Appendix 1.7.1: Budget for producing peanut using one hectare land and 45 kg of seed per hectare, farmers do not sort peanut (Savalou)

* Planting in April
* 15 kg of seed per ha
* Harvesting in August
* Sell unshelled and by bag of 100 kg
* Sell in local markets
* Straight line method for depreciation

	Unit	Quantity	Price	Value
Revenue				
Peanut	kg	1,200.00	$0.42	**$504.20**
Variable costs				
Seed	kg	15.00	$0.45	$6.78
Labor	hrs	52.50		$58.23
Material and Equipment	each			$6.30
Interest on oper. Cap	6%			$0.00
Total variable costs	$			**$71.31**
Income above variable costs	$			**$432.90**
Fixed costs				
Repair and maintenance	$			$1.00
Depreciation equip.	$			$0.47
Total fixed costs	$			**$1.47**
Total costs	**$**			**$72.78**
Net returns above all expenses	**$**			**$431.42**
Break-even price (per kg sold)				
to cover variable expenses	$			$0.06
to cover total expenses	$			$0.06

Quantities and prices come from survey data

Appendix 1.7.2: Budget for producing peanut using one hectare land and 45 kg of seed per hectare, farmers do not sort peanut (Savalou)

* Planting in April
* 15 kg of seed per ha
* Harvesting in August
* Sell unshelled and by bag of 100 kg
* Sell in local markets
* Straight line method for depreciation

	Unit	Quantity	Price	Value
Revenue				
Peanut	Kg	1,188.00	$0.42	**$499.16**
Variable costs				
Seed	kg	15.00	$0.45	$6.78
Labor	hrs	55.00		$61.38
Material and Equipment	each			$6.30
Total variable costs	$			**$74.46**
Income above variable costs	$			**$424.70**
Fixed costs	$			
Repair and maintenance	$			$1.00
Depreciation equip.	$			$0.47
Total fixed costs	$			**$1.47**
Total costs	**$**			**$75.93**
Net returns above all expenses	$			**$423.23**
Break-even price (per kg sold)				
to cover variable expenses	$			$0.063
to cover total expenses	$			$0.064

Quantities and prices come from survey data

Appendix 1.8.1; Budget for producing peanut using one hectare land, 18kg of seed per hectare and based on the decision of not sorting (Abomey-Bohicon)

* Planting in March (end)
* 10 kg of seed per ha
* Harvesting in July
* Sell unshelled and by bag of 100 kg
* Sell in local markets
* Straight line method for depreciation

	Unit	Quantity	Price	Value
Revenue				
Peanut	Kg	800.00	$0.42	**$336.13**
Variable costs				
Seed	kg	10.00	$0.45	$4.52
Labor	hrs	52.50		$58.23
Material and Equipment	each			$4.20
Interest on oper. Cap	6%			$0.00
Total variable costs	$			**$66.95**
Income above variable costs	$			**$269.19**
Fixed costs				
Repair and maintenance	$			$1.00
Depreciation equip.	$			$0.64
Total fixed costs	$			**$1.64**
Total costs	$			**$68.59**
	$			
Net returns above all expenses	$			**$267.54**
	$			
Break-even price (per kg sold)				
to cover variable expenses	$			$0.08
to cover total expenses	$			$0.09

Quantities and prices come from survey data

Appendix 1.8.2: Budget for producing peanut using one hectare land, 18kg of seed per hectare and based on the decision of sorting (Abomey)

* Planting in March (end)
* 10 kg of seed per ha
* Harvesting in July
* Sell unshelled and by bag of 100 kg
* Sell in local markets
* Straight line method for depreciation

	Unit	Quantity	Price	Value
Revenue				
Peanut	kg	792.00	$0.42	**$332.77**
Variable costs				
Seed	kg	10.00	$0.45	$4.52
Labor	hrs	55.00		$61.38
Material and Equipment	$			$4.20
Interest on oper. Cap	6%			$0.00
Total variable costs				**$70.10**
Income above variable costs	$			**$262.68**
Fixed costs	$			
Repair and maintenance	$			$1.00
Depreciation equip.	$			$0.64
Total fixed costs	$			**$1.64**
Total costs	$			**$71.74**
Net returns above all expenses	$			**$261.03**
Break-even price (per kg sold)				
to cover variable expenses	$			$0.09
to cover total expenses	$			$0.09

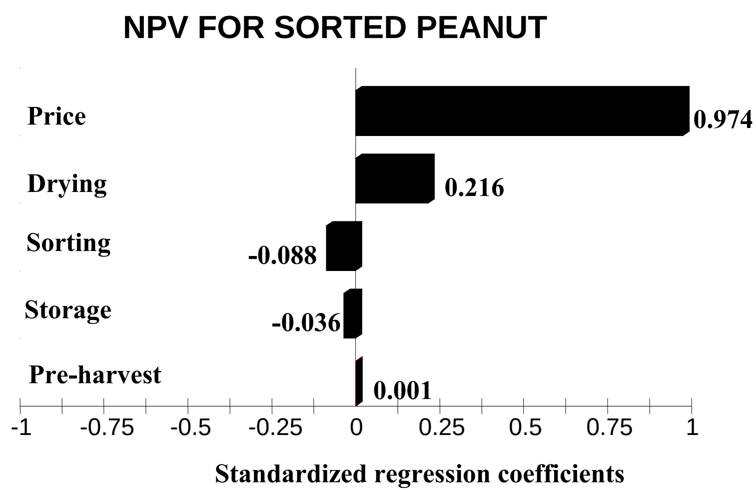
Quantities and prices come from survey data

Appendix 1.9-Estimated cost and returns budget (per hectare) per region

	Kandi		Savalou		Abomey	
	Not sorted	Sorted	Not sorted	Sorted	Not sorted	Sorted
Quantity (Kg)	1,500.00	1,485.00	1,200.00	1,188.00	800.00	792.00
Revenue ($)	630.25	623.95	504.20	499.16	336.13	332.77
Labor costs ($)	58.23	61.38	58.23	61.38	58.23	61.38
Total variable costs ($)	86.43	89.58	71.31	74.46	66.95	70.10
Total fixed costs ($)	1.64	1.64	1.47	1.47	1.64	1.64
Income above variable costs ($)	543.82	534.37	432.90	424.70	269.19	262.68
Net returns ($)	542.18	532.72	431.42	423.23	267.54	261.03
Break-even price ($/kg)	0.06	0.06	0.06	0.06	0.08	0.09
NPV (6%)	5,714	5,614	4,536	4,450	2,811	2,743
PI (6%)	1,060	1,042.42	1,134.02	1,112.44	522.46	509.75
IRR	95.13	93.47	10.08	98.79	46.88	45.74

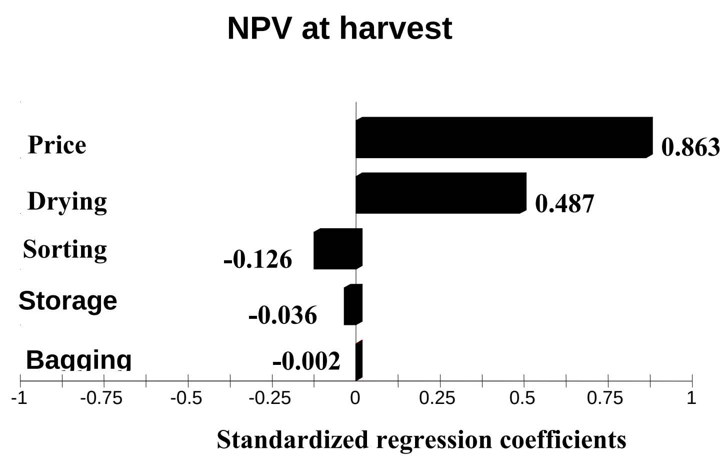
Assuming after there is no change in price when farmers sort peanut

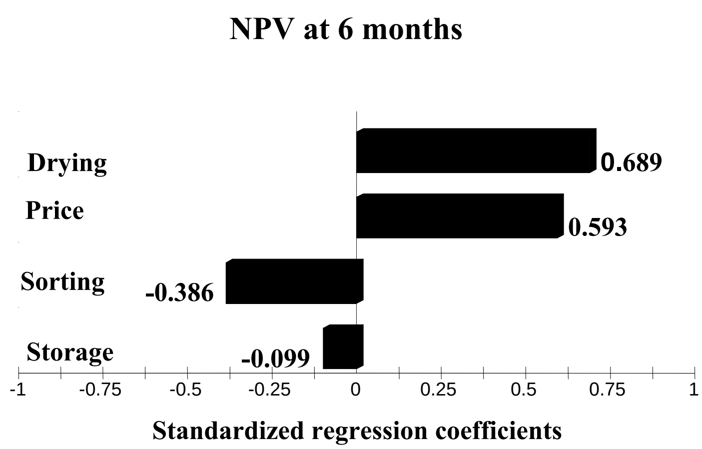
Appendix 1.10. Cumulative distribution of the net present value of peanut production; assuming that peanut is sorted before marketing.



Appendix 1.11. Tornado graphs for net present values when peanut are sorted immediately after harvest time and 6 months after harvest.

Assumptions: there is 5% increase in price for peanut sorted at harvest and 5% decrease in price when peanut are sorted 6 months after harvest.





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CHAPTER II: RISK OF AFLATOXIN CONTAMINATION ON MARKETING OF PEANUT IN BENIN

1. Introduction

Aflatoxin contamination of peanut (Arachis Hypogea L.) is a risk to human and animal health (Fandohan et al., 2005). It is identified as a major constraint to peanut trade in Africa (Lubulwa and Davis, 1994). According to Latha et al. (2007), aflatoxin reduces peanut quality and poses economic and trade problems at almost all stages of peanut marketing, especially during export.

Peanut is one of the most important food and cash crops in Benin; most of the peanuts produced in Benin are traded locally. Peanut in Benin is produced by small-scale farmers under poor farming conditions. A large percentage of the peanuts produced are contaminated with aflatoxin at post-harvest. Factors associated to high levels of aflatoxin contamination are handling, storage (Hell et al., 2003), temperature and moisture (Diener et al., 1987).

In Benin, and most tropical countries, peanut is one of the major crops contaminated by aflatoxins (Kaaya and Warren, 2005). Hell et al. (2000) also revealed that aflatoxins constitute a serious problem for many agricultural commodities. Results show a significant correlation between aflatoxin and factors such as storage of maize for 3 to 5 months, insect damage and use of local plants as storage protectants. Likewise, Lewis et al. (2005) indicated that fifty-five percent of maize products had aflatoxin levels exceeding the Kenyan regulatory limit of 20 ppb, thirty-five percent had levels greater than 100 ppb, and seven percent had levels greater than 1,000 ppb. Kpodo and Bankole (2008) linked aflatoxin contamination with poor farming practices and inadequate storage structure in developing countries including Benin. Given the warm and humid climate, and inappropriate storage conditions existing in Benin, a rapid increase in aflatoxin growth in food crops, such as peanut, maize and other cereals has been noted. When ingested at large doses, such aflatoxin contaminated foods can become a threat to human health.

The agricultural sector in Benin, as in most developing countries, faces problems like inadequate storage, poor transportation, and insufficient use of fertilizer or insecticide. Aflatoxin contamination of peanut and grain is often frequent at various marketing stages, especially at storage and processing. Hence, it is important to examine the economic effects of aflatoxin contamination at the marketing stages of peanut.

The main objective in this paper is to evaluate the effect of aflatoxin on the peanut marketing chain in three different production zones in Benin.

It has been shown that food contamination occurs mostly during post-harvest handling (Awuah, 2000). Hence it is important to investigate the effects of aflatoxin contamination on processing and storing peanut. What marketers would like to know is “should I buy sorted or non-sorted peanut to sell? Under what conditions should I store peanut and how long should storage be?

Our hypotheses are based on the assumption that sorting improves the quality of peanut, risk and net revenue of peanut. (1) The returns and risks from selling of peanut are influenced on who bears the costs of sorting peanut. (2) The purchase of sorted peanut influences the net returns and risk from peanut selling and processing; (3) the condition and length of storage influence net returns and risk from peanut sales.

2. Methodology

2.1.Sample and survey questionnaires

Data for this study were collected through face to face survey administered to a total of 15 traders, 15 stockers and 30 processors in each of the three ecological zones of Benin: Kandi, (North), Savalou (South-east) and Abomey-Bohicon (South).

As we already stated in chapter I, market participants were identified through the assistance of agricultural officers in the Ministry of Food and Agriculture (MoFA) and through the help of personnel from the University of Abomey-Calavi, Republic of Benin. Market participants were individually interviewed on their crop handling, sorting, storing practices and household revenues. Moreover, information on the economic and financial aspects of processing, storage, and marketing of peanut were also collected.

Peanut samples were collected under different processing and storage conditions. Aflatoxin levels in contaminated peanut under market participants' storage and marketing conditions were determined.

2.2.Data analysis

Survey data were analyzed using SAS software package version 9.1. The survey results were used to develop enterprise budgets for selling, storing and processing peanut. Furthermore, @RISK software was needed to simulate the risk of aflatoxin contamination on market participants' income from the storage, processing and trading of peanut. Parameters used for @risk are defined in appendix 1.

3. Results

3.1.Socio-demographics results

In this section, the socioeconomic and demographic characteristics of market participants (vendors, processors and stockers) are discussed by region.

3.1.1. Age

The range of ages for all the market participants is from 35 to 55 years.

Vendors: Table 2.1 indicates that 53.3% of vendors in Kandi are less than 35 years old, 33.3% are between 36 and 55 years and only 13.3% are greater than 55 years old. In Savalou, most of the vendors (53.3%) are between 36 and 55 years while 46.7% are over 55 years. About 20% in Abomey are under 35 years old, 73.3% between 36 and 55 years and only 6.7% are older (over 55 years).

Processors: The majority of all the respondents in Kandi (53.8%), Savalou (42.3%) and Abomey (65.4%) are between 36 and 55 years old. About 46.2% of the processors in Kandi, 19.2% in Savalou and 23.1 are 35 years old between 36 and 55 years, while 33.3% in Kandi are over 55 years old. In Abomey, 26.7% are under 35 and 13.3% are over 55 years old.

Stockers: In Kandi, most of the respondents (46.7%) are less than 35 years old, with 33.3% age between 36 and 55 years old and 20% older than 55 years old. In Savalou, 66.7% are between 36 and 55 years old and only 33.3% are greater than 55 years old. About 26.7% of the stockers are less than 35 years old, while most of them (60%) are between 36 and 55 years, and only 13.3% are over 55 years old.

3.1.2. Gender

Vendors: The majority of all the vendors in Kandi (66.7%), Savalou (100%) and Abomey (66.7%) are women (Table 2.1). Very few men trade peanut in Benin.

Processors: Survey results indicate that only women transform and sell peanut.

Stockers: Similar results are found in Savalou, where all the stockers are women. However, in Kandi and Abomey, 53.3% of the respondents in each region are men.

3.1.3. Education

A large number of the respondents in each region are illiterate.

Vendors: About 80% of the respondents in Kandi, 66.7% in Savalou and Abomey have no formal education (table 2.1). However, 13.3% in Kandi, 26.7% in Savalou and Abomey attended primary school, and only 6.7% in Savalou and Abomey completed secondary school.

Processors: Similar results are found for the processors in each region. The majority did not receive any formal education. Approximately 65.4% in Kandi and Savalou, and 73.1% in Abomey had no formal education. Percentage for those who attended primary school is 26.9% in Kandi, 30.8% in Savalou and 23.1% in Abomey.

Stockers: About 66.7% of the respondents in both Kandi and Savalou and 73.3% in Abomey have no formal education. However, 26.7% stockers in each region completed primary school but only 6.7% in Kandi and Savalou attended secondary school.

3.1.4. Years of experience

Years of experience for each market participant are shown in table 2.2.

Vendors: The majority of vendors have been involved in peanut marketing for less than 15 years, except for Savalou, were 60% had between 16 and 30 years of experience.

Processors: About 63.3% of them in both Kandi and Abomey and 43.3% in Savalou have been processing peanut for a period of less than 15 years. Results for the processors who have been involved for a period between 16 and 30 years are 33.3% in Kandi, 50.0% in Savalou and 30.0% in Abomey. However, only 3.3% in Kandi, 6.7% in Savalou and Abomey have been involved in the processing for more than 30 years.

Stockers: Years of experience for the majority of stockers in Kandi (60.0%), Savalou (60.0%) and Abomey (46.7%) are less than 15 years. Those who have done this business between 16 and 30 years represent 20.0%, 40.0% and 33.3% of the respondents in Kandi, Savalou and Abomey respectively. Only 20.0%of stockers of peanut in Kandi and Abomey have been involved for more than 30 years (Table 2.2).

3.1.5. Land ownership

Vendors: A number of vendors own land used to produce peanut. Of 15 vendors interviewed in each region, 80.0% in Kandi, 66.7% in Savalou and 33.3% in Abomey use their own land to grow peanut. Only 20% in Kandi, 33.3% in Savalou and 66.7% in Abomey rent land.

Processors: The majority of the respondents in Kandi (93.3%), in Savalou (53.3%) and in Abomey (63.3%) are owners of their land. However, very few rent or live with family and friends on their own farms; for instance in Kandi, only 6.7% use rented land for peanut production.

Stockers: A large percentage of land owners is observed in Kandi with 93.3% and Savalou with 86.7%, while in Abomey, 33.3% grow peanut on their own land (Table 2.2).

3.1.6. Income levels

Results for each market participant are shown in table 2.3. Data collected on income levels are for only one growing season of three months duration.

Vendors: Of a total of 15 respondents, 40.0% in Kandi, 60.0% in Savalou and only 13.3% generate revenues for sale of 5,500 kg of peanut of less than $525.21. Those making revenue between $525.21 and $1,050.42 represent 26.7% of the vendors in Kandi, 40% in Savalou and 53.3% in Abomey. In both Kandi and Abomey, 26.7% between $1,050.42 and $2,100.84, and only 6.7% earn income over $2,100.84.

Processors: Revenue for sale of 96 kg of peanut butter is relatively low. A large number in Kandi (80%) report that their revenue is less than $525.21. Just a few (13.3%) make between $525.21 and $1,050.42, and only 6.7 earn revenue between $1,050.42 and

$2,100.84. In Savalou, half of the processors' revenues are between $525.21 and $1,050.42, 33.3% are less than $525.21, and only 16.7% are between $1,050.42 and $2,100.84. About 76.7% of processors in Abomey earn less than $525.21 while, 20.0% are between $525.21 and $1,050.42 and only 3.3% is between $1,050.42 and $2,100.84.

Stockers: Stockers' revenues are costs of storage of 1,000 kg of peanut. Table 2.3 indicates also that income generated from storing peanut is less than $525.21 for 53.3% of the stockers in Kandi, 20.0% of the stockers in both Savalou and Abomey. About 13.3% of the revenues in Kandi range between $525.21 and $1,050.42. The same percentage (13.3%) is found for stockers whose revenue is between $1,050.42 and $2,100.84, and 20.0% of them earn more than $2,100.84. Results show that this activity is more profitable in Abomey and savalou than in Kandi. The majority in Savalou (80%) and Abomey (53.3%) generate incomes between $525.21 and $1,050.42, and approximately 26.7% have income levels greater than $1,000.42.

3.1.7. Aflatoxin knowledge and identification

Table 2.4 displays the results on aflatoxin knowledge and identification by market participant and by region.

Vendors: Overall, 68.9% of vendors state that they do not know about aflatoxin, 22.2% answer "yes", and the remaining 8.9% report that they heard about it but the only information they received was that aflatoxin affects maize. They also know that contaminated grain is not good for consumption. Table 2.4 indicates that vendors who do not know about aflatoxin represent 86.7% of the respondents in Kandi, 66.7% in Savalou, and 80.0% in Abomey.

Processors: All respondents in Abomey never heard about aflatoxin. In Kandi, 93.3% never heard about the word aflatoxin, and only 6.7% are sure of aflatoxin consequences on human health. Those aware of aflatoxin effects are those who report that they always purchase sorted peanut, sort peanut again before processing, discard the spoiled grains and never consume them. In Savalou, most of peanut processors (73.3%) have no knowledge of aflatoxin and only 26.7% have heard about aflatoxin. They use aflatoxin contaminated peanut as charcoal, and to feed their animals.

Stockers: A large number of peanut stockers (93.3%), in Kandi and Abomey-Bohicon, reveal that they have never heard of the word aflatoxin and its impact on the crops. However, only 6.7% (1) of them are aware of the problem. In Savalou, 53.3% owners of storage houses ignore the problem and about half (46.6%) are aware of aflatoxin.

3.1.8. Storage and sorting practices

Household decisions on sorting and storing peanut are presented in table 2.5.

Vendors: Based on survey responses, only retailers said that they are likely to sort peanut. Approximately, 80.0% (36) of 45 market vendors purchase sorted peanut and 20.0% (9) do not purchase sorted peanut. About 2.2% (2) of them plan to do it in the future and the remaining, 77.8% (7) are not likely to do so. However, 91.1% (41) of vendors said that they always check and sort the nuts before marketing, and only 8.9% (4) do not sort peanut. Moreover, half of them plan to sort peanut before selling in the future. About 31.7% (13) report that they sell the spoilt nuts at a lower price, and 68.3% (28) state that they just throw them away.

Processors: About 74.44% (67) of the 90 processors surveyed responded that they purchased sorted peanut while 21.11% (19) do not purchase the sorted nuts, and do not plan to do so in the future (Table 2.5). One reason given was that the price would be higher for sorted nuts. However, the remaining 4 reported that they do not purchase sorted peanut and do not plan to in the near future. About 90 % (81) of them sort peanut before processing it into paste, oil or other products, 7.78% (7) do not sort the nuts before processing them but are willing, and plan to do it in the future. Only 2.22% (2) refuse to sort before processing. In addition, of 81 respondents who sort peanut before processing, 41.9% (34) report that they discard the spoiled grains, usually throw them away, burn or use them as charcoal. However, the remaining consumes them (25) or uses them as animals feed (13), or sell them at a lower price (9). About 89.5% of the processors mention that they usually store peanut for a period of 6 months.

Stockers: There is little difference in the decision of sorting made by the stockers. Results concern most of stockers that also produce and sell peanut. About 66.7% (30) respond that they always purchase sorted peanut and only 33.3% (15) purchase non-sorted peanut. Among those who do not purchase sorted peanut, 80% intend to buy the cleaned nuts and only 20% are not likely to do it. Fifty-three percent of peanut stockers, who respond that they sort peanut before selling, are those who also produce, sell and/or process peanut. The remaining (46.7%) only specialize in storing products. However, for those who sort peanut before marketing, about 62.5% throw away or burn the spoiled grains, and 37.5% feed their animals with the rejected nuts.

3.1.9. Aflatoxin level

Table 2.6 shows the distribution of aflatoxin level for each market participant. Different limits of tolerance are used based on regulatory limits set for various countries: less than 4 ppb (European countries), between 4 and 15 ppb (FDA), between 15 and 20 ppb (W.H.O.) and greater than 20 ppb, over 100 ppb.

Based on the European standard, we observe that peanut from 91.53% of farmers, 83.33% of the processors, 95.83% of the vendors and 79.49% of the stockers can be considered safe for sale and consumption. Also, aflatoxin levels from both processors and vendors (4.17%) are lower than the tolerance limit set by the Food and Drug Administration (15 ppb), except for the stockers where 2.56% exceed 15 ppb. Nevertheless, aflatoxin found at processors (12.50%) and stockers (10.26%) levels exceed 20 ppb, the limits recommended by the W.H.O. Looking at the level of tolerance proposed for animal feed, table 2.6 shows that stockers' level are the highest (10.26%), followed by the processors (8.33%).

Overall, high risks of aflatoxin contamination were determined in processors and stockers peanut. Highest mean of aflatoxin level is found in the processors samples with a maximum level of 980 ppb, while in the producers and stockers'samples, maximum levels of aflatoxin are respectively 230 ppb and 610 ppb, which are much higher than the recommended levels. Samples collected with vendors have a lower concentration of aflatoxin (7.3 ppb). However, this exceeds the limit set by European countries which is 4 ppb.

3.2.Effects of aflatoxin on selling peanut

3.2.1. Enterprise budgets for market vendors

Different types of budgets for market vendors in Benin are presented in table 2.7 based on the assumption that consumers consider all nuts the same and pay the same price. The first budget concerns vendors who purchased non-sorted peanut and sell without sorting; the second budget shows costs and net returns for those who purchased non-sorted peanut, but sort it before selling. In the third case, they purchase sorted peanut at a higher price and they do not sort again before selling. The assumption in this case, is that market vendors are aware of peanut quality, and the risk of consuming contaminated peanut, and consumers are willing to pay a higher price for improved food safety.

Table 2.7.1 displays the estimated costs and returns for market vendors who sell only unshelled peanut (wholesalers). Comparing results from budgets 1 and 2, it is observed that vendor's revenue for 52.25 bags of 100 kg of peanut decreases when they decide to sort peanut ($768.38). Since the costs of sorting are transferred from farmers to vendors, labor costs for traders increase by $13.00, resulting in higher variable costs ($626.19) and consequently, smaller net returns of $140.06 (Table 2.7.1). It is, therefore, less profitable for vendors who decide to sort peanut before marketing the product. Very few of the respondents know aflatoxin and are able to identify contaminated peanut. However, in regard to aflatoxin effects, it is risky to sell the product without sorting them if they are contaminated with aflatoxin. The third case, in table 2.7.1, shows a budget where the decision makers (wholesaler) purchase already sorted peanut at a higher price; we assume that the buyers are aware of aflatoxin contamination. Hence, vendors generate lower net returns ($76.90) than in the second case. Higher purchasing price ($0.13) for clean peanut leads to an estimated loss in revenue of $63.11.

Results are similar for retailers; in terms of revenue, and net returns, it is not profitable to sort peanut before selling. Gross revenue for 4,500 kg decreases from $756.30 to $718.30 (Table 2.7.2) when sorting takes place. In addition, the purchase of a better quality product at a higher price results also in smaller net returns of $127.21.

Break even prices range from $0.11 to $0.13 for the wholesalers (Table 2.7.1) and $0.12 to $0.14 for the retailers (Table 2.7.2).

Based on the assumption that vendors purchase sorted peanut at a lower price because they are stored 6 months after harvest, it is observed in tables 2.7.3 and 2.7.4 that vendors generate lower net returns. With total costs of $572.35 (Table 2.7.3) and $498.19 (Table 2.7.4), wholesalers and retailers generate net returns of $5.38 and $69.04, respectively.

3.2.2. Risk analysis for market vendors

Probability distribution for net returns for wholesalers who do not sort peanut is presented in figure 2.1. Purchasing price is the most dominant variable in the regression. There is a positive relationship between selling price and net returns (0.55). This indicates that as selling price increases by one standard deviation, net returns for peanut wholesalers increase by 0.55 standard deviation. However, there is a negative relationship between net returns and purchasing price and sorting. Coefficients are -0.753 and -0.228 respectively. Figure 2.2 shows similar results when market vendors purchase sorted peanut at a high price and sell it without sorting again. Purchasing price is the most important variable in the model. Purchasing already sorted peanut at a higher price causes net returns to decrease by 0.931 standard deviation. As selling price increases by one unit, net returns increase also by 0.355. In addition, coefficient for variable “Purchase sorted peanut” is positive (0.013). By purchasing already sorted peanut, vendors avoid the cost of sorting which is left to the sellers. In figure 2.3, assumptions are made on the effect of storage time on vendors’ net returns. Assuming that vendors are aware of low peanut quality after a long storage period, they will purchase peanut at a lower price. Tornado graphs presented in figure 2.3, show that purchasing price is the most dominant variable (-0.783) influencing traders’ net returns. When variable “purchase price” of sorted peanut goes up by one standard deviation, net returns also goes down by 0.783; results also show that variable sorting (-0.068) has a negative influence on vendors’ net returns when they sort peanut to improve quality. The decision to buy clean nuts is for the vendors to make. Moreover, there is a positive correlation between the variable “Purchase sorted peanut” and net returns (coefficient = 0.106).

A comparison of the net present value for different decision makers is made in figure 2.4, based on assumptions used to generate previous budgets in table 2.7.1 to 2. 7.2. Vendors in option A are vendors who purchase sorted peanut and sort again before selling; Vendors in option B are those who purchase sorted peanut and do not sort again before selling and vendors in option C are those who do not purchase sorted peanut and sort before selling. There is a risk transfer from buyers (vendors) to sellers when vendors purchase already sorted peanut. No change in labor cost is observed for the vendors. Figure 2.4 shows that with a probability of 18%, NPV for all options are less than zero and then become positive, but option C is less risky than option B, and finally than option A. For all level of discounted profits, option C would be considered the most efficient set and would be the most rational.

3.3. Effects of aflatoxin on processing peanut

3.3.1. Enterprise budgets for processors

Results from enterprise budgets for processing peanut are shown in tables 2.8.1 and 2.8.2. Following the assumptions that aflatoxin increases with storage time, costs and returns for non-sorted peanut are compared to the costs and returns generated by processors who sort peanut stored for 3 months and for 6 months. Processors who do not sort peanut generate higher revenues ($705.88) and net returns ($236.30) (Table 2.8.1). When they sort peanut that was stored for a period less than 3 months, they pay more in labor ($174.58), resulting in lower net returns of $168.73. Because of peanut's lower quality after 6 months of storage, processors have to throw away 5% of peanut quantity which results in lower net returns ($147.56). Hence, to compensate for the loss due to sorting, we assume that a change in price is accompanied by sorting stored peanut for various time periods (table 2.8.2); it is observed that net returns above all costs drop for processors who sort peanut 3 months after harvest ($133.44) and increases for processors with peanut stored for more than 6 months ($197.98).

3.3.2. Risk analysis for processors

Results from regression sensitivity analysis for net returns are shown in figure 2.5 for processors who do not sort peanut, and who sort peanut for less than 3 months and more than 6 months. Selling price plays an important role in processors net returns; coefficients are 0.90 when peanut is not sorted, 0.84 for sorted peanut stored less than 3 months and, 0.90 for sorted peanut stored more than 6 months. However, when the decision makers are willing to sort peanut, there is a negative relationship between variables sorting (-0.26 and -0.37), peanut purchasing price (-0.46 and -0.23), storage (-0.026 and -0.028) and shelling (-0.001). Variables winnowing and sorting costs have a positive effect on processors net returns.

Cumulative distributions of the NPV for processors, as price vary due to sorting and storage, are presented in figure 2.6. Processors who sort peanut and pay a higher price for sorted peanut stored for 3 months, have a smaller NPV than the processors who do not sort peanut. With a probability of 20%, NPV is equal to $600 (Figure 2.6), which is smaller than the other ones ($1,400). For some reason, the NPV curves for processors who sort peanut for a period less than 3 months and for those who sort peanut for a period greater than 6 months are very close, and almost at the same points. However, we can observe that it is more profitable for processors to sort peanut stored for a period of less than 3 months.

3.4.Effects of aflatoxin on storing peanut

3.4.1. Enterprise budgets for stockers

Result for enterprise budgets for stockers is displayed in tables 2.9.1 and 2.9.2. Two types of storage practices are studied; traditional stockers store peanut on the floor, plastic bags, hay or on the top of the roof of their house while, the improved stockers use treated storage rooms. Average income for peanut stockers using the traditional method is $735.29 for 1,000 kg of stored peanut, at a total cost of $10.70 and net returns of $724.60 (Table 2.9.1). Stockers using the improved method, however, generate revenues of $1,050.42 per month, total costs of $12.61 and net returns of $1,037.81. It was assumed that if owners of stored products (farmers or vendors) were asked to sort peanut after a given period of time, they would have to throw away a certain amount (2-5%) of the product resulting from deterioration due to storage time; therefore, the amount they would have to pay would be smaller. This assumption is based on the investigation by Kaaya and Warren (2006). Results based on this assumption are also presented in table 2.9.1 and Table 2.9.2. For less than 3 months of storage, revenue decreases to $720.59 with the same variable costs ($8.18) and reduced net returns of $709.89 (Table 2.9.1). After 6 months of storage, traditional stockers ‘income is reduced to $698.53 (Table 2.9.2). Net returns are reduced by $22.06. In Table 2.9.2, we note that as peanut quality is lowered due to storage time, stockers' revenue is also reduced from $1,029.41 to $997.90, resulting in a decrease in net returns from $1016.80 to $985.29.

Break-even analysis to cover variable expenses, however, increases from $0.009 to $0.013 (Table 2.9.2).

3.4.2. Risk analysis for stockers

Tornado graphs in figure 2.7 show the sensitivity analysis for the net returns of each stocker. Price for storing is the most important variable in the regression model. Coefficient for price is 0.99 for both types of stockers indicating that as price increases by one percent, net returns will also increase by 99 percent. In addition it is shown that net returns are negatively influenced by sorting (-0.059) and storage (-0.022). Figure 2.8 shows the NPV for each type of stockers when they do not sort peanut. There is a 5% chance both type of stockers will have an NPV between $6,038.6 and $9,050.6. In addition, we note that stockers who use the improved methods have a higher NPV than those using the traditional methods.

Another comparison is made between stockers who use the traditional storage method and those who use the improved method for peanut conservation. Figure 2.9 shows that with a probability of 80%, stockers who use treatment to conserve peanut quality obtain a higher NPV ($12.6) compared to those with a traditional storage method ($8.4).

4. Discussion and conclusion

This study summarizes the results of the effects of aflatoxin contamination on marketing of peanut in Benin. Survey was conducted in three agro-ecological zones of Benin. Questionnaires were administrated to market vendors, processors and stockers. The study examines the effects of aflatoxin peanut contamination on market vendors, processors and stockers' revenue.

Very few of the respondents know about aflatoxin contamination. For instance in Kandi, the majority (86.7%) of the vendors never heard about aflatoxin. About 93.3% of the processors and stockers don't know about aflatoxin. Results are similar in the other two regions. Answers given by market participants in the survey show that the majority of the respondents do not have any information of aflatoxin contamination on peanut, and its harmful health effects. Jolly et al. (2006) also note similar responses for Ghanaian market participants. It also shows clearly that most of them are not able to identify aflatoxin contaminated nuts, but only signs of spoilage like discoloration or insect damage.

Results for aflatoxin level show that the majority of the samples collected from the vendors (95.8%), processors (83.3%), and stockers (79.5%) are less than the European standard (4 ppb). However, for levels between 4 ppb and 15 ppb (FDA), stockers have the highest percentage (7.7%). About 12.5% of the processors sample and 10.3% of the stockers' samples exceed 20 ppb. This result confirms that aflatoxin production is most common in storage and poor management practices. Several studies in most developing countries, especially in Benin reveal that aflatoxin contamination is related to storage conditions (Hell, 2000, and Fandohan et al, 2005). Risk analysis also confirmed that it is more risky for market participant to either, purchase already sorted peanut before selling, or purchase non-sorted and sort it themselves before selling. A comparison made between cost and returns for peanut stored for less than 3 months and those from peanut stored more than 6 months indicate that net returns after 6 months are the smallest due to lowered peanut quality.

Enterprise budgets and risk analysis were developed to examine the risk of aflatoxin contamination on peanut marketing. When market participants sort peanut, total costs increase, resulting in lower net returns. Assuming that consumers consider all nuts the same and pay the same price, net returns for vendors who sort peanut before selling decreases by $52.39 for 5,225 kg sold.

For the processors, budgets were developed to compare the costs and returns when they do not sort peanut and when they do at different storage times. Results show that sorting causes an increase in labor costs ($174.58), and a decrease in net returns for selling 95 kg of peanut butter ($168.73). Moreover, when sorting is done for a period of more than 6 months, net returns decrease further ($147.56). Similar findings for stockers indicate that sorting peanut reduces net returns for storing 980 kg of peanuts from $1,037.81 to $1,016.80.

Sorting of nuts increases costs and lowers net returns. Market participants will be unwilling to sort peanut unless they receive a higher price for their peanut. Unless there is a policy in place for price increases for a better quality and safe product, market participants are likely to engage in cost shifting behaviors. Education is key factor to increase market participants' willingness to sort peanut (Awuah et al., 2009). Jolly et al. (2009) also emphasized increasing market participants' awareness of aflatoxin problem to encourage them to sort peanut.

Risk analysis for sorting shows that if the buyer purchase the nuts unsorted and sort the nuts in his business and sell the nuts, this would be less risky. Most peanut marketing enterprises in Benin have limited capital investment and entrepreneurs use considerable amount of family labor to sort their nuts. This is concluded in the study by Awuah et al. (2009) that young and older unemployed individuals are often used for sorting nuts. Hence, the labor cost is kept low and there is improvement in quality.

In conclusion, purchasing price negatively influences net returns and risks. The decisions to sort by the market intermediary negatively influences net returns from sale. It is important that the purchaser does all in his/her power to purchase clean nuts since the purchase of clean nuts positively influence his/her net returns.

For processors, selling price is the most dominant variable. Hence a processor must include in his/her promotion that the product is clean and safe, and try to obtain the highest possible price that will positively influence his net returns. Therefore, no sorting should be accompanied by a lower purchase price.

For storage, cost of storage has the most important influence on net returns; however, decision to sort and length of storage negatively affects net returns.

Results from this study suggest that aflatoxin contamination of peanut is significantly influenced by sorting and storage. Any measure to reduce aflatoxin level in peanut and other food crops must be explained to the population of Benin, and regulation on aflatoxin levels should also be imposed locally in order to protect consumers' health.

GENERAL SUMMARY

Aflatoxin (AF) contamination of peanut is a major problem in developing countries, especially in tropical countries where environmental conditions are favorable for aflatoxin production. Studies have been conducted on conditions that favor mold growth but not much has been done on practices to reduce the effects on market products. Further, there is still need to examine the economic and financial market risks associated with aflatoxin contaminated food products.

Factors significantly affecting aflatoxin contamination are post-harvest factors such as, sorting and drying. Results in this survey show that most farmers dry peanut but do no sort peanut before selling. One reason is they dry peanut in the field and then pack and sell immediately at the farm gate. The other reason is that sorting is time consuming and reduces final quantity. Enterprise budgets confirm that sorting reduces peanut quantity and then farmers' revenue. It is obvious that aflatoxins reduce peanut quality, and net revenues.

Results are similar for peanut market participants. A comparison is made between those who sort peanut and those who do not sort peanut before marketing or processing. We observe also that, market participants who do not sort peanut, are likely to generate higher net returns than those who sort peanut. Based on the assumptions that buyers are aware of aflatoxin contaminated peanut, we compare net present values for processors of peanut who purchase sorted peanut and those who do not purchase already sorted peanut. The findings show that net present value for those who purchase already sorted nuts at a higher price have the smallest net present value.

Several factors presented in this study, may help reduce aflatoxin contamination of peanut, and therefore, do not affect farmers revenue in Benin. Appropriate drying, sorting and good storage conditions are identified as remedies to control aflatoxin problems in Benin. The majority of farmers in Benin dry peanut after harvest because they are aware of high moisture content in peanut at harvest, and the nuts may spoil if they do not dry at a normal temperature. FAO recommends drying peanut as soon as possible and lowering the moisture content to less than 12%.

Poor storage systems in Benin have been linked to aflatoxin contamination of peanut. Farmers in Benin do not dispose of adequate and appropriate storage facilities, hence sorting of peanut is necessary. Since the risk of aflatoxin contamination in peanut, increases with length of storage time, adequate storage structures and sorting should be recommended to farmers to improve quality. In addition, market participants, such as vendors, processors and stockers, should also adopt these measures in order to assure good quality of peanut and reduce risk of aflatoxin contamination.

In conclusion, population in Benin is exposed to aflatoxin contamination not only due to its humid climate, but also its inadequate pre-harvest and post-harvest management practices.

As a result of this study, farmers, market participants, and consumers, not only in Benin, but also in other West African countries, should be sensitized about the financial and health risks of aflatoxin contamination of peanut along the marketing chain.

TABLES

Table 2.1. Socio-demographics characteristics for vendors, processors, and stockers peanut, by region.

	Kandi		Savalou		Abomey-Bohicon	
	Number	%	Number	%	Number	%
Age groups						
Vendors						
Under 35	8	53.3	0	0.0	3	20.0
36-55	5	33.3	7	46.7	11	73.3
over 55	2	13.3	8	53.3	1	6.7
Processors						
Under 35	12	46.2	5	19.2	6	23.1
36-55	14	53.8	11	42.3	17	65.4
over 55	0	0.0	10	38.5	3	11.5
Stockers						
Under 35	7	46.7	0	0.0	4	26.7
36-55	5	33.3	10	66.7	9	60.0
over 55	3	20.0	5	33.3	2	13.3
Gender						
Vendors						
Female	10	66.7	15	100.0	10	66.7
Male	5	33.3	0	0.0	5	33.3
Processors						
Female	26	100.0	26	100.0	26	100.0
Male	0	0.0	0	0.0	0	0.0
Stockers						
Female	7	46.7	15	100.0	7	46.7
Male	8	53.3	0	0.0	8	53.3
Education						
Vendors						
No formal education	12	80.0	10	66.7	10	66.7
Primary school	2	13.3	4	26.7	4	26.7
Secondary school	0	0.0	1	6.7	1	6.7
Processors						
No formal education	17	65.4	17	65.4	19	73.1
Primary school	7	26.9	8	30.8	10	23.1
Secondary school	2	7.7	1	3.8	1	3.8
Stockers						
No formal education	10	66.7	10	66.7	11	73.3
Primary school	4	26.7	4	26.7	4	26.7
Secondary school	1	6.7	1	6.7	0	0.0

Table 2.2. Years of experience in business and land ownership of market participants.

	Kandi		Savalou		Abomey	
	Number	%	Number	%	Number	%
Years of experience						
Vendors						
0-15	10	66.7	3	20.0	7	46.7
16-30	5	33.3	9	60.0	6	40.0
Over 30	0	0.0	3	20.0	2	13.3
Processors						
0-15	19	63.3	13	43.3	19	63.3
16-30	10	33.3	15	50.0	9	30.0
Over 30	1	3.3	2	6.7	2	6.7
Stockers						
0-15	9	60.0	9	60.0	7	46.7
16-30	3	20.0	6	40.0	5	33.3
Over 30	3	20.0	0	0.0	3	20.0
Land ownership						
Vendors						
Owner	12	80.0	10	66.7	5	33.3
Renter	3	20.0	5	33.3	10	66.7
Processors						
Owner	28	93.3	16	53.3	19	63.3
Renter	2	6.7	14	46.7	11	36.7
Stockers						
Owner	14	93.3	2	86.7	5	33.3
Renter	1	6.7	13	13.3	10	66.7

Table 2.3. Income levels of vendors, processors, and stockers of peanut in Benin.

	Kandi		Savalou		Abomey	
	Number	%	Number	%	Number	%
Vendors						
0-525.21	6	40.0	9	60.0	2	13.3
525.21 - 1,000.42	4	26.7	6	40.0	8	53.3
1,000.42 - 2,000.84	4	26.7	0	0.0	4	26.7
Over 2,000.84	1	6.7	0	0.0	1	6.7
Processors						
0-525.21	24	80.0	10	33.3	23	76.7
525.21 - 1,000.42	4	13.3	15	50.0	6	20.0
1,000.42 - 2,000.84	2	6.7	5	16.7	1	3.3
Over 2,000.84	0	0.0	0	0.0	0	0.0
Stockers						
0-525.21	8	53.3	3	20.0	3	20.0
525.21 - 1,050.42	2	13.3	12	80.0	8	53.3
1,000.42 - 2,100.84	2	13.3	0	0.0	4	26.7
Over 2,100.84	3	20.0	0	0.0	0	0.0

-Incomes for vendors are from sale of 5,500 kg of peanut.
-Incomes for processors are from sale of 96 kg of peanut butter.
-Incomes for stockers are 1,000 kg of peanut stored.

Table 2.4. Aflatoxin knowledge by peanut market participant and by region.

Aflatoxin knowledge	Vendors		Processors		Stockers	
	Number	%	Number	%	Number	%
Kandi						
Yes	2	13.3	2	6.7	1	6.7
No	13	86.7	28	93.3	14	93.3
Savalou						
Yes	5	33.3	8	26.7	7	46.7
No	10	66.	22	73.3	8	53.3
Abomey						
Yes	3	20	0	0	1	6.7
No	12	80	30	100	14	93.3

Source: survey data

Table 2.5. Storage and sorting practices for each market participant.

Decision	Vendors		Processors		Stockers	
	Number	%	Number	%	Number	%
Purchase sorted peanut						
Yes	36	80.0	67	74.4	30	66.7
No	9	20.0	19	21.1	15	33.3
Plan to purchase sorted peanut						
Yes	2	2.2	-	-	12	80.0
No	7	77.8	19	100.0	3	20.0
Sort peanut before processing or marketing						
Yes	41	91.1	81	90.0	24	53.3
No	4	8.9	9	10.0	21	46.7
Plan to sort peanut before processing or marketing						
Yes	2	50.0	7	77.8	-	-
No	2	50.0	2	22.2	-	-
Discard spoiled or contaminated nuts						
Just throw them away or Burn	28	68.3	34	41.9	15	62.5
Auto-consumption	-	-	25	30.9	-	-
Animal feed	-	-	13	16.1	9	37.5
sell for a lower price or other	13	31.7	9	11.1	-	-

-Answers were given by stockers who besides storing, also produces, sell and/or transform peanut.

Table 2.6. Frequency of aflatoxin level for each market participant (percent)

Aflatoxin level (ppb)	0-4	4-15	15-20	Over 20	Over 100
Market Vendors	95.83	4.17	0.00	0.00	0.00
Processors	83.33	4.17	0.00	12.50	8.33
Stockers	79.49	7.69	2.56	10.26	10.26

Source: Analysis of marketed peanut

Table 2.7.1. Estimated annual costs and returns budget for vendors (wholesalers) in Kandi, under the following assumptions:

1-Vendors purchased non-sorted peanut do not sort before marketing.
2- Vendors purchased non-sorted peanut and vendors sort before marketing.
3- Vendors purchased sorted peanut at a higher price; they do not sort before marketing.

	Unit	<u>1</u> Value	<u>2</u> Value	<u>3</u> Value
Unshelled peanut	kg	*5,500*	*5,225*	*5,500*
Price	$	*0.15*	*$0.15*	*0.15*
REVENUE	**$**	**808.82**	**768.38**	**808.82**
VARIABLE COSTS				
Quantity purchased	kg	*5,500*	*5,500*	*5,500*
Price	$	*0.11*	*0.11*	*$0.13*
Purchasing costs	$	577.73	577.73	693.28
Labor hour	hour	28.5	54.00	28.50
Labor costs	$	7.63	20.63	7.63
Material and equipment	$	28.89	27.84	28.89
Total variable costs		614.24	626.19	729.03
Income above variable costs	**$**	194.58	142.19	79.03
FIXED COSTS				
Repair and maintenance	$	1.00	1.00	1.00
Depreciation equip.	$	1.13	1.13	1.13
Total fixed costs	$	2.13	2.13	2.13
TOTAL COSTS	$	616.38	628.33	731.92
Net returns	**$**	**192.45**	**140.06**	**76.90**
Breakeven price (per kg sold)				
to cover variable expenses	$	0.111	0.120	0.133
to cover total expenses	$	0.112	0.120	0.133

-Peanut is sold to vendors at the farm gate price, which is 50 F CFA per kg ($0.105).
-Wholesalers are vendors selling unshelled peanut in local and neighbors' villages.
-In the third case (<u>3</u>), the purchased cost of 1kg of peanut already sorted is 60 F CFA = $0.126.
-Material and equipment are considered as variable costs because they are renewed every year.

Table 2.7.2. Estimated annual costs and returns budget for vendors (retailers) in Kandi, under the following assumptions:

1-Vendors purchased non-sorted peanut do not sort before marketing.
2-Vendors purchased non-sorted peanut and vendors sort before marketing.
3-Vendors purchased sorted peanut at a higher price (+5%); they do not sort before marketing.

	Unit	1 Value	2 Value	3 Value
Peanut	Kg	*4,500*	*4,275*	*4,500*
Price	$	*0.17*	*0.17*	*0.17*
REVENUE	**$**	**756.30**	**718.49**	**756.30**
VARIABLE COSTS				
Quantity purchased	kg	4,500	4,500	4,500
Price	$	0.11	0.11	0.13*
Purchasing costs	$	472.69	472.69	567.23
Labor	hour	68.50	87.00	68.50
Labor	$	34.50	43.75	34.50
Material and equipment	$	23.63	22.58	23.63
Total variable costs	$	530.82	539.02	625.36
Income above variable costs	$	225.48	179.46	130.94
FIXED COSTS				
Repair and maintenance	$	2.50	2.50	2.50
Depreciation equip.	$	1.23	1.21	1.23
Total fixed costs	$	3.73	3.71	3.73
TOTAL COSTS	$	534.55	542.73	629.09
Net returns	$	**221.75**	**175.76**	**127.21**
Breakeven price (per kg sold)				
to cover variable expenses	$	0.118	0.126	0.139
to cover total expenses	$	0.119	0.127	0.140

-Peanut is sold to vendors at the farm gate price, which is 50 F CFA per kg ($0.11).
-Retailers are vendors who sell only shelled nuts; price of shelled peanut is higher than the unshelled nuts
-In the third case (3), the purchased cost of 1kg of peanut already sorted is 60 F CFA = $0.13.
-Material and equipment are considered as variable costs because they are renewed every year.

Table 2.7.3. Enterprise budget for peanut wholesalers in Kandi, under the following assumptions:

1-Vendors purchased sorted peanut. 2-Sorted peanut is purchased at a lower price
3-Storage condition: 6 months after harvest. 4- Vendors sort again before marketing

	Unit	Quantity	Price	Value
REVENUE				
Peanut	Kg	5,500.00	$0.11	**577.73**
VARIABLE COSTS				
Quantity purchased	kg	5,500.00	$0.09	519.96
Labor	hrs	56.00		21.38
Material and equipment	each			28.89
Total variable costs				570.22
Income above variable costs				7.51
FIXED COSTS				
Repair and maintenance				1.00
Depreciation equip.				1.13
Total fixed costs				2.13
TOTAL COSTS				572.35
Net returns				**5.38**
Breakeven price (per kg sold)				
to cover variable expenses				0.104
to cover total expenses				0.104

-Since peanut is perceived as bad quality peanut, it is assumed that it is sold at a lower price: 45 F.cfa ($0.09) per kilogram.
-Material and equipment is considered as variables costs they are renewed every year.

Table 2.7.4. Enterprise budget for peanut retailers in Kandi, under the following assumptions:

1-Vendors purchased sorted peanut. 2-Sorted peanut is purchased at a lower price
3-Storage condition: 6 months after harvest. 4- Vendors sort again before marketing

	Unit	Quantity	Price	Value
REVENUE				
Peanut	Kg	4,500.00	$0.13	**567.23**
VARIABLE COSTS				
Quantity purchased	kg	4,500.00	$0.09	425.42
Labor	hrs	91.00		45.75
Material and equipment	each			23.63
Total variable costs				494.80
Income above variable costs				72.42
FIXED COSTS				
Repair and maintenance				2.50
Interests on Capital invest				0.00
Depreciation equip.				0.88
Total fixed costs				3.38
TOTAL COSTS				498.19
Net returns				**69.04**
Breakeven price (per kg sold)				
to cover variable expense				0.110
to cover total expenses				0.111

-Since peanut (shelled) are perceive as bad quality peanut, it is assumed that they are sold at a lower price: 45 F.cfa ($0.09) per kilogram.
-Material and equipment are considered as variable costs because they are renewed every year. .

Table 2.8.1. Budget for processing peanut, using 2,400 kg of whole grain peanut per month, purchased at $0.15 per kilogram, and sold at $7.35 a bassin of peanut butter.

		Not Sorted	**Sorted**	
			< 3 months	> 6 months
	Unit	**Value**	**Value**	**Value**
Peanut butter (1kg @ $7.35)	Kg	96.00	95.04	92.16
REVENUE	$	$705.88	$698.82	$677.65
VARIABLE COSTS				
Whole grains (2,400 kg @ $0.15/kg)	Kg	$352.94	$352.94	$352.94
Labor hours	hour	186.00	258.00	258.00
Labor cost	$	$114.08	$174.58	$174.58
Material and equipment	$	$0.63	$0.63	$0.63
Total variable costs	$	$467.64	$528.15	$528.15
Income above variable costs	$	$238.24	$170.68	$149.50
FIXED COSTS				
Repair and maintenance	$	$1.00	$1.00	$1.00
Depreciation equip.	$	$0.95	$0.95	$0.95
Total fixed costs	$	$1.95	$1.95	$1.95
TOTAL COSTS	$	$469.59	$530.09	$530.09
Net returns	$	**$236.30**	**$168.73**	**$147.56**
Break-even price (per kg sold)	$			
to cover variable expenses	$	$4.87	$5.56	$5.73
to cover total expenses	$	$4.89	$5.58	$5.75

-Material and equipment are considered as variable costs because they are renewed every year.

Table 2.8.2. Budget for processing peanut, using 2,400 kg of whole grain peanut per month, purchased at different price due to storage and sorting.

		Not Sorted	Sorted	
			< 3 months	> 6 months
	Unit	Value	Value	Value
REVENUE				
Peanut butter	Kg	96.00	95.04	92.16
Price	$	$7.35	$7.35	$7.35
Revenue	$	**$705.88**	**$698.82**	**$677.65**
VARIABLE COSTS				
Whole grains (2,400 kg)	Kg	2,400	2,400	2,400
Unshelled nuts price	$	$0.13	$0.16	$0.13
Purchasing costs	$	$317.65	$388.24	$302.52
Labor hours	hrs	186.00	258.00	258.00
Labor cost	$	$114.08	$174.58	$174.58
Material and equipment	$	$0.63	$0.63	$0.63
Total variable costs	$	$432.35	$563.44	$477.73
Income above variable costs	$	$273.53	$135.38	$199.92
FIXED COSTS				
Repair and maintenance	$	$1.00	$1.00	$1.00
Depreciation equip.	$	$0.95	$0.95	$0.95
Total fixed costs	$	$1.95	$1.95	$1.95
TOTAL COSTS	$	$434.29	$565.39	$479.67
Net returns	$	**$271.59**	**$133.44**	**$197.98**
Break-even price (per kg)				
to cover variable expenses	$	$4.50	$5.93	$5.18
to cover total expenses	$	$4.52	$5.95	$5.20

-Material and equipment are considered as variable costs because they are renewed every year.

Table 2.9.1 Estimated costs and returns for peanut storage activities. (Traditional method)

- No treatment was used to store peanut.
- Decision maker authorize customers (farmers, vendors or processors) to sort peanut;
- Peanut is stored for less than 3 months and more than 6 months

	Unit	normal Value	3 months Value	6 months Value
Peanut stored	Kg	1,000.00	980.00	950.00
Price	$	$0.74	$0.74	$0.74
REVENUE	$	**$735.29**	**$720.59**	**$698.53**
VARIABLE COSTS				
Labor hour	hrs	6.67	6.67	6.67
Labor costs	$	$2.63	$2.63	$2.63
Material and equipment	$	$6.25	$6.25	$6.25
Total variable costs	$	$8.18	$8.18	$8.18
Income above variable costs	$	$726.42	$711.71	$689.65
FIXED COSTS				
Repair and maintenance	$	$1.00	$1.00	$1.00
Depreciation equip.	$	$0.82	$0.82	$0.82
Total fixed costs	$	$1.82	$1.82	$1.82
TOTAL COSTS	$	$10.70	$10.70	$10.70
Net returns	$	**$724.60**	**$709.89**	**$687.83**
Break-even price (per kg sold)				
to cover variable expenses	$	$0.009	$0.009	$0.010
to cover total expenses	$	$0.011	$0.011	$0.012

-Percent of quantity rejected in 2% for peanut stored less than 3 months and 5% for peanut stored after six months

-Material and equipment are considered as variable costs because they are renewed every year.

Table 2.9.2 Estimated costs and returns for peanut storage activities (improved method)

	Unit	<u>**normal**</u> Value	<u>**3 months**</u> Value	<u>**6 months**</u> Value
Peanut stored	Kg	1,000.00	980.00	950.00
Price	$	<u>$1.05</u>	<u>$1.05</u>	<u>$1.05</u>
REVENUE	$	**$1,050.42**	**$1,029.41**	**$997.90**
VARIABLE COSTS				
		3.67	3.67	3.67
Labor	hrs	$2.94	$2.64	$2.64
Material and equipment	$	$6.25	$6.25	$6.25
Total variable costs	$	$8.88	$8.88	$8.88
Income above variable costs	$	$1,042.54	$1020.54	$989.02
FIXED COSTS				
Repair and maintenance	$	$2.00	$2.00	$2.00
Depreciation equip.	$	$1.74	$1.74	$1.74
Total fixed costs	$	$3.74	$3.74	$3.74
TOTAL COSTS	$	$12.61	$12.61	$12.61
Net returns	$	**$1,037.81**	**$1016.80**	**$985.29**
Break-even price (per kg sold)				
to cover variable expenses	$	$0.009	$0.009	$0.009
to cover total expenses	$	$0.013	$0.013	$0.013

-Same assumptions as in table 9.1
-Material and equipment are considered as variable costs because they are renewed every year.

Figures

Figure 2.1. Tornado graph for net returns for peanut wholesalers in Benin.

Assumptions: vendors do not purchase sorted peanut and sort them before marketing.

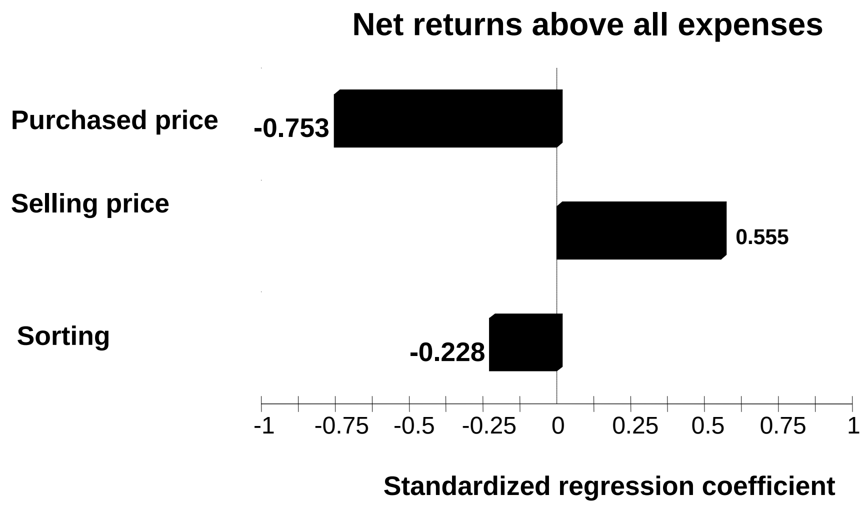


Figure 2.2. Tornado graph for net returns for peanut wholesalers in Benin

Assumptions: vendors purchase sorted peanut at a high price and refuse to sort again for marketing.

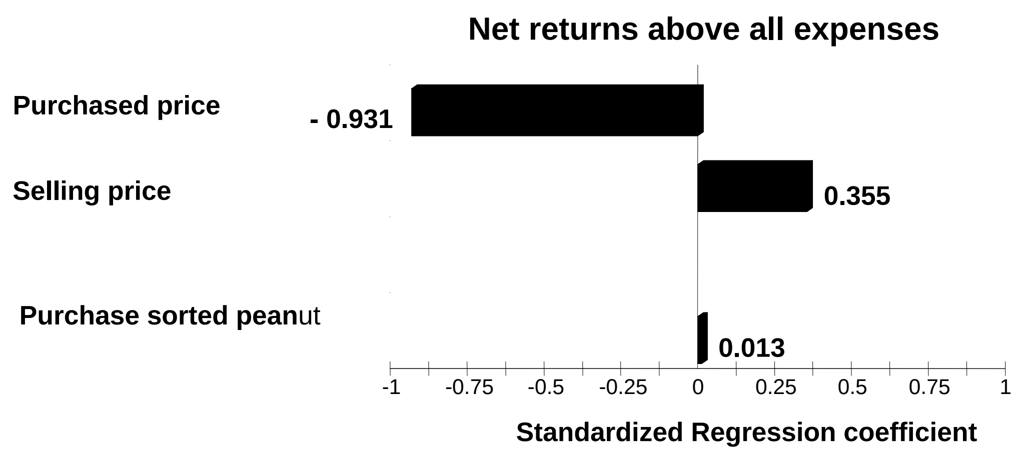


Figure 2.3. Tornado graph for net returns for peanut wholesalers in Benin.

Assumptions: 1- Vendors purchase sorted peanut at a lower price ($0.09) due to storage time; 2- they sort again for marketing.

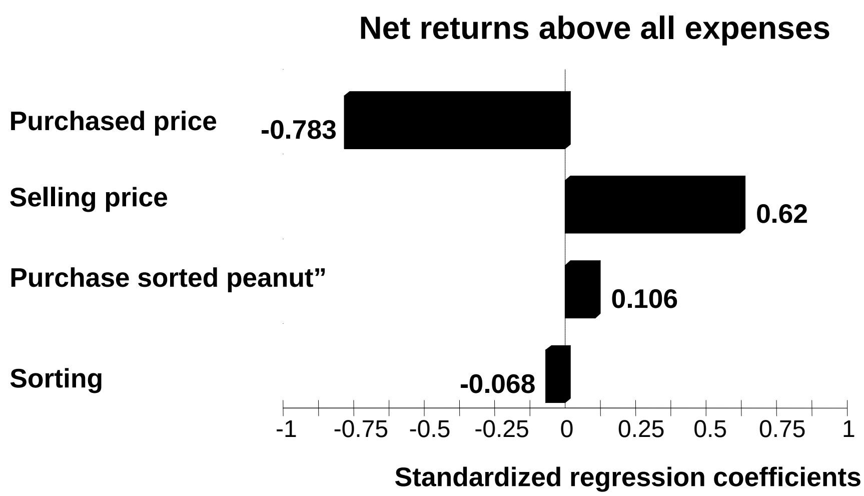


Figure 2.4. Cumulative probability distribution of net present values for vendors, discounted at 6% and using the assumptions shown in table 7.3 and 7.4.

Assumptions:
Option A: Vendors purchase sorted peanut and sort again before selling
Option B: Vendors purchase sorted peanut and do not sort before selling
Option C: Vendors purchase non-sorted peanut and sort before selling

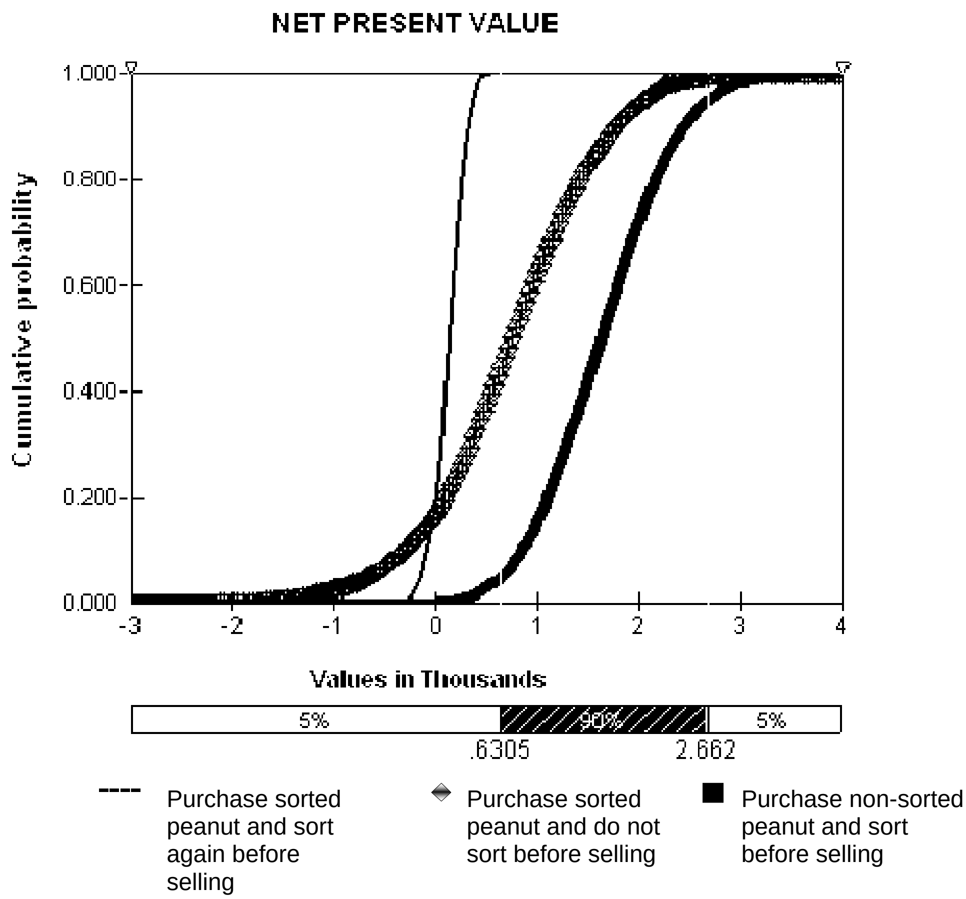


Figure 2.5. Tornado graphs for net returns above all expenses

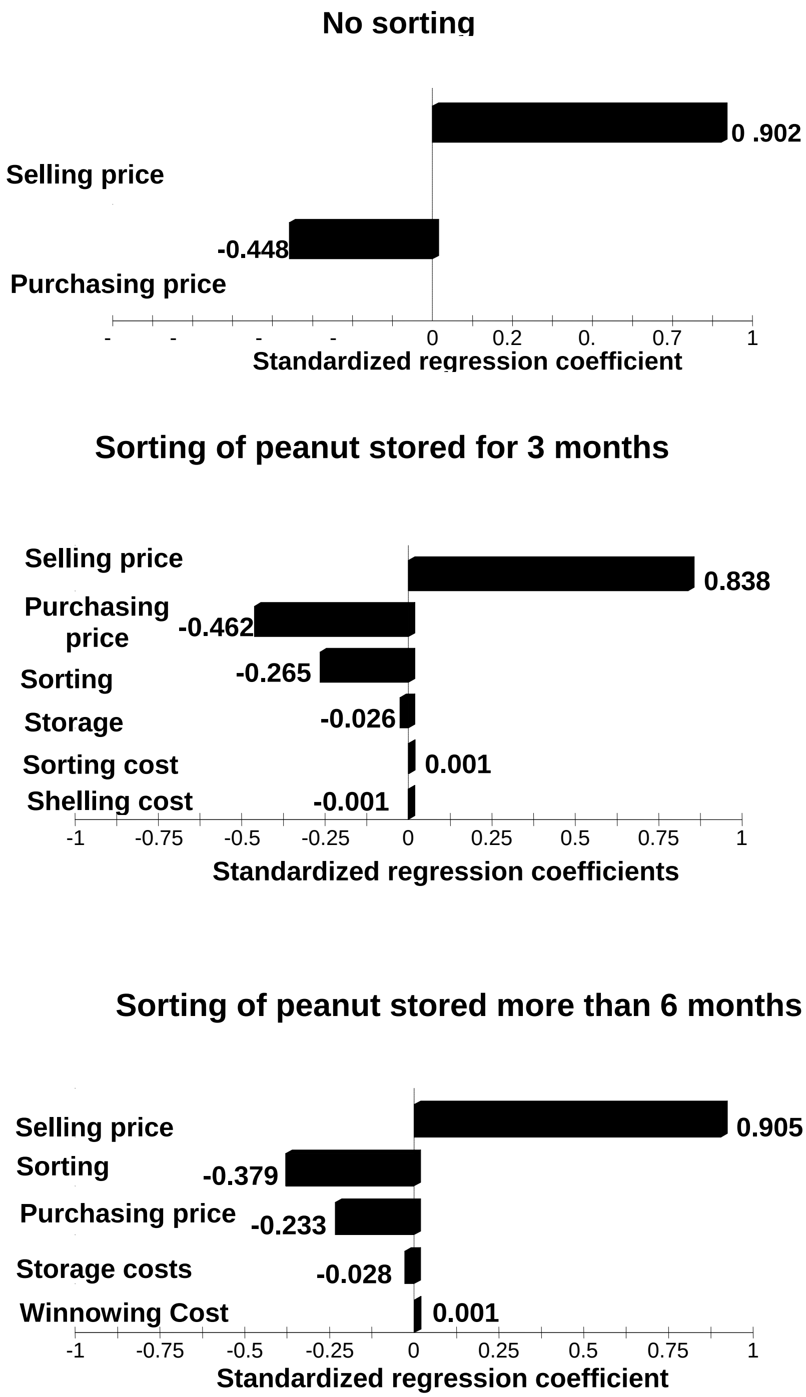


Figure 2.6. Cumulative probability distribution for the net present values of processors, as price changes due to sorting and storage time.

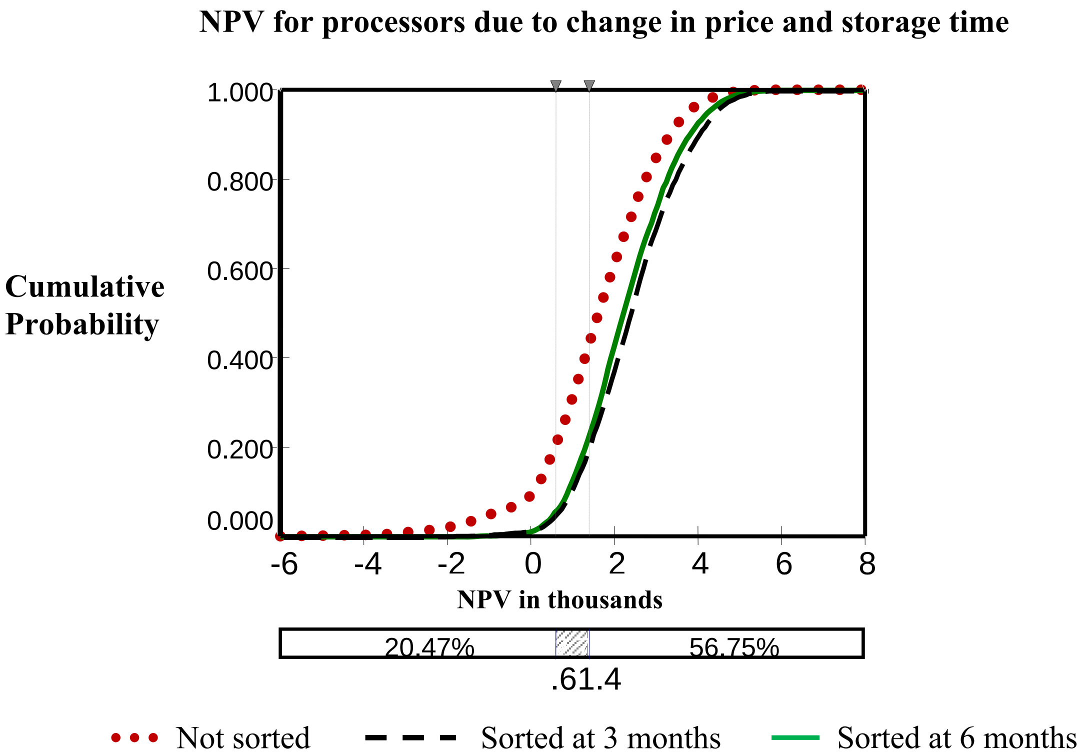
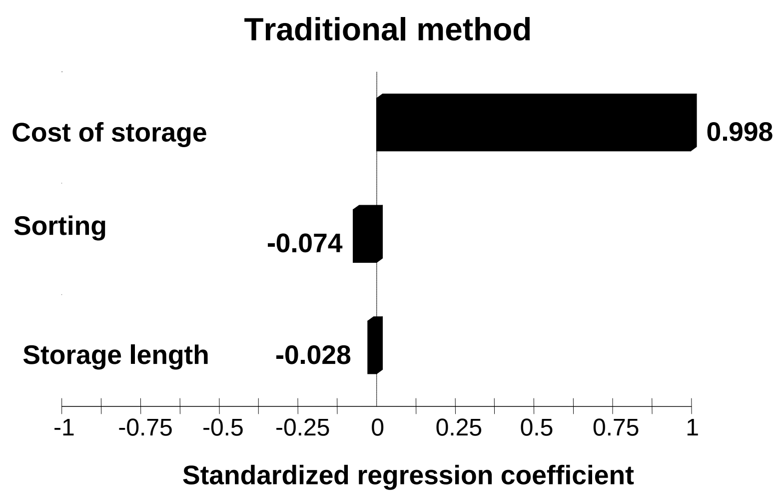


Figure 2.7. Tornado graphs for stockers' net returns



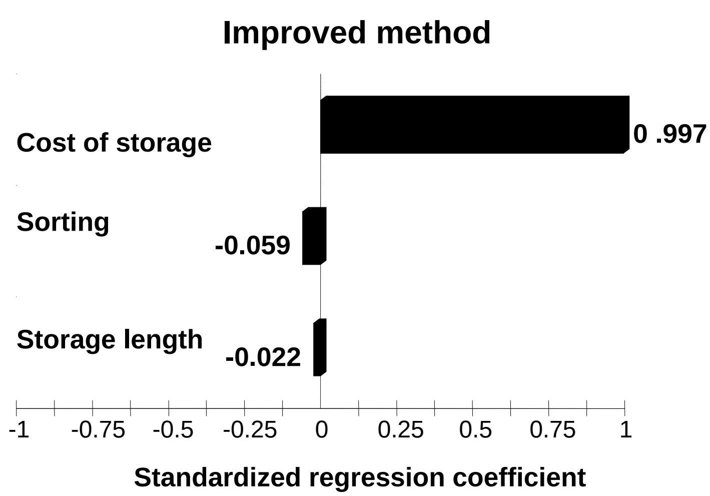


Figure 2.8. Cumulative probability distribution for the net present values for each type of stockers when they do not sort peanut.

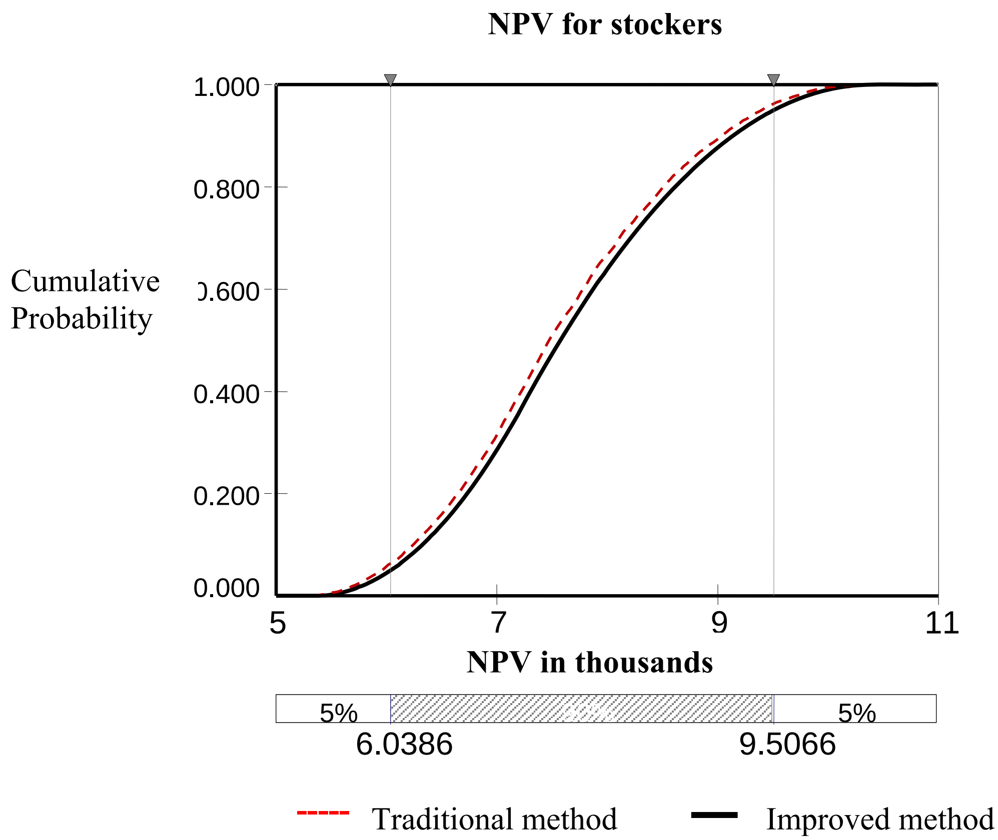
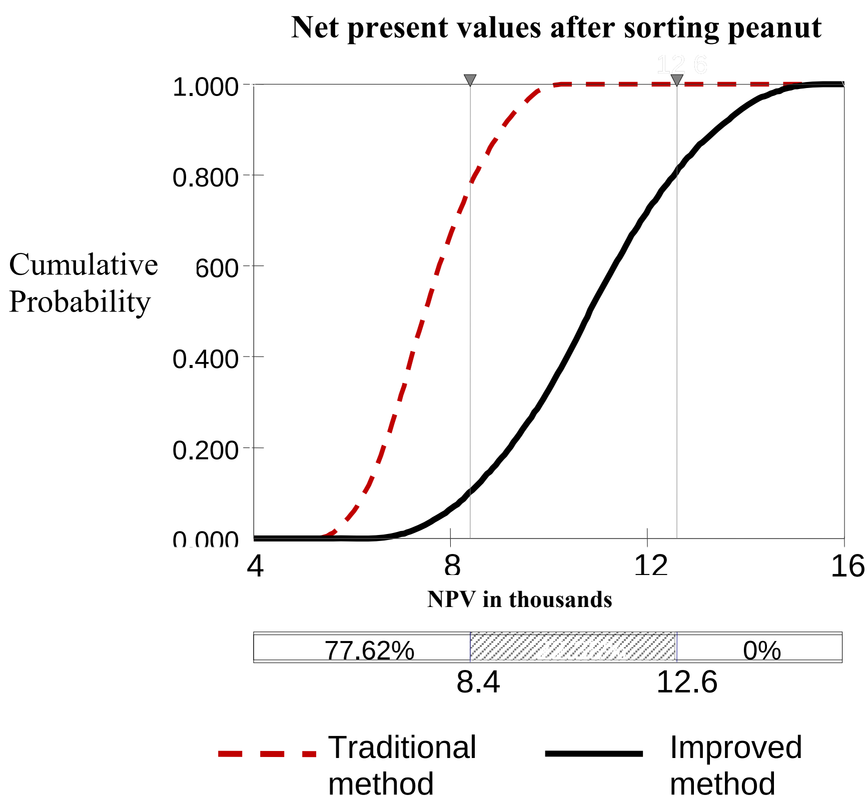


Figure 2.9. Cumulative probability distribution for the net present values for each type of stockers when sorting is done.



Appendix 2.1. Definition of parameters (inputs) used for risk models.

Parameters	Vendors	Processors	Stockers
Price (selling)	RiskTriang (0.09, 0.11, 0.13)	RiskTriang (5, 7, 10)	RiskTriang (0.63, 1.05, 1.5)
Purchasing price	RiskTriang (0.06, 0.09, 0.11)	RiskTriang (0.1, 0.15, 0.2)	
Purchase sorted peanut*	RiskDiscrete ({0,1},{0.2,0.8})	RiskDiscrete{0,1},{0.21,0.74})	
Sorting* No (0), Yes (0)	RiskDiscrete ({0,1},{0.91,0.09})	RiskDiscrete ({0,1},{0.9,0.1})	RiskDiscrete ({0,1},{0.60,0.40})
Storage	RiskTriang (0, 4, 8)	RiskTriang (0, 3, 6)	RiskTriang (0, 3, 7)
Sorting costs	RiskTriang (11, 13.75, 16.5)	RiskTriang (0, 60.5, 120)	RiskTriang (0.5, 2, 4)
Bagging	RiskTriang (4.5, 6.88, 9.5)		
Transportation	RiskTriang (0.5, 0.75, 1)		
Shelling	RiskTriang (26, 28.13, 30)	RiskTriang (10, 12.5, 15)	
Winnowing (1)		RiskTriang (0, 2.5, 5)	
Frying		RiskTriang (20, 22.75, 25.5)	
Winnowing (2)		RiskTriang (0.5, 1.8, 3)	
Sorting (2)**		RiskTriang (2.5, 5, 7.5)	
Milling		RiskTriang (27.5, 30.25, 33)	
Conditionment		RiskTriang (32.5, 35.25, 38)	
Treatment			RiskTriang (0, 2, 4.5)
Stocking			RiskTriang (0, 0.5, 1.5)

*Based on survey report.

* Purchase sorted peanut stands for the decision made by market participant on purchasing sorted peanut (No=0, Yes=1)

* Sorting stands for the decision made by market participant on sorting peanut (No=0, Yes=1)

**Processors sort twice peanut before processing into butter.

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