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Economics of Agricultural and Food Markets

Guest Editors: Anthony N. Rezitis, José M. Gil, Maria Sassi, and George Baourakis

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Editorial Board

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Editorial

Economics of Agricultural and Food Markets

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The agricultural and food sectors are very important components of economies around the world at national, regional, and global levels. Although production agriculture constitutes a very small percentage of the gross domestic product (GDP) in developed countries, the food system (incorporating the transportation, processing, distribution, and retailing of food products) represents a much higher percentage of the GDP. The main aim of this special issue is to publish high-quality economic research investigating supply and demand issues related to the agricultural and food markets. This is because during recent decades there has been a significant change in various components of the world agricultural and food sectors. This special issue publishes six research articles related to issues such as commodity food prices, food price inflation, food production and ecocertified food markets, consumption and demand for particular goods, that is, milk and vegetables, and financial and economic risks due to the aflatoxin contamination of peanuts as follows.

(i) The article entitled "*Commodity food prices: review and empirics*" provides a literature review of studies examining the potential causes and consequences of recent surges in food and agricultural commodity prices and develops a structural time series model to analyze the behavior of the IMF monthly commodity food price index for the past 20 years. The empirical results indicate that commodity food prices present seasonality and cyclicality with the longest periodicity of two years, and the forecasts show high and volatile commodity food prices.

(ii) The article entitled "*Food price inflation rates in the euro zone: distribution dynamics and convergence analysis*" examines the mean reversion attitude of food price inflation rates as well as the comovement of the inflation rates among different food subgroups in the Euro zone using nonparametric econometric methods. The results do not fully support the hypothesis of the food price inflation rates convergence for the whole period under investigation. Mean reversion shows up in different time periods and in different food categories.

(iii) The article entitled "*Firm's decisions based on consumers' choices in ecocertified food markets*" proposes a framework for examining whether a food production enterprise, attempting to build an ecocertification strategy, connects the creation of environmental value with the creation of economic value, balancing environmental sustainability with economic sustainability. An empirical investigation of the model using consumer data indicates that a variety of factors, such as consumer's age and profession, family's income and purchasing strategy, and product quality association in consumers' mind and the retailing outlet, play an important role in shaping the respondents' intention to pay for the producers' ecofriendliness.

(iv) The article entitled "*A case study of probit model analysis of factors affecting consumption of packed and unpacked milk in Turkey*" focuses on the effects of some sociodemographic factors, which influence the consumers' decision to purchase packed or unpacked fluid milk in Sivas, Turkey. The empirical results indicate that consumers with lower household size and higher income level tend to consume packed milk, while consumers sensitive to price are less likely to consume packed milk considering that packed milk price is expensive compared to unpacked milk price.

(v) The article entitled "*Demand for fresh vegetables in the United States: 1970–2010*" analyzes a demand system for eight major fresh vegetables in the USA using a first-differenced Linear Approximate Almost Ideal Demand System (LA-AIDS) to estimate price and expenditure elasticity of demand, imposing homogeneity and symmetry restrictions. The empirical findings indicate that consumers are not only responsive to changes in own prices, but they also respond significantly to changes in prices of other fresh vegetables consumed. Conditional budget share allocation to lettuce, cabbage, and celery has declined, while the share of the consumer dollar going to tomatoes, peppers, and onions has increased.

(vi) The article entitled "*Economic risks of aflatoxin contamination in marketing of peanut in benin*" examines the financial risk associated with sorting and storing of peanut and peanut products along the marketing chain. Study results show that the prices paid for peanut, prices received, the costs of sorting, and storage are dominant factors in reducing aflatoxin levels in peanut. Practices such as drying, sorting, and storing, however, pose financial risks in the market of peanut traders.

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Review Article

Commodity Food Prices: Review and Empirics

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The present paper provides a literature review of studies examining the potential causes and consequences of recent surges in food and agricultural commodity prices. Furthermore, this paper uses the structural trend methodology proposed by Koopman et al. (2009) to analyze movements in the IMF monthly commodity food price index for the period 1992(11)–2012(10) and to provide forecasts for the period 2012(11)–2014(12). The empirical results indicate that commodity food prices present seasonality and cyclicality with the longest periodicity of two years. The empirical findings identify certain structural breaks in commodity food price series as well as outliers. These structural breaks seem to capture the trend component of the price series well, while the outliers take account of temporal effects, that is, short-lived spikes. Finally, the presented forecasts show high and volatile commodity food prices.

1. Introduction

Commodity food prices have surged upwards in dramatic fashion in recent years after several decades of relative stability and low levels. In particular, commodity food prices increased dramatically between late 2006 and mid-2008, and by reaching high levels later on (i.e., during 2010, early 2011, and the third quarter of 2012), they caused serious concerns about a repeat of the 2006–2008 food crisis. This phenomenon has motivated several analyses of the factors that have caused commodity food prices to increase in recent years.

The purpose of the present paper is twofold. First, it reviews the empirical studies that identify and analyze the possible causes of the recent food and agricultural commodity spikes. Second, it uses a structural time series approach to analyze the behavior of the monthly commodity food price index for the past 20 years. In the empirical part, the present paper departs from previous detrending methods and employs a structural time series approach [1], which provides the possibility of discovering commodity price cycles. Furthermore, this approach permits not only the possibility of stochastic cycles but also the presence of stochastic trends in levels and growth rates and provides efficient forecasts on the commodity food price index.

The remainder of this paper is organized as follows. Section 2 presents and discusses the literature on the causes of commodity food price increases in recent years. In Section 2.1, specific discussion is devoted to the possible linkages between fuel and food prices, while in Section 2.2 the possible relation between speculation and food prices is provided. Section 3 presents the empirical part of the paper. In Section 3.1, the specification of the structural time series model used in the present paper is provided, while Section 3.2 discusses the data used in the estimation of the model. In Section 3.3, the discussion of the empirical results is presented. Conclusions are drawn in Section 4.

2. Literature Review and Main Findings

The literature distinguishes between agreed and disputed causes of the food price spikes that have characterized the new millennium (see, e.g., [2–4]). The former can be further articulated according to their operational time horizons and natures. Following Wiggins et al. [5], the evolution of the

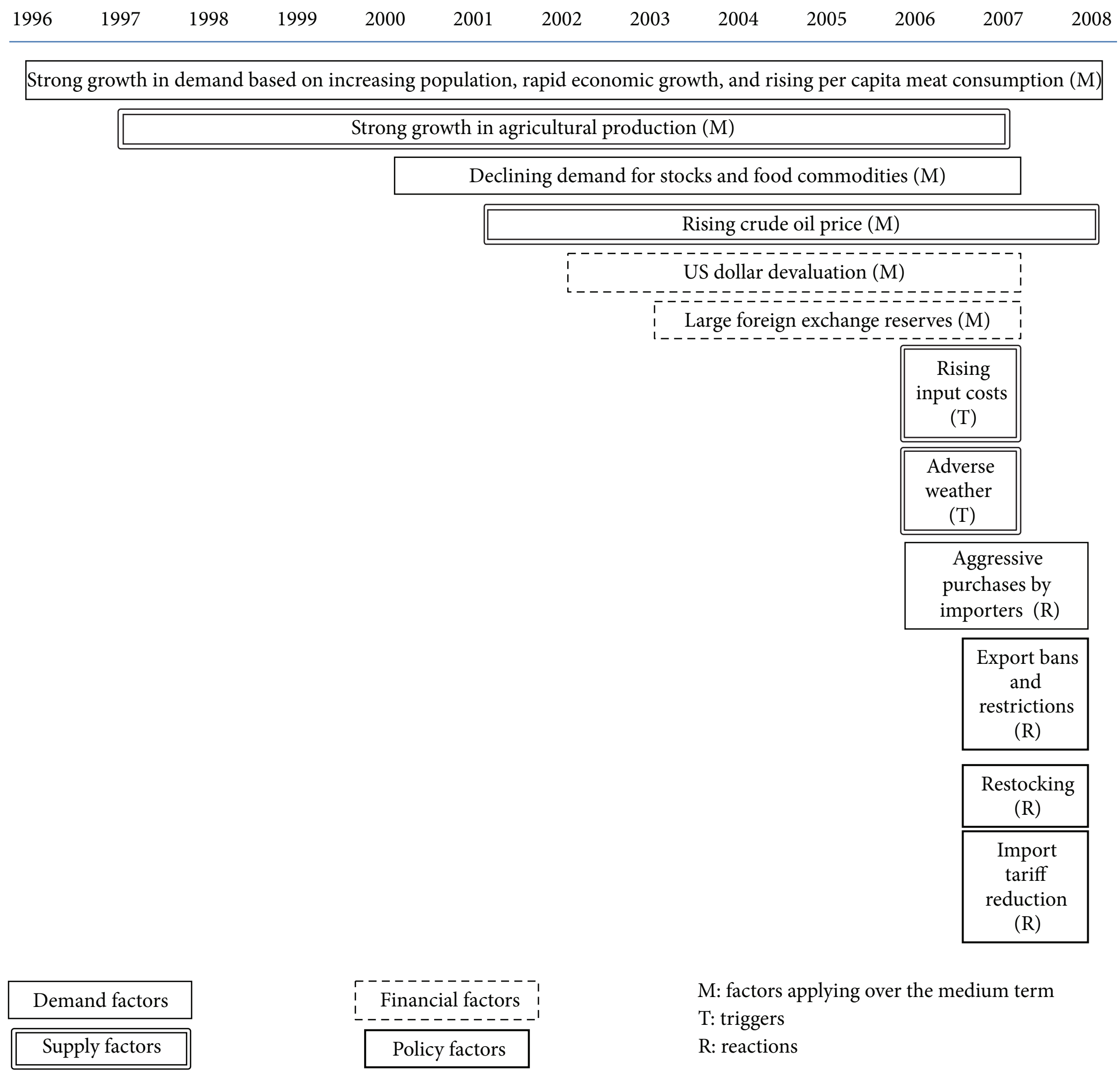


Figure 1: Timeline for the 2006–2008 price spike. Source: adapted from [6].

first price spike can be described as a combination of factors affecting the medium term from 2000 to 2006, triggers applying to the short (2006-2007) and very short (mid-2007-2008) periods during the spike, and panic reactions to the initial price increase that exacerbated the rise. The major common factors and triggers have a demand; supply and financial nature are illustrated in Figure 1.

Prakash and Gilbert [6] compare these factors with those at the basis of the 1973-1974 food crisis to highlight the similarities. However, the consequences were more severe in the 2007-2008 turmoil due to a different scenario. The 2007-2008 shock arose in a different context, characterized by at least two new elements. The former refers to the fact that the increase in commodity food prices on international markets was transmitted into the domestic market, contributing to making inflationary pressure more severe, particularly in developing countries (for a review of Sub-Saharan Africa see, e.g., [7]).

Despite the emphasis placed on this mechanism, the empirical literature suggests that at the level of each single country, the transmission of changes in international food prices on domestic food prices is far from straightforward. Further, the extent of such a transmission varies a lot according to several factors, such as dependence on food imports, transport costs, pass-through margins, the tradability of domestic foods, and exchange rate variations [8].

The second new element that distinguished the 2007-2008 food crisis context refers to the net trade position of developing countries, which become net importers from the 1990s, from the net exporters of agricultural and food commodities. The increase in commodity food prices means that these countries have to spend more for providing food on their domestic markets with the deterioration of the food trade balance, other macroeconomic difficulties, and an increase in food dependence from highly volatile international commodity markets.

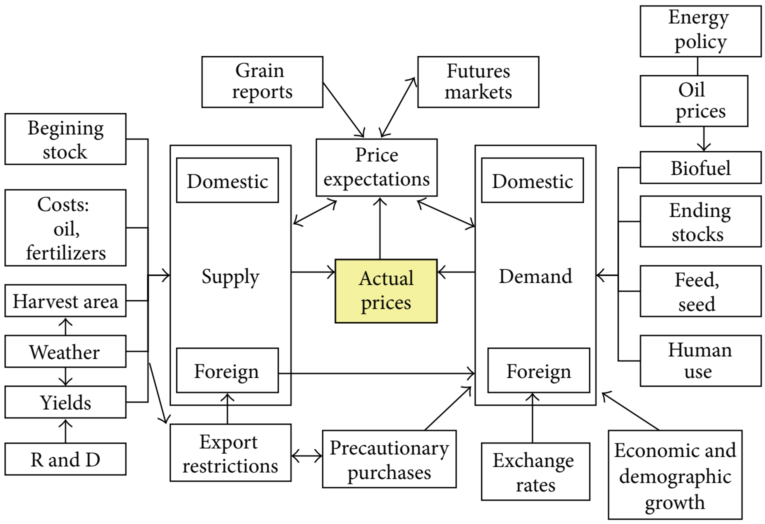


Figure 2: The nature of grain commodity price formation. Source: [9].

In the 2011 price spike, the above-mentioned factors find confirmation but with some differences related to the fact that international price increases are more widespread across agricultural commodities, weather-induced production shortfalls are more of a factor now, price volatility is greater, and policy responses are amplifiers of exceptional shocks.

If there is consensus on the role of the above-mentioned factors in affecting the 2007-2008 and 2011 food crises, the isolation of the extent of their impacts on food and agricultural commodity prices is a difficult task. As suggested by Headey and Fan [9], this is because of the complicated nature of grain price formation on the international market. As shown in Figure 2, this is the result of complex interactions among supply, demand, actual prices, and price expectations.

These complexities complicate the identification of the specific causes of price spikes and the intensity of their impacts. Table 1 provides a selection of contributions that investigate the fundamental drivers of food price spikes.

Important gaps in the literature include the so-called disputed causes of food price spikes, namely, biofuels and speculation on food and agricultural commodity markets.

2.1. Food Prices and Biofuels. The literature on food prices and biofuels (e.g., bioethanol and biodiesel) can be organized into two main bodies according to the focus of the analysis. On one side, there are studies that use time series techniques to investigate the dynamic linkages between biofuels and food commodities by referring to historical data on commodity prices and food indexes. Table 2 provides a selection of the results found by these studies in terms of the percentage weighting assigned to biofuels in rising food prices.

The linkages between fuel and food prices vary from 5% to 75% depending on the country analyzed, the typology of food and fuel taken into consideration, the reference price (indices, national, farm, or world prices), the methodology and assumptions adopted, and the time dimension of data. All these aspects make the findings from these studies difficult to compare [10]. However, a common aspect underlined by the majority of them is the identification of expanding biofuel consumption as a driver of rising food prices [11].

A second part of the literature is based on numerical models. These project the impact of the introduction of various biofuel trade and policy scenarios on food and commodity quantities and prices in the medium term, that is, between 2015 and 2020. Their findings are based on partial equilibrium (PE) or computable general equilibrium (CGE) models and, as in the case of the previous body of the literature, they generally, but not always, underline an increase in agricultural commodity prices as a consequence of expanded biofuel production. Apart from the expected smaller price effect in CGE models than in PE models due to their incorporation of the almost complete adjustment throughout the economy to the initial stimulus, the scale of the effects varies widely across studies.

The results based on the PE model elaborated by IFPRI—the IFPRI IMPACT model—suggest price increases, by 2020 with respect to 1997, of between 16% and 43% at best and between 30% and 76% at worst, depending upon the commodity [12]. Rosegrant [13] finds that with respect to 2007, freezing or eliminating biofuel production has a positive impact on commodity food prices by 2010 and 2015, projecting a decrease of between 1% and 20%. Wiggins et al. [14], using a CGE model, show the projected food commodity export price change by 2020 with respect to 2007 assuming that the EU and North America and Brazil follow their major biofuel mandates, targets, and support policies. The major findings are presented in Table 3.

As underlined by Pfuderer et al. [15], PE and CGE models show many limitations. Among them, four seem to be the most relevant. These models

(i) explain annual variation in prices and for this reason they do not consider volatility, a phenomena observed in some commodity markets that need monthly, weekly, and sometimes daily prices in order to be understood;

Table 1: Selection of studies aimed at investigating fundamental drivers for food price spikes.

Potential driver	Economic rationale	References
	Supply side factors	
Shocks in production	Production shortfalls caused by adverse weather conditions result in lower levels of global supply and stocks	[32]
Energy and fertilizer prices	High input prices increase agricultural production and transportation costs	[3, 4, 33]
Export policies	Some of the net exporting countries introduced restrictive trade policies aimed at isolating their economies and controlling the pass-through mechanism	[4]
Low level of global inventories	A consequence of production shortfalls and political decisions	[34, 35]
Neglected investment in R & D and infrastructure	A limit to the growth in agricultural productivity	[33]
	Demand side factors	
Emerging economies and structural change in global demand	Economic growth in BRIC raises individual welfare as well as urban population with a consequent shift in consumption patterns towards an increasing global demand for superior agricultural products. Effect on food prices is indirect via demand for crude oil	[36]
High oil prices	Reduction in price advantage of fossil fuels relative to biofuels and consequent increase in demand for competitive renewable energies	[33]
Global biofuels production	Increase in demand for crops used as input factors in biofuels production; driving prices of other crops through substitution effects in food utilization and through competition in the use of agricultural land	[3, 33, 34, 36, 37]
Import policies	Some of the importing countries lift import restrictions and taxes in order to alleviate domestic consumption; no decrease in aggregated global trade despite food inflation	[34, 37]
	Macroeconomic factors and market conditions	
Depreciation of USD	On the international level grains are traded in USD; due to the USD's depreciation price increases less in other countries' currencies relative to U.S. prices and import remained constant	[3, 4, 33]
Inelastic markets	Due to prevailing market conditions neither supply nor demand responded to price incentives; no expansion of supply or reduction of global demand	[37]

Table 2: Influence of bio-fuels on rising food prices.

Studies	Institution	Percentage change in food prices assigned to bio-fuels
[3]	World Bank	70–75
[38]	OECD	5–16
[13]	IFPRI	25–30

Source: [17].

(ii) estimate medium-term elasticities and for this reason are suitable for the analysis of medium-term market variations rather than short-term supply shocks;

(iii) are misleading because in order to generate the significant impact of biofuels on agricultural commodity prices they should introduce the two inconsistent assumptions of inelastic supply and large direct effects;

(iv) underestimate the role of other factors than biofuels representing important drivers of food price spikes.

Table 3: Projected food commodity export price percentage change by 2020—baseline 2007 prices (FOB prices).

Crops	EU-27	NAFTA	Brazil	Sub-Saharan Africa
Rice	−2.0	−0.6	−0.8	0.2
Wheat	−2.6	−0.7	0.2	0.1
Grains	14.9	21.3	4.8	10.8
Oilseeds	53.2	71.8	25.2	24.9
Sugar	−0.7	1.6	−0.5	2.5
Vegetable oil and fat	5.1	22.0	−1.4	3.0

In the study the world is aggregated into the four listed regions.
Source: [14].

As far as this latter issue is concerned, a body of the literature attempts to assess the relative importance of biofuel expansion in combination with other possible factors that contributed to the food price increases in 2007-2008 and 2011. Among them, Hochman et al. [16] include economic growth, exchange rate fluctuation, the rise in energy costs and inventory levels, and cross-price elasticity in Hochman et al. [10], while Arseneau and Leduc [17] take into consideration

Table 4: Selection of studies supporting the Masters' hypothesis.

Studies	Object of investigation	Econometric approach	Time series range
[27]	Potential feedback loop of high food prices driven by excessive speculation	Rolling window Granger causality tests	01/2002–02/2008
[39]	Supply, demand, and market factors affecting food prices	OLS regression; rolling window Granger causality tests	1/2002–06/2009
[2]	Impacts of demand and supply shocks on commodity prices	Univariate Granger causality tests; regression analysis	1971–2009
[40]	Linkage between commodity markets; special focus on rice markets	Daily rolling window Granger causality tests	31/12/1999–02/07/2008

the interest rate. These simulation models suggest that the impact of biofuel expansion on commodity prices can be amplified or reduced according to the factors included in the analysis. Hochman et al. [16] also show the important role of US biofuel production in affecting the price of several food commodities between 2001 and 2007.

2.2. Food Prices and Speculation. The literature on the role of speculation in food price crises can be articulated into two main bodies. On one side, there are the empirical studies that find evidence of a commodity price bubble due to excessive speculation and, on the other, there are those refuting this hypothesis. The analyses by bubble proponents find their origin in Masters' hypothesis [18]. Observing the comovements between commodity indices and the total amount of financial resources involved in commodity index funds from 1970 to 2008, Masters argues that commodity prices in 2007-2008 were mainly driven by the rapidly increased engagement of common index traders in futures markets. In contrast to those for physical and financial assets, hedgers and speculators coexist in commodity futures markets; as soon as speculators start to dominate markets, price bubbles may come into existence if trade is detached from fundamental movements. Following this line of thought, a group of studies investigates Masters' hypothesis using more rigorous econometric approaches. The majority of these are based on evidence derived from Granger causality tests (Table 4).

This body of the literature interprets speculation on futures markets as a factor that amplifies price spikes and volatility during food crises without measuring the intensity of the effect. Bass [19] sheds light on this aspect. Forecasting fundamental prices and assessing their divergence from historical trends, he estimates that speculation raised international food prices by around 10% to 15% from 1978 to 2008, particularly from 2004 to 2006 and from 2007 to 2009. However, it should be noted that this analysis shows many limitations, as Bass [19, page 52] himself admits, particularly because it adopts an ordinary least squares regression on annual data with a low number of observations. A final major contribution is by von Braun and Tadesse [20] that, among other aspects, detects the conditions for the emergence of price bubbles. The analysis concludes that short-term price spikes can be related to excessive speculative activity on futures markets, while volatility is better explained by demand shocks since oil price spikes increase demand for agricultural commodities.

Bubble opponents argue that the view of the proponents of this hypothesis lacks explanatory power and is rather unrealistic; in particular, they suggest that it requires a better understanding of the essential mechanisms of futures markets [21]. The main argument is that additional money on futures markets does not equal more demand. Futures markets are different from physical markets, since supply on long positions in theory is unlimited and to every additional long position held by index traders there exists a short counterpart. Moreover, opponents criticize the strict differentiation between hedgers and speculators and argue that today noncommercials as well as commercials strategically invest in long and short positions. Since all informed participants could easily react to index traders' mechanical behavior, it seems to be unlikely that such traders possess the power to dominate or even manipulate futures markets. This issue is investigated by Irwin and Sanders [22]. Introducing a new econometric approach into the relevant literature, namely, the Fama-MacBeth regression procedure, the results confirm earlier achievements [23, 24], pointing out that, from 2007 to 2011, there are no signals of excessive speculation and no potential positive causation between financial engagement and price volatility in futures markets.

Most of the speculative positions held by index traders are offset before the expiration date. They are detached from the delivery process and do not affect physical supply and demand. Krugman's argument directly addresses the transmission of futures to spot prices [20]. In his view, transmission only works by means of arbitrage and the physical hoarding of commodities. If detached high prices were transmitted from futures to spot markets, this would be indicated by means of an accelerated accumulation of global stocks. Bubble opponents also critically discuss the degree of reliance of the used Commodity Futures Trading Commission data, stating that they only provide a fair approximation of the realized position changes of commodity index traders [25].

The close examination of the econometric analyses conducted in different studies finds that some studies have not clearly differentiated between different market levels and their relations. In many of them, the link between speculative activities, futures markets, and spot prices remains undefined. An attempt to consider these aspects is the study by Sassi and Werner [26] that focuses on the speculative activity of different typologies of speculators on the futures market of the Hard Red Winter wheat from 2000 to 2012, introducing a methodology that distinguishes between the realized effects of futures and spot prices. Their evidence supports the hypothesis by Robles et al. [27] in the sense that speculation may have been influential on futures price returns of the analyzed commodity at least for certain periods of time.

3. Empirics

This section investigates the long-run and short-run fluctuations in commodity food prices by adopting a structural time series model, that is, the unobservable component time series model. This approach consists of useful components, such as trends, cycles, seasonal, and irregular, for analyzing the time series under consideration. Each component can be modeled as a stochastic process that depends on normally distributed disturbances. The unobservable component model used in the present paper has the additional advantage that it can also be used to generate effective forecasts, since more weights are given to the most recent observations. Previous empirical work employing structural time series models to analyze commodity prices includes that by Labys et al. [28]. (The study by Labys et al. [25] examines short-term cycles in primary commodity prices including the prices of corn, rice, soybeans, sugar, tea, and wheat.) Furthermore, the study by Cashin and McDermott [29] provides a literature review of the empirical work on the behavior of real commodity prices. The aforementioned work indicates that the most common model used to analyze commodity price movements is the unit root model or the stationary autoregressive model. The present paper, however, employs the unobserved component model, which has not been extensively used in the literature, to analyze and forecast movements in commodity food prices.

3.1. Model. To obtain a better understanding of the evolution of commodity food prices, the structural trend methodology of Koopman et al. [1] is used, which decomposes commodity food price series into components (trends, seasonal, cycles, interventions, and irregular). Let the logarithm of the commodity food price index be presented as y_t, and then a structural model is given as

$$\begin{aligned} y_t &= \mu_t + \gamma_t + \psi_t + \sum_{\tau=1}^{p} \phi_\tau y_{t-\tau} + \sum_{i=1}^{k} \sum_{\tau=0}^{q} \Delta_{i\tau} x_{i,t-\tau} \\ &\quad + \sum_{j=1}^{h} \lambda_j d_{j,t} + \varepsilon_t, \quad \varepsilon_t \sim N\left(0, \sigma_\varepsilon^2\right), \end{aligned} \tag{1}$$

where μ_t is the trend; γ_t is the seasonal; ψ_t is the cycle; x_{it} is an exogenous variable; d_{jt} is an intervention (dummy) variable; ε_t is the irregular; and ϕ_τ, $\Delta_{i\tau}$, and λ_j are unknown parameters.

The trend (μ_t) indicates the long-run permanent component of the series and shows the direction towards which the series is moving. In particular, the trend component captures permanent demand and supply changes as well as changes in any unobserved factor that are considered to be permanent. In the present analysis, the empirical results support the fact that the trend component should be better specified as a fixed term and given by

$$\mu_t = \mu_{t-1} + \eta_t, \quad \eta_t \sim \mathrm{NID}\left(0, \sigma_\eta^2\right) \quad \text{with } \sigma_\eta^2 = 0. \tag{2}$$

The seasonal component (γ_t) captures the fact that agricultural commodities are influenced by the weather. Furthermore, most primary crops (wheat, soybeans, and corn) are harvested once per year, which causes seasonal fluctuations in prices. In the present model specification, the seasonal component has a trigonometric deterministic seasonal form, which is given by

$$\gamma_t = \sum_{j=1}^{[s/2]} \gamma_{j,t}, \tag{3}$$

where each $\gamma_{j,t}$ is given by

$$\begin{bmatrix} \gamma_{j,t} \\ \gamma_{j,t}^* \end{bmatrix} = \begin{bmatrix} \cos\lambda_j & \sin\lambda_j \\ -\sin\lambda_j & \cos\lambda_j \end{bmatrix} \begin{bmatrix} \gamma_{j,t-1} \\ \gamma_{j,t-1}^* \end{bmatrix} + \begin{bmatrix} \omega_{j,t} \\ \omega_{j,t-1}^* \end{bmatrix}. \tag{4}$$

Note that $j = 1, \ldots, [s/2]$, $t = 1, \ldots, T$, $\lambda_j = 2\pi j/s$ is the frequency, in radians, while the seasonal disturbances ω_t and ω_t^* are two mutually uncorrelated normally and independently distributed disturbances with zero mean and common variance σ_ω^2. Since, in the present model specification, the seasonal component has a deterministic form, then $\sigma_\omega^2 = 0$.

Agricultural commodity prices are known for exhibiting price cycles beyond that explained by seasonality. In particular, livestock prices, such as hog and cattle prices, exhibit cyclical behavior. According to Sterns and Petry [30], hog cycles last for about four years, while based on Lawrence [31], cattle price cycles last for about 10 years. In this model, the cycle component (ψ_t) has a stochastic form that is given by

$$\begin{bmatrix} \psi_t \\ \psi_t^* \end{bmatrix} = \rho_\psi \begin{bmatrix} \cos\lambda_c & \sin\lambda_c \\ -\sin\lambda_c & \cos\lambda_c \end{bmatrix} \begin{bmatrix} \psi_{t-1} \\ \psi_{t-1}^* \end{bmatrix} + \begin{bmatrix} \kappa_t \\ \kappa_t^* \end{bmatrix}, \tag{5}$$

where ρ_ψ $(0 < \rho_\psi \leq 1)$ is the damping factor that reflects the speed with which various food price swings are dampened; λ_c $(0 < \lambda_c \leq \pi)$ is the frequency in radians that defines the basic cycle underlying the fluctuating food price series; and κ_t, κ_t^* are two mutually uncorrelated normally and independently distributed disturbances with zero mean and common variance σ_κ^2. The period of the cycle is $2\pi/\lambda_c$ and this indicates the time taken to go through its complete sequence of values. In estimating the model, the variance of the cycle itself (σ_ψ^2), rather than σ_κ^2, is taken to be the fixed parameter. (Note that $\sigma_\kappa^2 = (1 - \rho^2)\sigma_\psi^2$.) Note that in the present model two cycles are considered, that is, cycle 1 and cycle 2.

The variable $y_{t-\tau}$ indicates the lagged values of the dependent variable. In the present model, four lagged values,

Table 5: Descriptive statistics.

Variables	Means	Standard deviations	Variables (logarithms)	Means	Standard deviations
cfpi	111.97	30.451	lcfpi	4.6855	0.24925
coil	83.247	59.802	lcoil	4.1745	0.70054
reer	105.55	8.1379	lreer	4.6563	0.075735

cfpi stands for the commodity monthly food price index (2005 = 100), coil stands for crude oil (petroleum) monthly price and is measured in U.S. dollar per barrel, reer stands for the U.S. real effective exchange rate (2010 = 100).

that is, 1, 3, 4, and 5, are included because these are found to be statistically significant. Two exogenous variables (x_{it}), such as crude oil (petroleum) and the US real effective exchange rate, are included in structural model (1). The crude oil (petroleum) price is considered because when it increases farmers face higher prices for fuel and fertilizer and thus livestock and crop production costs increase. Furthermore, high oil prices make biofuel production more profitable and this causes increases in the prices of grain, sugar, and vegetable oils, which are used not only in food production but also in biofuel production. The US real effective exchange rate is used because the US dollar is the main currency for the global trade of most commodities and other goods. Commodity food prices measured in dollars increase when the dollar depreciates against other currencies and decrease when the dollar appreciates. The inverse relationship between the exchange rate and commodity food prices can also be attributed to inflation. More specifically, when the dollar depreciates, investors and speculators concerned about higher inflation rates invest in commodities futures such as grains, thereby driving up commodity food prices.

Intervention variables (d_{jt}) are dummy (or indicator) variables that are used to capture structural breaks or outlying (irregular) observations. A structural break is modeled by a step intervention variable that takes the value of zero before the event and one after. The structural break dummy variable shifts the level of the series (μ_t) up or down and can be attributed to permanent events, such as changes in economic policies and structural reforms. An outlier (irregular) is modeled by an impulse intervention variable that takes the value of one at the time of the outlier and zero otherwise. An outlier can be considered to be a temporally large value of the irregular disturbance at a given time and can be attributed to temporary events such as oil price or weather shocks.

3.2. Data. The data set used is monthly data on the logarithm of the commodity food price index (lcfpi) from 1992(11) to 2012(10), with 2005 = 100. The commodity food price index includes the price indices for cereals, vegetable oils, meat, seafood, sugar, bananas, and oranges, and it is obtained from the International Monetary Fund (IMF). Two exogenous variables are used in the present model: the logarithm of crude oil monthly prices (lcoil) and the logarithm of the US monthly real effective exchange rate (lreer). The crude oil (petroleum) price is measured in US dollars per barrel

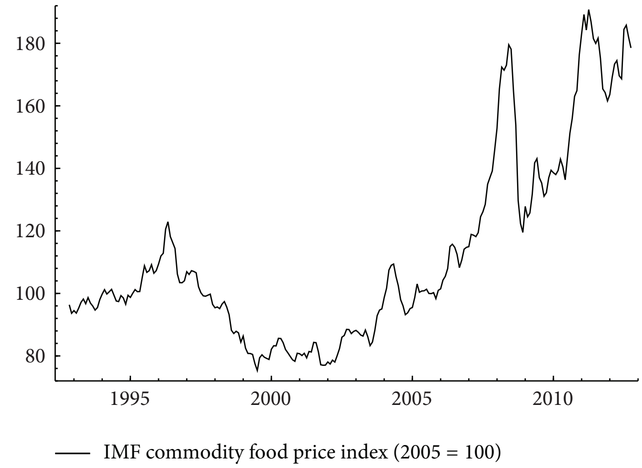


Figure 3: Evolution of the IMF commodity food price index 1992(11)–2012(10).

and is a simple average of three spot prices, that is, Dated Brent, West Texas Intermediate, and the Dubai Fateh. It is obtained from the World Bank. The US real effective exchange rate is a real (CPI-based) narrow monthly index (2010 = 100) comprising 27 economies that is obtained from the Bank of International Settlements. Thus, the US real effective exchange rate measures the overall value of the dollar against a basket of 27 currencies. The descriptive statistics (means and standard deviations) of the data set used in the present paper are reported in Table 5.

Figure 3 presents the evolution of the IMF commodity food price index from 1992(11) to 2012(10). Commodity food prices increased dramatically between late 2006 and mid-2008. Prices then fell drastically in the final months of 2008, after peaking at their highest level in 30 years in the second quarter of 2008. They reached at a level slightly higher than that of 2008 in the first months of 2011 and then rose in the first half of 2009 and during 2010. They decreased in the second half of 2011 but increased again during 2012 and by the third quarter of 2012 reached the 2008 price level. The resurgence of high commodity food prices in 2010, early 2011, and by the third quarter of 2012 prompted concerns of a repeat of the 2006–2008 food crisis, threatening increasing food insecurity, food price inflation, and civil unrest. (Note that the causes of the 2006–2008 food crisis have been discussed in detail in previous sections of the present paper.)

Table 6: Diagnostics and goodness-of-fit statistics.

Statistics	Values
Log L	759.049
$N(\chi_2^2)$	1.3586 [0.5069]
$H_{63}(F_{63,63})$	1.2753 [0.1685]
DW	2.0077
$Q(24, 18)$	25.286 [0.1172]
R^2	0.8054

Values in brackets are P values.

Table 7: Variance of disturbances: values and q-ratio.

Variance of disturbances	Values	q-ratio
σ_η^2	0.00000	0.0000
σ_ω^2	0.00000	0.0000
$\sigma_{\kappa_1}^2$	3.015×10^{-5}	0.2283
$\sigma_{\kappa_2}^2$	0.00013	1.0000
σ_ε^2	0.00000	0.0000

q-ratio is the ratio of each variance to the largest.

Table 8: Parameters of cycles 1 and 2.

Parameters	Values
$\sigma_{\psi_1}^2$	0.0001
$2\pi/\lambda_{c_1}$	6.4499 (0.5375 years)
λ_{c_1}	0.9741
ρ_{ψ_1}	0.8420
$\sigma_{\psi_2}^2$	0.0009
$2\pi/\lambda_{c_2}$	25.1651 (2.0970 years)
λ_{c_2}	0.2496
ρ_{ψ_2}	0.9196

3.3. Results. Models (1) to (5) can be estimated using the maximum likelihood approach, as shown in Harvey [41]. In the estimation, the variance hyperparameters, that is, $\sigma_{\kappa_1}^2$ and $\sigma_{\kappa_2}^2$, are first obtained and then the trend, seasonal, and two cycle components can be extracted by a smoothing algorithm, as in Koopman [42]. The empirical results obtained using the STAMP 8.2 package of Koopman et al. [1] indicate strong convergence.

Table 6 presents some diagnostics and goodness-of-fit statistics, such as the Log L (log-likelihood), $N(\chi_2^2)$ (normality test statistic having an χ^2 distribution with two degrees of freedom), $H_{63}(F_{63,63})$ (heteroskedasticity test statistic having an F distribution with $(63, 63)$ degrees of freedom), DW (the classical Durbin-Watson test statistic), $Q(24, 18)$ (the Box-Ljung statistic based on the first 24 autocorrelations and tested against an χ^2 distribution with 18 degrees of freedom), and R^2 (coefficient of determination). The aforementioned statistics do not indicate any deficiencies in the estimated model.

Figure 4 presents additional information about the estimated model, namely, graphs of the standardized residuals, residual correlogram, spectral density, and density. The residuals are the standardized one-step-ahead perdition errors or innovations, as defined in Koopman et al. [43], and for a correctly specified model, they are assumed to be normally and independently distributed. Thus, the aforementioned statistics (Table 6) and graphs presented in Figure 4 are the means of checking the validity of the model. In particular, the correlogram and spectral density graphs presented in Figure 4 indicate that the residuals are not autocorrelated. (Note that the theoretical spectrum is a horizontal straight line for white-noise residuals.)

Figure 5 shows the extracted unobserved components for trend (level, regression, and interventions), seasonal, and the two cycles, that is, cycle 1 and cycle 2.

As indicated from the q-ratios in Table 7, the fluctuations in the irregular component are zero, implying that all variations in the series are attributed to cycles 1 and 2, since the level and seasonal components are fixed. Furthermore, the q-ratios indicate that the fluctuations in cycle 2 are a more important source of variations than those in cycle 1.

Table 8 presents the cyclical parameters in more detail and indicates that the shorter cycle, that is, cycle 1, has a variance ($\sigma_{\psi_1}^2$) of 0.0001, a period of 0.5375 years, and a damping factor (ρ_{ψ_1}) of 0.8420, while the longer cycle, that is, cycle 2, has a variance ($\sigma_{\psi_1}^2$) of 0.0009, a period of 2.0970 years, and a damping factor (ρ_{ψ_1}) of 0.9196. These results indicate that even though both cycles show a high degree of persistence, they are stationary, since their damping factors are less than one. Thus, in the long run the cyclical components dissipate, and the forecast of the commodity food price series converges towards its trend value. The estimated periodicity of cycle 2 is about two years, which could be considered to be the result of the averaging process in which the cyclical values of individual commodity food price series constituting the aggregate commodity food price index interact. More specifically, the cyclical activity in agricultural food prices is often the result obtained with a one-year cycle for annual crops, up to two-year cycles for livestock production, and up to six-year cycles for perennial crops. (The empirical results of the present paper related to the cyclical activity of commodity food prices are comparable with those proposed by Labys et al. [25].) An inspection of the graph corresponding to the long cycle (cycle 2) in Figure 5 indicates that the more pronounced cycle activity occurred after 2003. This finding is consistent with the literature which indicates that factors causing higher and more volatile commodity food prices came into effect in 2003 and eventually these factors caused the 2006–2008 food crisis as well as the subsequent food price variability.

The maximum likelihood estimates of the final state vector and regression effects (lagged endogenous variables,

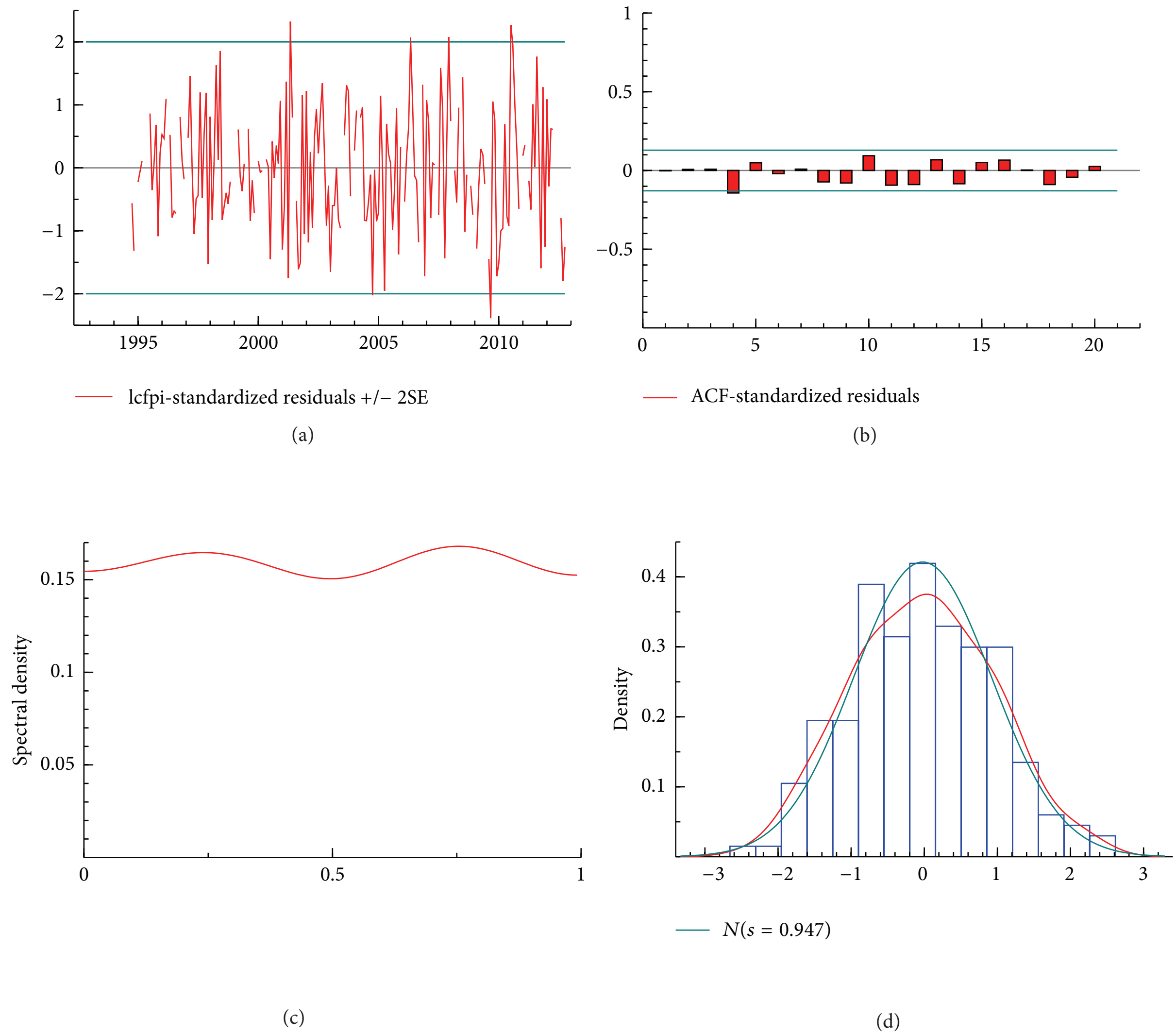


Figure 4: Commodity food price index (lcfpi) residuals.

exogenous variables, and intervention dummies) are presented in Table 9.

Taking the exponential of μ_T(=6.469) yields the level value of the commodity food price index at the end of the period (651.837). The results also indicate that the amplitude of cycle 1 as a percent of the level is 3.279%. The importance of seasonal effects is statistically significant since the χ^2-statistic presented in Table 9 is significant. In particular, seven out of 12 seasonal effects are statistically significant at conventional levels of significance. These effects indicate that from August to December commodity food prices drop below the trend level; from February to May they are above the trend level; and for the months of January, June, and July they are at the trend level. (Seasonal effects can be provided as factors of proportionality by using "antilog" analysis. Thus, the commodity food price index is, on average, lower than the trend level by 0.82% in August, 1.11% in September, 1.85% in October, 1.88% in November, and 0.62% in December. However, it is, on average, higher than the trend level by 1.65% in February, 1.61% in March, 0.96% in April, and 1.41% in May.) The impact of seasonality might be mainly attributed to crop production such as corn, soybeans, and wheat. Most of these crops are harvested once per year, in fall, and thus the price level drops below the trend line in the fall, as indicated by the empirical results presented in Table 9. By contrast, the price level is above the trend line earlier in the year, that is, from February to May, since food manufacturers buy high quantities of crops to protect themselves against possible tight crop supplies later in the year, that is, after the harvest. Note that this drives up commodity food prices earlier in the year, but as harvest time approaches, that is, June and July, commodity food prices approach the trend price level.

The empirical results in Table 9 show that the effects of the four lagged values on the commodity food price index, that is, y_{t-1}, y_{t-3}, y_{t-4}, and y_{t-5}, are statistically significant,

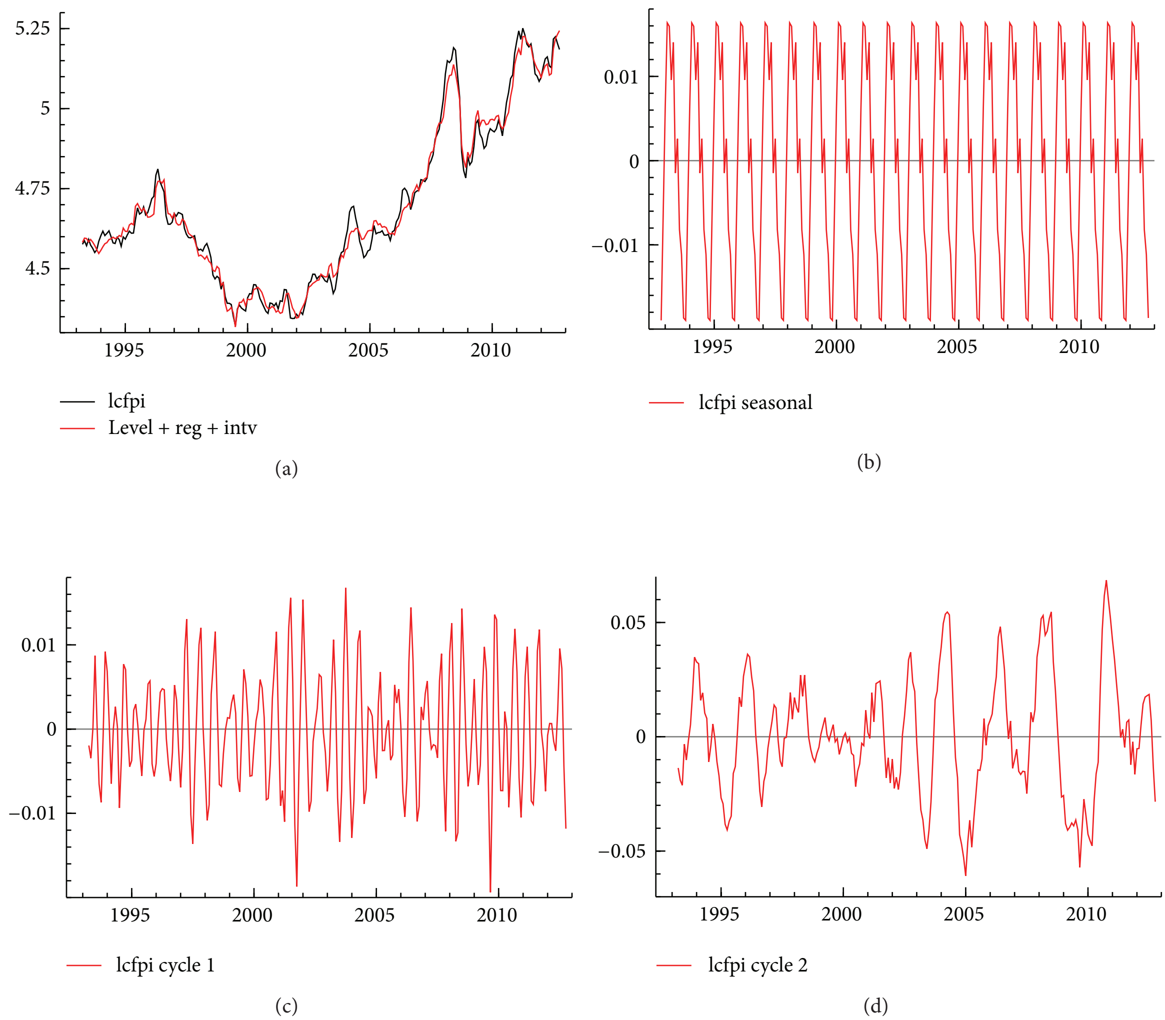


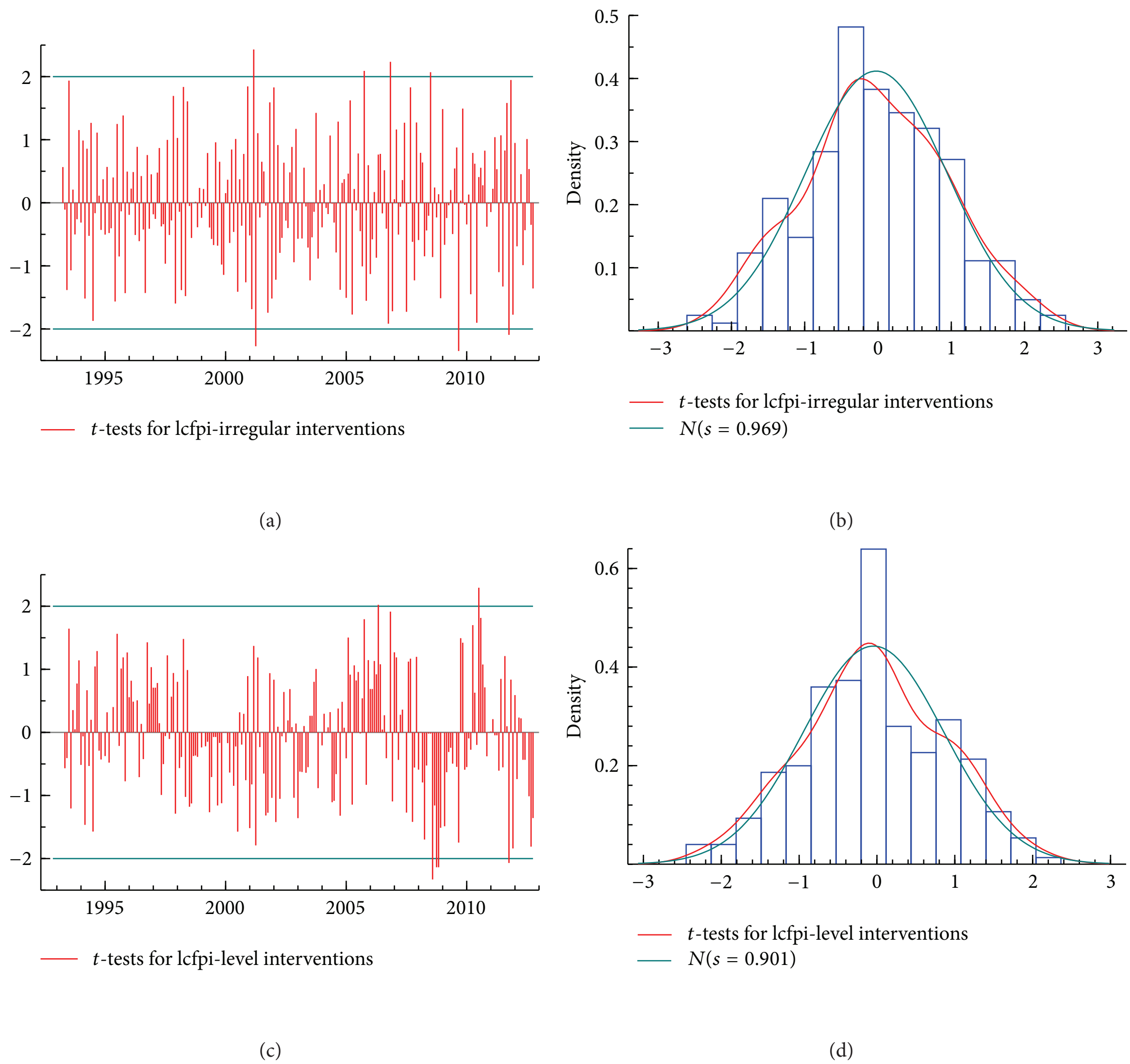
Figure 5: Commodity food price index (lcfpi) decomposition.

indicating that past prices affect the current price level. In the same manner, the effects of the two explanatory variables, that is, crude oil (lcoil) and the US real effective exchange rate (lreer), are statistically significant and they have the expected signs. Further, the diagnostic tests on the auxiliary residuals are presented in Table 10 and these indicate that they are generally well behaved. (Auxiliary residuals are smoothed estimates of irregular and level disturbances [44].)

Figure 6 shows the graphs of the t values corresponding to the estimated auxiliary residuals. These graphs show that the t values do not exceed three in absolute value, indicating that the most extreme interventions have been included in the model.

The empirical results on the intervention effects reported in Table 9 show that 18 effects are related to structural breaks while nine are related to outliers. Most of the structural breaks, that is, 12 out of 18, have a positive effect on the price level, while most of the outliers, that is, seven out of nine, have a negative effect. It is worth noting that the 2006–2008 food crisis is captured by the structural break interventions, that is, 2006(10), 2007(6), 2008(2), and 2009(1), while the 2009 price decrease (due to the dollar appreciation) is captured by the 2009(7) break intervention. Furthermore, the 2010 and 2012 price increases are captured by the corresponding break dummies, 2010(12) and 2012(7), respectively. It should also be stated that the remaining structural break dummies take into account the trend of the price level series quite well. For example, the 1996(9), 1998(12), and 1999(2) structural break interventions take into account the downward trend in the commodity food price level from 1996 to 1999, while the 1995(6) and 1996(4) ones capture the upward trend in price level. Finally, the outliers capture some temporal effects, that is, short-lived spikes, well.

Figure 7 shows the prediction graphics created by estimating the model from 1992(11) to 2010(11) and reserving 2010(12) to 2012(10) for the out-of-sample forecast. Predictions are made using the information at the end of 2010 and are updated with the arrival of each new observation. The predicted values of the commodity food price index (lcfpi) and residuals are inside the prediction intervals, set at two



(a) (b) (c) (d)

Figure 6: Auxiliary residuals: irregular and level.

root mean square errors (RMSEs). The CUSUM plots testing parameter stability and forecast accuracy indicate that the model specified in the present paper is a good one and that its forecasting performance is generally accurate.

Furthermore, the post-sample predictive tests presented in Table 11 reconfirm the aforementioned argument.

Figure 8 provides forecasts of the commodity food price index (lcfpi) from 2012(11) to 2014(12). The forecasted values are given within a forecasting interval of one RMSE on either side. The forecasts indicate that commodity food prices are expected to remain above their historical trend levels at least until late 2014.

4. Conclusions

A considerable number of empirical studies identify and analyze the possible causes of recent food and agricultural commodity spikes. Several of these factors are commonly identified as being responsible for the price shift, while other potential explanations are controversially discussed or even negated. Moreover, the literature argues about the econometric approaches adopted for the investigation of how these factors affect food and agricultural commodity price formation. These different positions are often difficult to reconcile and perhaps should be interpreted in order to understand common global trends in a series of food crises that are not the result of a single casual event but rather the consequence of a momentous combination of distinct but strongly interrelated factors.

This paper uses the structural time series approach to analyze movements in the monthly commodity food price index for the period 1992(11)–2012(10). The price series is decomposed into components such as trend, seasonal, cycle, interventions (dummies), and irregular. Then, forecasts are obtained for each month of the period 2013-2014. The empirical results indicate that the price series is best described

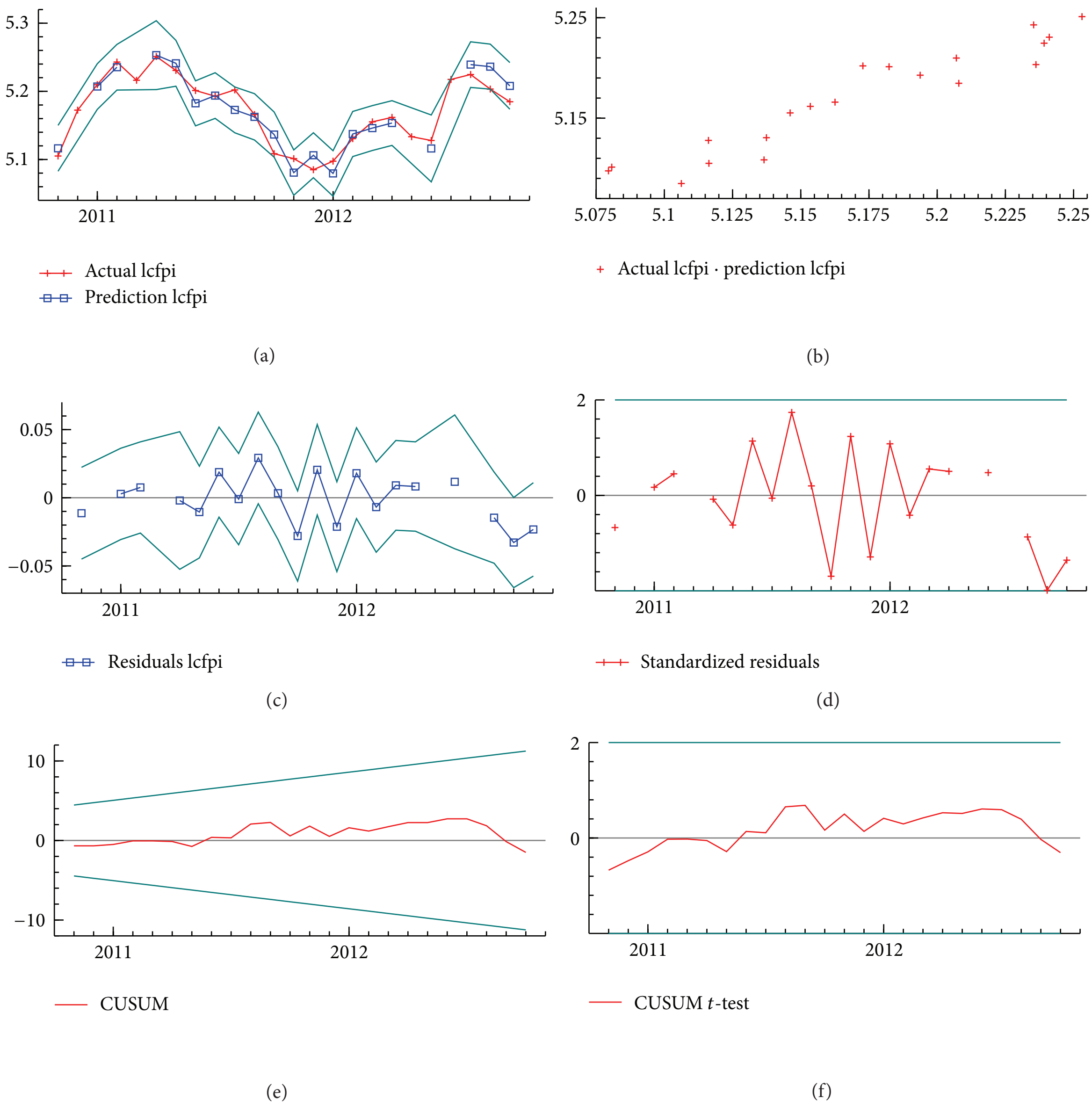


Figure 7: Prediction testing for the commodity food price index (lcfpi).

by a fixed level; fixed seasonal; two stochastic cycles; two explanatory variables, that is, crude oil and the US real effective exchange rate; and several intervention dummies, that is, structural breaks and outliers. Both cycles show a high degree of persistence but they dissipate in the long run. The longer cycle shows a periodicity of two years, and the more intense cyclical activity takes place after 2003, which is consistent with the literature and indicates that the consequences of that factors affecting commodity food prices began to appear after 2003. The effect of the explanatory variables on commodity food prices is the expected one and this finding is supported by the literature. In particular, crude oil has a positive effect, while the US real effective exchange rate has a negative effect. The structural break dummies capture the trend component of the price series adequately, while the outliers capture some temporal effects, that is, short-lived spikes, well. The structural break dummies generated by the estimation process also coincide with the years that are most extensively discussed by the literature analyzing movements in commodity food prices. Finally, the model presented in the present paper provides monthly forecasted values of the commodity food price series from 2012(11) to 2014(12). The forecast shows high and volatile commodity food prices for the medium term, that is, the next two years. High and volatile commodity food prices have a devastating effect on developing countries and the world's poor. Some short- and long-term strategies for coping with food price volatility in ACP counties are stabilizing food prices, setting up emerging food stocks at a regional level, facilitating the exchange of agricultural data, protecting the most vulnerable populations, and raising smallholder productivity [45].

Table 9: State vector analysis and regression effects in final state at time 2012(10).

State vector analysis at period 2012(10)		
	Value	Probability
Level (μ_T)	6.47980	[0.0000]
Seasonal χ^2 test	57.32373	[0.0000]
Cycle 1 (ψ_T) amplitude	0.03280	.NaN
Seasonal effects (γ_T)		
Period	Value	Probability
1	0.00616	[0.1813]
2	0.01636	[0.0004]
3	0.01594	[0.0006]
4	0.00958	[0.0358]
5	0.01404	[0.0022]
6	−0.00147	[0.7401]
7	0.00260	[0.5499]
8	−0.00819	[0.0616]
9	−0.01116	[0.0124]
10	−0.01867	[0.0000]
11	−0.01896	[0.0000]
12	−0.00620	[0.1889]
Regression effects in final state at time 2012(10)		
	Coefficient	Probability
y_{t-1}	0.32500	[0.0000]
y_{t-3}	0.12425	[0.0033]
y_{t-4}	0.10608	[0.0177]
y_{t-5}	−0.21217	[0.0000]
lcoil	0.03990	[0.0021]
lreer	−0.78676	[0.0000]

Interventions (d_j)					
	Coefficient	Probability		Coefficient	Probability
Level break 1994(12)	0.05223	[0.0006]	Outlier 1997(1)	0.02872	[0.0102]
Level break 1995(4)	−0.04487	[0.0033]	Outlier 1999(7)	−0.04228	[0.0001]
Level break 1995(6)	0.05778	[0.0002]	Outlier 1999(12)	−0.03371	[0.0028]
Level break 1996(4)	0.06678	[0.0000]	Outlier 2003(7)	−0.02340	[0.0322]
Level break 1996(9)	−0.04478	[0.0020]	Outlier 2006(1)	−0.02928	[0.0078]
Level break 1998(12)	−0.05266	[0.0004]	Outlier 2008(6)	0.03060	[0.0057]
Level break 1999(2)	−0.03371	[0.0028]	Outlier 2008(10)	−0.05242	[0.0000]
Level break 2000(4)	0.03415	[0.0127]	Outlier 2011(3)	−0.04188	[0.0002]
Level break 2001(7)	0.03540	[0.0037]	Outlier 2012(5)	−0.02677	[0.0155]
Level break 2003(12)	−0.04459	[0.0027]			
Level break 2004(3)	0.05025	[0.0006]			
Level break 2006(10)	0.07013	[0.0000]			
Level break 2007(6)	0.04911	[0.0014]			
Level break 2008(2)	0.03841	[0.0124]			
Level break 2009(1)	0.07851	[0.0000]			
Level break 2009(7)	−0.06275	[0.0000]			
Level break 2010(12)	0.07104	[0.0000]			
Level break 2012(7)	0.07473	[0.0000]			

Values in brackets are P values.

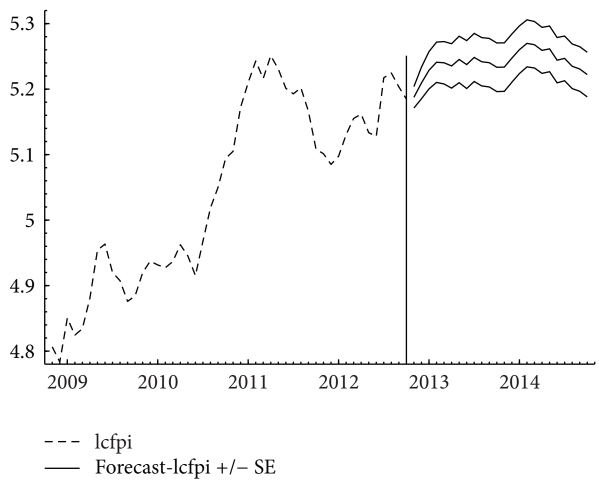


Figure 8: Commodity food price index (lcfpi) forecast.

Table 10: Normality tests (χ^2 tests) for auxiliary residuals: irregular and level.

	Skewness	Kurtosis	Bowman-Shenton
Irregular	0.04860 [0.8255]	1.44640 [0.2291]	1.49500 [0.4735]
Level	0.00765 [0.9303]	1.24770 [0.2640]	1.25540 [0.5338]

Values in brackets are P values.

Table 11: Postsample prediction tests on commodity food price index (lcfpi).

Failure χ^2_{20} test	20.1958 [0.4457]
CUSUM $t(20)$ test	−0.3339 [1.2581]

Values in brackets are P values.

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Research Article

Firm's Decisions Based on Consumers' Choices in Ecocertified Food Markets

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The present paper proposes a framework for examining whether a food production enterprise, attempting to build an ecocertification strategy, connects the creation of environmental value with the creation of economic value, balancing environmental sustainability with economic sustainability. More specifically, the paper combines demand theory with a discreet choice consumers' model in an embryonic ecocertified food market, to examine whether economic value is created and to identify the determinants of this value creation. An empirical investigation of the model using consumer data indicates that a variety of factors, such as consumer's age and profession, family's income and purchasing strategy, product quality association in consumers' mind and the retailing outlet, play an important role in shaping the respondents' intention to pay for the ecofriendliness of products. The proposed framework can help enterprise management to balance the consumers' and enterprise owners' claims in cases where certification schemes or standards exist that enable enterprises to communicate social responsibility to their customers.

1. Introduction

The corporate environmental behavior evolves from a regulation-driven reactive mode to a proactive approach, since firms that adopt proactive environmental management strategies become more efficient and competitive [1]. This transition in business thinking from a reactive to a more proactive approach reveals operations, systems, processes, and actions that yield environmentally responsible products and services as outputs. Thus, enterprise management needs methods enabling it to develop innovative products and services that contribute to environmental protection and social welfare, without eroding the firm's viability. Since the existing methodologies have been criticized as reactive rather than proactive [2, 3], enterprises need new methodological tools for designing strategies and building environmentally responsible organizations efficiently.

In some cases, the proactive policies of environmentally responsible enterprises focus on adopting ecocertification/ecolabeling schemes. These schemes emerged as important market-based mechanisms aimed at internalizing the externalities generated throughout the supply chain, by aligning private incentives with social values attached to natural resources and the environment [4, 5]. In these new ecocertified/ecolabeled products markets (embryonic markets), if consumers recognize the ecolabels and trust the information, they might be willing to pay price premiums for certified products supplied in the market (in fact, OECD [6] reports, based on a survey of over 10,000 households in 10 OECD countries, that half of the respondents recognize organic food labels and that labeling and certification are a key factor in purchasing organic food. Within an evolutionary game theoretic framework, Lozano et al. [7] show that certification is a very powerful signaling device dominating uncertified environmental practices and gradually replacing them). If ecolabeling successfully bridges the information gap for consumers, then the price premiums could compensate for the additional costs incurred by the businesses when implementing a certification program [8]. Thus, enterprises would be able to plan and implement an ecocertification strategy and create (shared) value for relevant stakeholders, especially for those who demand environmental responsibility (customers) and who are owners or investors.

This paper develops a framework for examining whether the enterprise creates economic value when it creates environmental value by combining demand theory with a consumer choice model in an embryonic market, such as the ecocertified food products market. In addition, it identifies the determinants of economic value that provide useful information to enterprises, certification organizations, and public authorities. The present paper contributes to the literature by considering a broader group of factors influencing consumers' decisions, including such as, product ecofriendliness, the marketing environment, and consumer characteristics. Thus, it will be useful for enterprises to efficiently integrate (shared) value creation into their strategies, moving towards more sustainable thinking in which environmental/societal issues are at the core and not on the periphery.

The rest of the paper is structured as follows. Section 2 presents the literature review, while Section 3 examines the environmental responsible firm's decisions, and Section 4 attempts to connect the profit function with the consumers' choice decisions. Section 5 presents the intention-to-pay model, Section 6 presents the results of the empirical analysis, and, finally, the conclusions and propositions for future research are presented in Section 7.

2. Literature Review

A growing body of literature examines consumers' purchasing behavior concerning ecocertification and product ecolabeling in conjunction with consumers' socioeconomic characteristics. Govindasamy and Italia [9] evaluate the demographic characteristics of consumers that impact their willingness to purchase Integrated Pest Management products. Blend and van Ravenswaay [10] examine how consumers' economic and sociological characteristics affect their intentions to purchase ecolabeled apples. Magnusson and Cranfield [11] examine the effect of various consumers' characteristics on their demand for pesticide-free products in three Canadian cities. Furthermore, Brécard et al. [12] examine the determinants of the demand for ecolabeled seafood products and they find that "green" behavior in this market is highly correlated to consumer information, intrinsic motivation and socioeconomic status.

There are also studies examining the role of the consumers' attitudinal, cognitive, and informational factors on purchase decisions. Grankvist and Biel [13] examine the relationship between consumers' attitudes and their buying behavior towards ecolabeled food products, and Souza et al. [14] examine consumers' understanding of labeling and empirically investigate the association of consumers' demographic profile with their attitudes towards such labels. Mostafa [15] investigates the influence of three cognitive and attitudinal factors on gender differences in green purchase behavior, and van Amstel et al. [16] analyze five food labels and test the reliability of the information they provide.

A number of studies in the last decade examine the impact of socio-economic profiles on WTP. For example, Jensen et al. [17] study the role of some demographic and attitudinal factors on WTP for three types of wood products. Loureiro and Lotade [18] examine WTP for organic and fair-trade coffee in conjunction with some demographic characteristics, and Krystalis et al. [19] offer insights into organic consumer profiles and their WTP.

Another branch of the literature examines the role of consumers' attitudinal, perceptual, cognitive, behavioral, and informational factors on WTP. Vlosky et al. [20] examine the relationships between intrinsic environmental motivations and WTP for environmentally certified products. They suggest that there are positive correlations between WTP and environmental consciousness and certification involvement and perceived importance of certification. Loureiro et al. [21] assess WTP for ecolabeled apples and conclude that people with strong environmental and food safety concerns are more likely to pay a premium. Botonaki et al. [22] examine consumer attitudes and behavior towards organic products and products produced under the Integrated Management System and compare the socio-economic characteristics and attitudes that impact WTP for these certification systems. Their findings suggest that consumers' level of awareness and information towards the certification systems is low. Barnard and Mitra [23] study the impact of consumers' attitudes and some demographic characteristics on WTP, indicating the significance of a third party certification, and Moon et al. [24] address the issue of WTP for food produced with techniques consistent with environmental stewardship, identifying differences in WTP between residents of two different districts of the same city based on their preferences, beliefs, and values. In a recent published study, Akaichi et al. [25], using experimental auctions, assess the determinants of consumers' WTP for organic milk in a multiunit shopping scenario. Their results suggest that health issues, high price of organic foods, taste, and lack of information on organic foods are factors that influence WTP for organic milk.

As is apparent from the literature review above, most studies examine the effect of a relatively small number of factors or specific categories of factors (demographic, attitude, socio-economic, cognitive, informative, beliefs, and values) on WTP. However, given the complexity of decision making, it is clear that WTP depends on a wider range of parameters. The present paper attempts to integrate a large number of factors affecting WTP, including consumer characteristics, product ecofriendliness, and the marketing environment, connected to an enterprise's ecofriendly decisions. Thus, a framework is proposed to identify the conditions under which a food enterprise creates economic value by creating environmental value, balancing environmental sustainability with economic sustainability.

3. Environmentally Responsible Firms' Decisions

Environmentally responsible approaches in natural resource-based industries address the problem of resource degradation through less intensive use of natural resources, safer use of harmful inputs like hazardous substances, and reduced waste dispersion. Environmentally responsible enterprises

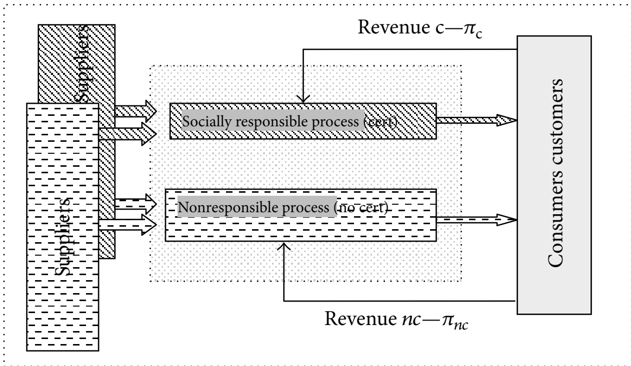

Figure 1: Enterprise decision framework.

can integrate new (eco)quality dimensions in their strategy by adopting an environmental management system in a process or facility and by communicating their certified efforts to customers. For example, firm in the food production sector can make a production unit/line ecofriendly and label its products properly to inform its customers. The firm's actions imply specific costs including investing in green technologies and actions, purchasing green inputs, investing in soil protection and improvement, R&D costs, training and information acquisition, implementation of an ecomanagement system, and certification fees.

In the embryonic stage of a market, little product differentiation is expected as firms focus on production process and satisfying growing demand [26]. Assume that a firm in the food sector (farm, processing facility, or marketing unit) plans to build a new ecofriendly production process that provides an ecocertified product to a certain market. Since ecocertification imply certain costs, as mentioned above, the ecofriendly firm will be at a cost disadvantage relative to conventional competition.

The firm's profit function before the ecocertification is

$$\pi = yp - c, \tag{1}$$

where y is the quantity of products, p is the price, and c is the cost before the ecocertification. After building an ecofriendly/ecocertified production process, the firm chooses its inputs to meet ecocertification requirements of a market segment, and it incurs costs $c+\Delta c$, ($\Delta c \geq 0$). We assume that it provides customers with certified products at a price $p + \Delta p$, ($\Delta p \geq 0$). We can now view two production processes in the enterprise (certified, c; noncertified, nc) operating as strategic business units (Figure 1). If the proportion of ecocertified output offered in the market, a, is such that $1 \geq a \geq 0$, the enterprise profit increases or decreases ($\Delta\pi$) according to the sum of profits for the two processes, π_c for certified and π_{nc} for noncertified. Assuming that there are no economies of scope, we can view the profit functions of the two strategic units as follows:

$$\begin{aligned} \pi_c &= a\left[y\left(p+\Delta p\right)-\left(c+\Delta c\right)\right] \quad \text{for the certified process,} \\ \pi_{nc} &= (1-a)\left(py-c\right) \quad \text{for the non certified process.} \end{aligned} \tag{2}$$

Combining (1) and (2), we have

$$\Delta\pi = \left(\pi_{nc} + \pi_c\right) - \pi = a\left(y\Delta p - \Delta c\right). \tag{3}$$

Equation (3) expresses the change in profit ($0 > \Delta\pi \geq 0$) expected from implementing the ecofriendly strategy assuming that consumers are willing to pay a price premium for the ecocertified product. If the right-hand side of (3) is negative then profits decrease and the ecocertification cannot create economic value. In such case, firm's management will not approve the ecofriendly/ecocertified process, unless it either expects indirect benefits, such as improved market position and brand image, or attempts to avoid penalties. If, however, this term is positive, ecocertification creates economic value, and so, there is a direct incentive for approving the ecofriendly process. Finally, if the right-hand side of (3) is zero, management is indifferent between adopting the environmentally responsible process and continues with the status quo. In this case, the management may decide to go ahead looking for long-run benefits from improved branding. Without considering potential benefits from economies of scope and spillovers, the sufficient condition for the firm's profits to increase is that the price premium for the products offered from the ecocertified process exceeds average incremental costs:

$$\Delta p \geq \frac{\Delta c}{y}. \tag{4}$$

If the above condition is satisfied, the enterprise creates economic value by creating environmental value, which means that the enterprise operates in a sustainable way.

4. Profit Function and Consumers' Choices

As defined above, we can view environmental responsibility as a form of quality incorporated into the product that is produced by two processes. Thus, the firm's product includes ecoquality (Q), taking the value 1 in the case of ecocertification and 0 in the case of no certification.

4.1. Integrating Consumer Choices into the Demand Function. Following the above analysis, we focus on a profit maximizing enterprise competing in a specific, for example, a national, market where the consumers can choose a product of quality Q (certified and not certified). In the long run, this competitive firm chooses to create environmental value and builds an ecoprocess, deciding its output level according to the demand function $y = Y^D(p, Q, I, Cc, \Psi, N)$ [27], where y is the product quantity, p is the price paid, Q is the product ecoquality, I is the income distribution, Cc indicates demographic characteristics of the consumers, Ψ are public policy parameters affecting the distribution of knowledge, such as consumer education programs and product labeling regulation, and N is the number of consumers in the population.

The ecoquality the enterprise chooses to offer depends on investments in green technologies, actions, such as soil protection and improvement, laboratory hiring, training and information acquisition, implementation of an ecomanagement system, and certification fees. The competitive firm chooses the ecoquality of the product to produce jointly with its output level, and it views the price as a function of quality [27]. This quality depends on capital stock. Taking the capital stock as given for simplicity, the static maximization problem is

$$\begin{aligned} &\max \pi = py - c\left(y, Q, w, k\right) \\ &\text{such that } p = P\left(y, Q, I, Cc, \Psi, N, w, K\right), \end{aligned} \tag{5}$$

where, w is the factor prices, k is the capital stock, and K is the vector of k or aggregate capital stock.

The ecoquality communicated to consumers by the ecolabel can add value for customers [28, 29], determining their intent to pay a price premium (Δp) for the ecocertified product. Since we refer to a certain market, we can maintain y and N stable. If we assume that factor prices and capital stock changes are connected to the ecoinputs, these can be included in the costs and replaced by c. For simplicity, we assume that the ecofriendliness' price premium depends on factors such as the consumers' social and economic characteristics. The above expressions enable us to connect the enterprise decisions with consumers' willingness to pay a price premium, and with the determinants of this intention. The partial derivatives help to identify the expected signs.

If consumers are willing to pay a price premium this would compensate for the additional costs incurred in implementing the certification strategy and the enterprise can decide to develop the environmentally responsible process. In the case that there is no intention to pay a price premium, the enterprise management faces two alternatives: the consumers are indifferent or they are not willing to pay. In the first case, the enterprise shareholders/owners may view the environmental responsible action as an expense which may attract some customers' interest in the future, but in the second case, they may view the ecocertification as a misuse of the enterprise resources, since the additional costs to be covered by the consumers are not expected.

Moreover, if we accept Porter and Kramer's [30] proposition that enterprises creating shared value will be more effective and far more sustainable than the majority of current corporate efforts in the social arena, then the enterprise managers have to balance conflicting stakeholder claims. In particular, they should aim at acheiving a balance between environmental sustainability and economic sustainability by taking into account, in addition to their own private economic net benefits, the value their actions generate for (a) society (including social welfare increase, quality of life enhancement, new knowledge, and new jobs introduction); (b) public authorities (including the lowering of the cost of environmental controls and developing new (eco) technologies); (c) managers and workers (including a healthier working environment and improvement of market position); and (d) suppliers of green inputs (including higher prices for their products and services).

4.2. The Discrete Consumers' Choice Framework. Consumer intention or willingness to pay a price premium (equal to Δp) for the ecocertified product can be studied by the discrete choice framework, which is appropriate for analysis concerning a newly introduced ecoscheme. Discrete choice models can be used to examine how consumer purchasing behavior and preferences are influenced by the conditions under which they are realized. Such conditions concern the product attributes and characteristics that directly affect consumer choices and the environmental dimensions surrounding these choices [31, 32]. The main idea of a discrete choice model is to ask consumers to indicate their choice among various alternative purchasing options available to them.

Consider a consumer whose preference shifts from purchasing a conventional product to an ecocertified one sold at a higher price. She/he does so because the choice of the certified product increases her/his utility. In this case, her/his WTP (or intention to pay) a premium for a certified product over a non-certified one is discrete. Thus, it is evident that a utility (choice) model should be used. In this context, consumer utility, and hence, her/his intention to pay or WTP are affected by a set of factors categorized and presented in the next section. However, since some factors affecting consumer intention or WTP may be omitted from the model, a random component should be added representing the unobservable factors, such as unobservable variation in preference, random individual behavior, and measurement errors. Since the random component is unobservable, we must assume a cumulative distribution function to model the discrete choice. Several distributions can be used to capture the probabilistic nature of choice. A logistic distribution function leads to the logit model, while a standard normal distribution function leads to the probit model.

There are different variants of choice modeling corresponding to different ways of measuring consumer preferences. In the present paper, we assume that a consumer (j) will choose the alternative i if the utility she/he expects to derive (u_{ij}) is greater than the expected utility of all alternatives presented to her/him, where $j = 1, \ldots, n$. As we stated above, the utility that the consumer derives from each alternative depends on the set of attributes and characteristics for this alternative. Thus, the consumer's utility can be presented as

$$u_{ij} = \alpha_{ij}\chi_{ij} + e_{ij}, \tag{6}$$

where χ_{ij} is the vector of attributes for the alternative i, α is the vector of estimated parameters, and e_{ij} is the random error component that captures unobservable consumer characteristics, missing attributes and characteristics, measurement errors, preferences heterogeneity, and so on.

5. The Intention-to-Pay Model

Combining (5) and (6), we develop a model (Figure 2) which relates the intention to pay for a certified product with a set of factors, which are grouped into seven categories: consumers' socio-economic characteristics, their family's characteristics, behavioral factors (such as consumer or family purchasing strategies), cognitive factors (such as the level of consumer

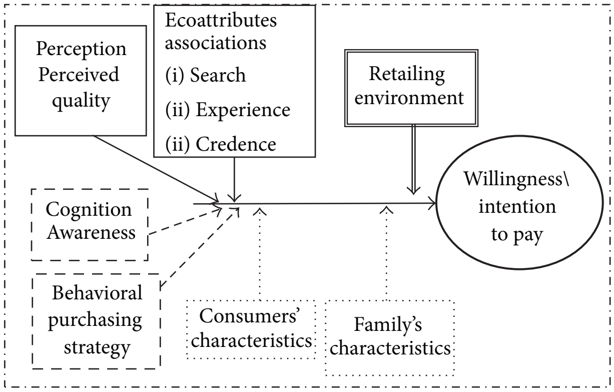

Figure 2: Intention to pay model.

awareness to the ecolabel), perceptual factors (such as consumer perception of product quality), associations in a customers' memory linked to the ecolabel and connected to product attributes and characteristics [28], and finally factors related to the marketing environment (such as the type of retailer).

In this model, the utility a consumer derives from purchasing an ecofriendly product is assumed to be a function of perceived quality, consumer awareness, and the three groups of ecolabel associations connected to the product attributes and characteristics or production conditions (Following Trijp van et al. [33] and Karipidis et al. [34], we group the product attributes and characteristics into search, experience, and credence. The search attributes are observable by the consumer prior to the purchasing decision, the experience attributes become observable after purchasing the product, and credence attributes are observed long after the consumption of the product). It is also a function of individual consumer-related characteristics, such as age, education, and occupation, and family characteristics such as household income, household size (a large family implies the presence of children which could be a crucial parameter in our analysis), and purchasing strategy.

Among the members of a family, there could exist substantial differences, based on a variety of reasons such as age, education, life-event transitions, cross-cultural differences, child/parent interaction and conflict-type interactions, which influence needs, preferences, and, thus, the purchasing behavior of each individual member [35, 36]. However, when the respondent purchases a certified (food) product, it is likely that she/he takes into consideration the preferences of all family members. Thus, the needs and preferences of other family members can influence intention to pay a premium for certified products. It is impossible though to take into account other family member's characteristics directly through the survey. To capture the effect of family preferences on respondent's intention to pay indirectly, we introduce a variable representing the whole family's intention to purchase certified products. This variable is termed "purchasing strategy."

Furthermore, since the retailing environment can impact consumer choices, we choose to include some additional explanatory variables indicating preferred retail outlets. Retailers provide additional information to consumers about product attributes and characteristics and consequently impact buying decisions [34]. Thus, we expect the retailer to affect intention to pay for ecocertified products, because it is likely that the retailer could provide consumers with information about production conditions. Because differences can exist between the retail outlets' marketing (communication) strategies and their capabilities to provide information (ecofriendly definition) to customers [37], we expect the type of retailer to be a factor affecting intention to pay.

Incorporating the above analysis into the utility function in (6), that is, splitting the vector χ_i in seven subvectors of attributes yields

$$u_{ij} = \sum_{k=1}^{7} \beta_{ij}^{k} Z_{ij}^{k} + e_{ij}, \tag{7}$$

where Z_{ij}^{k}, $k = 1, \ldots, 7$, are vectors corresponding to the seven groups of characteristics, β_{ij}^{k}, $k = 1, \ldots, 7$, are the vectors of the related parameters.

6. Empirical Investigation

6.1. Model Specification and Measurements. Since we focus on newly introduced schemes in embryonic markets, the discrete event modeled in the present paper is whether consumers intent to pay a price premium (Δp) for the certified product, relative to the price of a conventionally produced product. To test the model empirically, first we examine the case of a certain certification scheme implemented in fruit and crop production. This scheme (called AGRO-2.2 in Greece) falls between Integrated Production Management and organic agriculture and meets the basic requirements of the ISO 14001 standard. It is a voluntary ecocertification/ecolabel scheme that introduces a particular set of environmentally friendly production processes that involve cautious use of hazardous substances (agrochemicals) and rational use of natural resources.

We choose to analyze the intention of consumers to pay for a particular fresh food product (peach). Since this ecoscheme has been introduced only recently (embryonic market), survey respondents had limited practical experience, and so a written definition of the scheme was provided. Survey respondents were asked to indicate which of the following three alternatives would best match their intentions: (1) "no intent to pay," if the utility they expect the ecocertified product to derive does not justify the cost they pay; (2) "perhaps or indifferent," if they are not sure that the utility which the ecocertified product provides justifies the cost they pay; or (3) "intent to pay," if the utility which they expect the ecocertified product provides justifies the cost they pay. These alternatives correspond to the three scenarios of the enterprise profits. The data were collected by developing a questionnaire which was delivered by students, to households in their home towns during the summer months of 2006, when the ecoscheme was newly introduced. After discarding

Table 1: The independent variables of the consumers' choice model.

Category of factors		Independent variables	Values	Type of variable	Expected sign
Consumers' characteristics	Z_1^1	Consumers' age	<40	Dichotomous	±
	Z_2^1	—	40–60	Dichotomous	±
	Z_3^1	Low education level (compulsory)	Yes = 3 No = 1	Dichotomous	−
	Z_4^1	Entrepreneur	Yes = 3 No = 1	Dichotomous	±
	Z_5^1	Employee	Yes = 3 No = 1	Dichotomous	±
	Z_6^1	Farmer	Yes = 3 No = 1	Dichotomous	+
	Z_7^1	Educator/teacher	Yes = 3 No = 1	Dichotomous	+
	Z_8^1	Housekeeper	Yes = 3 No = 1	Dichotomous	±
Family's characteristics	Z_1^2	Family income	<12 thousand	Dichotomous	−
	Z_2^2	—	€12–20.000	Dichotomous	±
	Z_3^2	—	€20–40.000	Dichotomous	±
	Z_4^2	—	€40–80.000	Dichotomous	+
	Z_5^2	Family size	Persons	1–11	+
Behavioral	Z_1^3	Purchasing strategy	Percentage	Continuous	+
Cognitive awareness	Z_1^4	Consumption experience	Kg/family	Continuous	+
	Z_2^4	Experience of a peach-producing county	Yes = 3 No = 1	Dichotomous	+
Perceptive perception	Z_1^5	Perceived quality	3–9	Continuous	+
Ecolabel associations	Z_1^6	Search attributes	3–12	Continuous	−
	Z_2^6	Experience attributes	4–12	Continuous	+
	Z_3^6	Credence attributes	6–18	Continuous	+
Retailing environment	Z_1^7	Greengrocer's market	Yes = 3 No = 1	Dichotomous	+
	Z_2^7	Farmers' market	Yes = 3 No = 1	Dichotomous	−

a number of problematic questionnaires, we were left with a total of 529 questionnaires to analyze.

Table 1 presents the model's explanatory variables. They are grouped into seven categories according to the theoretical analysis presented above, and the elements within each group were selected from a larger set of variables. In selecting the explanatory variables, we used previous experience as well as the results of a small-scale pretest. Table 1 presents the type and value of the variables and the expected signs for each of them determined using partial derivatives.

The level of consumer awareness is captured by two objectively measured variables: the total peach quantity purchased by the respondent's household per week (Z_1^4) as an index of his/her purchasing experience, and the respondent's experience in a peach-producing county (Z_2^4) (whether he/she had visited one or ever lived there). Perceived quality (Z_1^5) is measured as the sum of the score of three dichotomous choice questions (yes = 3/no = 1). Each group of ecolabel associations, namely, search (Z_1^6), experience (Z_2^6), and credence (Z_3^6), is measured by the mean score of a number of dichotomous choice questions (4, 4, and 6, resp.).

The model uses two variables representing the two most commonly used categories of fruit retail outlets: greengrocers and farmers' markets. These variables attempt to capture the retailer's impact on the intention to pay a premium for certified products. We expect the greengrocer (Z_1^7) to positively impact intention to pay, because she/he can transmit information regarding ecolabels and explain their significance. On the contrary, the farmer selling her product in a farmers' market (Z_2^7) can transmit information regarding actual production conditions, thus minimizing the usefulness of the ecolabel. Therefore, we expect Z_2^7 to have a negative impact on the intention to pay a premium for certified peaches.

6.2. Model Estimation and Results. We model the observed response by considering a latent variable u_{ij}^*, ($u_{ij}^* > 0$, $u_{ij}^* = 0$, $u_{ij}^* < 0$). This variable depends linearly on the explanatory variables. Since we choose the logit model with an ordered dependent variable, the model was estimated using the ordered logit command in EVIEWS 5.1. The results of the ordered logit analysis are shown in Table 2 (coefficients, t-statistics, and P values).

The results indicate that 65,4% of respondents selected the intention to pay alternative. This percentage enables the enterprise to estimate its profit function (3) and, thus, to choose the proportion (a) of the outputs to be certified. A likelihood ratio (LR) test is used to test the null hypothesis that the estimated coefficients were jointly equal to zero. This hypothesis is rejected for the model. The null hypothesis that the estimated coefficients are equal to zero is rejected for six out of the 22 variables. This implies that there are six factors shaping the intention to pay a premium for the ecocertified product and, thus, differentiating the economic value creation in the conditions under which it is examined. The remaining variables are not found to significantly impact the dependent variable, which suggests that they are not important in explaining

Table 2: Results of the ordered logit estimation.

Category of factors	Independent variables		Coefficient	Std. error	t-statistic	Prob.
Consumers' characteristics	Z_1^1	Consumers' age	0.161475	0.100779	1.602263	0.100*
	Z_2^1	—	−0.032453	0.126482	−0.256583	0.797
	Z_3^1	Low education level	−0.072364	0.067504	−1.071999	0.283
	Z_4^1	Entrepreneur	0.067167	0.469345	0.143109	0.886
	Z_5^1	Employee	0.510620	0.431180	1.184240	0.236
	Z_6^1	Farmer	0.995558	0.585563	1.700173	0.089*
	Z_7^1	Educator/teacher	0.603099	1.055932	0.571153	0.567
	Z_8^1	Housekeeper	0.124082	0.499078	0.248623	0.803
Family's characteristics	Z_1^2	Family income	−0.431882	0.237696	−1.816956	0.069*
	Z_2^2	—	−0.306220	0.228257	−1.341557	0.179
	Z_3^2	—	0.191624	0.227386	0.842728	0.399
	Z_4^2	—	0.011135	0.013923	0.799798	0.423
	Z_5^2	Family size	0.082871	0.095615	0.866711	0.386
Behavioral	Z_1^3	Purchasing strategy	0.002096	0.000371	5.643678	0.000*
Cognitive awareness	Z_1^4	Consumption experience	0.053341	0.066169	0.806128	0.420
	Z_2^4	Experience of a peach-producing county	0.036850	0.110451	0.333627	0.738
Perceptive perception	Z_1^5	Perceived quality	0.055056	0.110508	0.498208	0.618
Eco-label associations for product characteristics	Z_1^6	Search attributes	0.010118	0.051409	0.196810	0.844
	Z_2^6	Experience attributes	0.042884	0.053525	0.801192	0.423
	Z_3^6	Credence attributes	0.083185	0.051046	1.629611	0.100*
Retailing environment	Z_1^7	Greengrocer's market	0.574712	0.237267	2.422218	0.015*
	Z_2^7	Farmers' market	−0.018296	0.240998	−0.075916	0.939
LR statistic (22 df)			82.40481	LR index (Pseudo-R2) 0.116827		
Probability (LR stat)			$6.49E-09$			

*Significant at 10% level.

the "intention to pay" variable. The LR index (Pseudo-R2) in the present study is 0.1168, which is higher than that in most similar studies, implying that the explanatory capacity of the model is improved [9, 11, 38].

With respect to the respondents' and her/his family's socioeconomic characteristics, we find that three out of six characteristics, are important in explaining the intention to pay a premium. We find that younger persons and farmers have higher intention to pay a premium for ecofriendly products. Farmers are more aware of health and environmental risks related to production, and this might explain their higher intention to pay a premium for certified peaches. This result confirms Mostafa's [15] findings regarding the effect of cognitive factors on green purchasing behavior. As expected, lower household income decreases the likelihood is that the respondent would be willing to pay a premium for certified products. This result is in accordance with previous studies [9–11]. Thus, it should be asserted that when the consumers are young and are aware of health and environmental risks, economic value is created through the creation of environmental value. Contrary to this, in the case of low income consumers, economic value is not created. Thus, the low income consumers do not incur the costs of environmental improvements that can be undertaken by medium/higher income consumers for whom there is no evidence that they are not willing to pay a premium.

A household's purchasing strategy, in particular the willingness to purchase certified peaches, has a positive effect on the consumer's intention to pay a premium for ecofriendly products. This suggests that there is a significant correlation between the respondents' intention to pay a premium for an ecocertified version of their favorite food product and their family's willingness to purchase ecocertified products. Thus, we confirm the alignment of the buyer's willingness with the family's purchasing strategy.

The results do not confirm our expectations that consumer awareness, as indicated by her/his food purchasing or consumption experience or by the respondent having lived in or visited a peach-producing county, has a positive impact on her/his intention to pay a premium. Similarly, perceived quality is not found to be of importance in explaining intention to pay a premium. This might be explained by the fact that although consumers perceive ecocertified products as being of higher quality, they do not believe that overall they are of better quality.

We next examine the importance of the three ecolabel associations (search, experience, and credence) in explaining consumer intention to pay a premium for certified peaches. As expected, search attribute associations were not found to be important in explaining the intention to pay a premium, since these attributes are perceivable prior to purchasing, and the ecolabel does not provide important additional information. We also find that experience attribute associations are not important, although they may not be perceivable before purchasing. On the contrary, credence associations were found to positively affect the intention to pay a premium for certified peaches. This result, although anticipated, is very important given the particular attributes included in the credence group and the percentage of positive responses received. Therefore, credence associations are far more important than either search or experience associations in explaining the intention to pay a premium for certified products and in the creation of economic value. This result indicates the importance of distinguishing between the different groups of associations when conducting similar studies. It also implies that in promoting ecolabels, emphasis should be given to credence characteristics and, in particular, to those that receive the highest social and consumer interest.

Finally, the results confirm our expectation that when the respondent's main fruit outlet is a greengrocers' store, it is more likely that the respondent would be willing to pay a premium for certified peaches. This result is consistent with the suggestion of Bougherara and Combris [39] regarding the importance of information, indicating that the greengrocer can help in the creation of economic value through the creation of environmental value. However, the results do not confirm our expectation that when the respondent purchases from a farmers' market she/he is not likely to pay a premium for ecofriendly products. This might be explained by the fact that the majority of sellers in many farmers' markets are not farmers, and thus, they do not transmit information to customers related to the ecofriendly production conditions.

7. Concluding Remarks

The present paper proposes a framework that facilitates the evaluation of the economic benefits a firm could derive when it engages in environmentally friendly actions, balancing thus, environmental with economic sustainability. More specifically, the framework used in the present paper combines demand theory with a discreet choice consumer model in an embryonic market, such as the ecocertified products market, to examine whether economic value is created and to identify its drivers. The rationale for building this model is that enterprises integrate the notion of shared value into their strategies in an attempt to balance conflicting stakeholder claims, such as between those demanding environmental responsibility and the owners.

We consider a food production (farm, manufacturing, or marketing) enterprise behaving proactively, deciding to build an ecocertified process producing an ecocertified product. Viewing certified ecofriendliness as a bundle of quality attributes and characteristics incorporated into the product, we examine whether consumers intent to pay a price premium to enable the enterprise to understand the conditions under which it creates economic value by creating environmental value. Second, we examine seven categories of factors, including socioeconomic characteristics, product characteristics, and marketing environment, and how they affect the intention to pay a premium.

The empirical investigation of a discrete consumer choice model is based on data collected by survey and reveals the impact of some factors on the intention to pay a premium for ecocertified food. The results indicate that ecocertification that creates environmental value creates also economic value and, thus, compensates, totally or partially, for the additional expenses incurred by producers and marketers. The ordered logit analysis indicates that a variety of factors play an important role in shaping the respondents' intention to pay for the ecofriendliness and drive the economic value creation, such as the consumer's age and profession, family's income and purchasing strategy, product quality association in consumers' mind and the retailing outlet.

The proposed framework can help enterprises to define conditions under which economic value can be created through creating environmental value, enabling managers to balance the main stakeholders' claims, especially those who demand social responsibility and the owners or shareholders. The owners or shareholders can benefit, since the profit remains at least equal to previous levels; in addition the enterprise can strengthen its market position and diminish potential punishments or penalties. Consumers also benefit because they can choose new, better, and safer products at the cost of development and certification, and they can live in a healthier environment. In addition to this, our analysis brings to light useful insights concerning all stakeholders, since a broad range of benefits is expected from the proactive ecofriendly behavior of enterprises. Thus, the market conditions can contribute to achieving enterprise sustainability. This framework can be implemented in several sectors, enterprise operations, and establishments and for different issues of social responsibility involving a certification scheme or a standard, such as the OHSAS 18001, SA 8000, ISO 14001, EMAS, and ISO 26000, enabling enterprises to communicate socially responsible characteristics to their customers.

The results have direct sustainability and policy implications for producers (farmers and manufacturers) and marketers as well as for certification organizations and policy decision-makers. Producers and marketers have a clear incentive to make decisions that create shared value more efficiently. They should engage in targeted communication campaigns for ecocertified products, increasing consumer awareness, a crucial driver of consumer intention to pay premiums. Furthermore, communication campaigns should target young and medium/high income customers and focus primarily on attributes and characteristics that are not perceivable prior to purchasing the product, such as those connected to risks to the environment and human health. On the other hand, certification organizations can strengthen the market position of ecolabeled products by providing credible information to consumers and encouraging producers to adopt ecocertification schemes. Given the importance of information, public authorities could consider engaging in information campaigns to increase awareness about ecolabeling among particular groups instead of only directing their resources towards subsidizing ecocertification. Public advertisement should have a long-term perspective, targeting consumer groups with the lowest (no or indifferent) intention to pay premiums.

An important limitation of our analysis is that it assumes a linear relationship between the intention to pay and its determinants. Future research should address this issue by introducing a more complex model possibly in structural form. Furthermore, it would be useful to examine the WTP specific price premiums by offering respondents quantified alternatives, such as 5%, 10%, or 15% above the price of the conventional variety, instead of the three alternatives offered in the present questionnaire.

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Research Article

A Case Study of Probit Model Analysis of Factors Affecting Consumption of Packed and Unpacked Milk in Turkey

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This paper focused on the effects of some sociodemographic factors on the decision of the consumer to purchase packed or unpacked fluid milk in Sivas, Turkey. The data were collected from 300 consumers by using face-to-face survey technique. The sample size was determined using the possibility-sampling method. Probit model has been used to analyze the socioeconomic factors affecting milk consumption of households. Four estimators (household size, income, milk preferences reason, and milk price) in the probit model were found statistically significant. According to empirical results, consumers with lower household size and higher income levels tend to consume packed milk consumption. Our study findings suggest that consumers who were sensitive to price were less likely to consume packed milk and believe that packed milk price is expensive compared to unpacked milk price. Also, milk price was effective factor concerning packed and unpacked milk consumption behavior. The majority of consumers read the contents of packed fluid milk and are affected by safety food in their shopping preferences.

1. Introduction

Milk is a unique food item that needs to be available in the market without any shortage since it plays a key role in infant feeding and alleviating nutritional poverty in all other age groups. It has been perceived by consumers as an important source of nutrients, especially calcium for good bone and teeth health [1]. Therefore, it is advisable to consume an adequate amount of milk and milk products for healthy lifestyle [2]. Although intake of a sufficient amount of fluid milk and milk products is recommendatory for healthy lifestyle of humans, consumers' fluid milk consumption behavior and preferences may vary among countries. There is a significant gap between developed and developing countries in terms of fluid milk consumption [3].

Increasing population and income, together with the growing popularity of dairy products, particularly among developing country consumers are a key factor behind strong demand in the medium term. Demand continues to be encouraged by the growing influence of retail chains and multinational companies in these countries, which is facilitating improved consumer access to dairy products. Also, in many countries consumption is enhanced by government programmes (i.e., school milk). The demand for milk and dairy products is expected to remain particularly strong in important developing dairy markets such as North Africa, the Middle East, and East Asia, but also in more mature markets such as those in the European Union, the United States and Russia. The rate of growth and per capita consumption of milk and milk products remains significantly different among regions. (LDCs) least developed countries consume less than 50 kg per person per year on average, compared with 100 kg per person for developing countries, while the developed regions of North America and Europe consume well in excess of 200 kg per person (in milk equivalent). Such a per capita consumption disparity represents an investment potential and future opportunities for both the domestic and global dairy sectors [4].

However, per capita milk consumption in Turkey is low by any comparison due to Turkish people's consumption patterns, income levels, and nutritional habits. Turkey is far behind the European countries and the world in milk consumption [5]. In Turkey, annual per capita milk consumption is 26 lt [6]. Per capita milk consumption is 66,9 lt in EU, 90.0 lt in USA, 91.5 lt in Canada, 108.14 lt in Austria, 78.2 lt in New Zealand, 87.2 lt in Russia, 97.0 kg in Sweden, and 80.1 lt in Ukraine [7].

Milk is consumed as unpacked fluid milk and packed fluid milk in Turkey. Unpacked fluid milk, also called street milk in Turkey, refers to milk that is produced at farms without any control and packed fluid milk refers to milk produced under fluid milk technology such as pastorization or UHT [5]. There are several reasons why some consumers prefer unpacked milk whereas others prefer packed milk. Unpacked milk is preferred by some consumers because it is cheaper than packed milk and delivered at the doorstep with no additional cost. Unpacked fluid milk is mainly delivered to consumers directly by individual farmer distributors in Turkey.

The milk is collected by wholesalers, street milk sellers, and village milk collectors such as local cooperatives and producer organizations [8]. Respective shares of milk processing plants in total milk consumption of Turkey are 27% modern dairy factories, 33% for medium sized establishments and dairies, 20% for uncontrolled producers, and 20% for producers' self consumption [5]. The direct sales performed by street milk sellers are important problems in Turkey because they produce or buy milk from farmers in uncooled, unprocessed, and unpacked form resulting in unhygienic fluid milk and pathogenic organism above tolerable limits. This raw milk which is produced without any control sells to potential consumers living in urban areas [8].

Consumers prefer packed milk because of its guarantee of quality, long shelf life, and packaging to carry and store. The desire to purchase a safe food product is also a reason to prefer packed fluid milk. In fact, not only education, age, income, and other demographic characteristics of consumers influence pasteurized and sterilized milk consumption choices but also factors such as increasing consumer awareness and concerns about health and food safety and advertising play important roles [9].

Because of the current marketing system in Turkey, it would be noted that determination of the socioeconomic and demographic characteristics affecting packed and unpacked milk purchasing behaviors of households is substantially important.

In the literature, many researchers have studied the effects of socioeconomic and demographic characteristics on milk consumption patterns and preferences. Fuller et al. [10] used 2001-2002 urban survey data collected to analyze demographics, cultural factors, and purchasing behaviors influencing the consumption of fresh milk, yogurt, ice cream, and powdered milk in urban areas of China. They also estimate consumption levels and participation equations with tobit and probit models. Hill and Lynchehaun [11] focused on sociodemographic factors affecting (personal values, attitudes, age, and ethnicity, presence of children, education, advertising, taste, packaging quality, food scares, prices, and income) buying organic milk. Hatirli et al. [2] investigated main factors affecting fluid milk purchasing sources of households in Turkey. From the collected household survey data, a multinomial logit model was estimated to analyze households' choices among unpacked, processed, and processed-unpacked fluid milk alternatives within the utility maximization framework. Pazarlioğlu et al. [5] investigated the demand for both farm milk (unpacked fluid milk), produced without safely controls, and fluid milk (packed fluid milk), produced under fluid milk technology such as pastorization or UHT, based on the data from a household survey which was carried out in Izmir, the third largest city in Turkey. They conducted an analysis using a Heckman selection model since selection bias was potentially an important problem in this study. Heckman estimations for farm milk and fluid milk were used to check whether Heckman correction was required for each type of milk. Alviola and Capps [12] examined the factors that affect the binary choice decision of buying organic and conventional milk at the household level. They utilized a probit model in characterizing the household choice between organic and conventional milk. Kilic et al. [13] studied consumer characteristics associated with preferences toward fluid milk alternatives. Using consumer survey data from Samsun province of Turkey and multinomial logit model, unpacked and packed fluid milk preferences were analyzed. Negassa [14] analyzed the determinants of consumer likelihood to purchase fluid milk and butter by using probit model. Günden et al. [8] estimate the impacts of factors affecting households unpacked and prepackaged fluid milk demand in Turkey using a bivariate censored system of demand model. Yayar [3] investigated socioeconomic and demographic characteristics of consumers that determine households' fluid milk consumption choices among packed, unpacked and both packed-unpacked milk consumption choices in Tokat province of Turkey.

Whilst several researchers studied general aspects and structure of milk production and consumption in Turkey, few have focused on milk consumption decisions of consumers for regional and provincial, effects of socioeconomic and demographic factors on milk consumption [2, 3, 9, 15, 16].

This paper aims to focus on sociodemographic factors affecting consumers' packed or unpacked milk consumption preferences. In order to reach these aims, we analyze that the milk consumption behavior is associated with socioeconomic and demographic characteristics of the consumers by estimated maximum likelihood as binary probit model.

The paper is structured as follows. Section 1 includes introduction. The next section presents the data, methodology, and econometric specification we used to estimate probit model. The empirical application of probit to Turkish households' milk consumption and empirical results of the study are presented in Section 3. Section 4 covers conclusions.

2. Data and Methods

2.1. Data. The survey was designed to provide representative household packed and unpacked milk consumption data for Sivas province, Turkey. The data was obtained by direct interviewing of the individual households of 300 residences. The survey was conducted in June 2009. The sample size was determined using the possibility-sampling method [17]:

$$n = \frac{(Nt^2 \cdot p \cdot q)}{(d^2N + t^2 \cdot p \cdot q)}, \tag{1}$$

where N is the number of households in Sivas province (63153) [18], t is z number which is the required confidence interval (for 95 percent confidence interval $t = 1.96$), p is possibility for an event to occur (the rate of consuming packed milk, 0.5), q is the possibility for an event not to occurr (the rate of not consuming packed milk, 0.5), d is acceptable error rate during sampling (0.0564).

The data above is formulated, and the sample size (number of people surveyed) was determined to be 300 according to the required confidence interval and the acceptable error rate. Sivas province was divided into six geographical locations for survey study. These six districts, whose geograpy represents households that have different income groups in Sivas, were chosen. A total of 300 face-to-face questionnaires were made with randomly selected households. We asked households questions about their milk purchasing preferences and socioeconomic information in the questionnaire form. According to the HDI (human development index) Sivas province occupies 37th rank among 72 provinces showing features of medium human development (MHD) [19]. Therefore, it can be said that Sivas province represents other provinces in this group (MHD). Armagan and Akbay [20] emphasize that it will be more appropriate to improve the marketing system with the knowledge of production and consumption structures. Regional discrepancies are also gaining importance; the data on the consumption of animal food products is limited, though. Therefore, they think it will be practical to study on certain products and to start the study from regional and provincial levels to obtain data.

2.2. Methods. In this study, we aimed to determine socioeconomic and demographic factors affecting the decision of the consumer to purchase packed or unpacked milk. Given the dichotomous nature of the consumer, a qualitative response model is appropriate. Qualitative response models relate the probability of an event to various independent variables. Such models are often useful when assessing consumer characteristics that are associated with purchasing decisions [21]. In order to provide a detailed analysis of the behavioral milk preferences, packed milk or unpacked milk, we applied a discrete choice probit model for binary choice (yes, no) responses to the milk consumption preferences question.

The probit model is a statistical probability model with two categories in the dependent variable [23]. Probit analysis is based on the cumulative normal probability distribution. The binary dependent variable, y, takes on the values of zero and one [24]. The probit analysis provides statistically significant findings of which demographics increase or decrease the probability of consumption.

In the binary probit model, packed milk preference was taken as 1, while unpacked milk as 0. It is assumed that the ith household obtains maximum utility, it has packed milk preference rather than unpacked one.

The probability p_i of choosing any alternative over not choosing it can be expressed as in (2), where ϕ represents the cumulative distribution of a standard normal random variable [25]:

$$\begin{aligned} p_i &= \text{prob}[Y_i = 1 \mid X] = \int_{-\infty}^{x_i'\beta} (2\pi)^{-1/2} \exp\left(-\frac{t^2}{2}\right) dt \\ &= \Phi(x_i'\beta). \end{aligned} \tag{2}$$

The relationship between a specific variable and the outcome of the probability is interpreted by means of the marginal effect, which accounts for the partial change in the probability. The marginal effect associated with continuous explanatory variables Xk on the probability $P(Y_i = 1 \mid X)$, holding the other variables constant, can be derived as follows [25]:

$$\frac{\partial p_i}{\partial x_{ik}} = \phi(x_i'\beta)\beta_k, \tag{3}$$

where ϕ represents the probability density function of a standard normal variable.

The marginal effect on dummy variables should be estimated differently from continuous variables. Discrete changes in the predicted probabilities constitute an alternative to the marginal effect when evaluating the influence of a dummy variable. Such an effect can be derived from the following [25]:

$$\Delta = \Phi(\overline{x}\beta, d = 1) - \Phi(\overline{x}\beta, d = 0). \tag{4}$$

The marginal effects provide insights into how the explanatory variables shift the probability of frequency of milk consumption. Using the econometric software LIMDEP [25], marginal effects were calculated for each variable while holding other variables constant at their sample mean values.

Factors influencing consumer attitudes and acceptance of a product may include product attributes, price as well as consumer's social demographic and possible interaction between these factors [26]. In previous studies [2, 3, 5, 8–10, 12, 13, 16, 27–29] characteristics such as household size, gender, age, education, professional status, marital status, household size, household income, ethnicity, price, and advertising were handled as explanatory variables.

In this paper, we assume that socioeconomic and demographic characteristics of the consumers affected the preferences for packed and unpacked milk consumption. These characteristics are gender, age, education, professional status of household head, marital status, household size, income, place of milk buying, reason of milk preference, and milk price.

Therefore, we handled the variables assumed statistically significant in the model. Table 1 shows the definition of variables and their mean values.

We formulate the following hypotheses relating to socioeconomic and demographic factors affecting packed

Table 1: Definition of variables.

Variables	Definition	Mean values
MILKPRE (milk preference)	Packed milk = 1, unpacked milk = 0	
GEN (gender)	1 = male; 0 = female	.643
AGE (age)	Age of household head (years)	38.047
EDU (education)	University and postgraduates = 1, otherwise = 0	.377
PS (professional status)	Employed = 1, unemployed = 0	.820
MS (marital status)	Married = 1, otherwise = 0	.783
HS (household size)	Number of people (people/family)	3.953
INC (income)	Average monthly household income; ($/month/household)	771.797
MILKPLACE (place of milk buying)	Buying supermarket = 1, otherwise = 0	.344338D+07
PREFREA (reason of milk preference)	Packed milk is hygienic and healthy (agree = 1; not agree = 0)	.657
MILKPRI (milk price)	Packed milk price is expensive compared to unpacked milk price (agree = 1; not agree = 0)	.420

and unpacked milk consumption. The main hypotheses are: (a) packed milk consumption is positively related to younger age, higher levels of education, smaller household, higher levels of income; (b) milk prices in relation to packed milk consumption have a negative correlation.

3. Results

According to the survey results, the male respondents constitute 64.34% of total respondents while female respondents constitute 35.66% of it. Approximately 41.33 percent of total respondents were between 18 and 35 years of age, while 27.34 percent of the respondents were older than 45 years of age. Average age was 38.04. Educational attainment was classified into five categories, illiterate and primary school graduates (14.33%), secondary school graduates (8.33%), high school graduates (39.67%), university graduate (36.67%), and post-graduates (2.00%) (Table 2).

Households earning less than $349 constituted 10 percent of total respondents, households earning between $350 and $1050 (49 percent) and households earning higher than $1051 (41 percent) (Table 2). The survey results illustrate that average annual income of households was found $8003 that was lower than the annual income per capita ($8215) of Turkey [30].

Average household size was found to be 3,95 people that is lower than the average household size (4.50 people) of Turkey [31]. The most frequent household size is 3-4 people with 50.67%. Average 60.97% of heads of household employed are in paid work and 39.03% are self-employed.

In Sivas, per capita average annual milk consumption is 39.96 kg per capita whereas it is 26 kg in Turkey [32]. In İzmir province per capita annual fluid milk consumption was found 139.68 kg [5] and 48.18 kg in Aydin province [20]. Survey results showed that 71.3 of households preferred packed milk while 28.7% unpacked milk. Some information about consumers who preferred packed milk is reported in Table 2. Consumption of packed and unpacked milk substitutes according to educational level. 41.86% of illiterate and primary school graduates and 82.30% of university graduates consume packed milk. While 73.33% of consumer in low income group consume unpacked milk, 90.24% of consumer in high income group consume packed. 39.54% of households preferred unpacked milk as a priority because it is cheaper than packed milk. It was found out that the most important reasons were quality (28.64%) and hygiene (28.64%) for packed milk choice of consumers (Table 3).

Respondents consumed unpacked milk provided by home delivery (62.79%) and buying from village (16.28%). Households consuming packed milk preferred supermarket (89.09%) and selling point (10.91%). According to the results, consumers made a point of sell-by date (44.09%), taste (36.82%), and brand (9.09%) for packed milk.

Table 4 presents results estimated from binary probit model. The model has been estimated by the maximum likelihood method. The model is significant at 1% level of probability. The estimated coefficients and standard errors reveal which factors influence respondents consumption intentions for fresh milk consumption. A statistically significant coefficient suggests that the likelihood of consumption of product will increase/decrease as the response of the explanatory variable increases/decreases [33]. The likelihood ratio test statistic results of the model indicate that four variables are statistically significant at 1%, 5%, and 10% levels of probability. McFadden's Pseudo-R^2 was calculated, and obtained values indicate that the independent variables included in the probit model explain significant proportion of the variations consumer's to purchase packed or unpacked milk. It was calculated about 0.6889. This value represents that variables placed in the model explain high level of the probabilities of packed and unpacked milk choice of consumers. Correct prediction rate obtained from probit model is 93%. This meant that that the probit model predicts 93% of the cases correctly.

We expected that packed and unpacked milk consumption was influenced by gender, age, education, professional status, marital status, household size, income, milk buying place, milk preferences, and milk price.

Table 2: Some socio-economic and demographic characteristics of households.

	Frequency	%
Gender		
Male	193	64.34
Female	107	35.66
Age		
18–25	36	12.00
26–35	88	29.33
36–44	94	31.33
45 or older	82	27.34
Education		
Illiterate and primary school graduates	43	14.33
Secondary school graduates	25	8.33
High school graduates	119	39.67
University graduates	107	36.67
Postgraduates	6	2.00
Income		
Less than $349	30	10.00
$350–$698	147	49.00
$699–$1050	82	27.33
More than $1050	41	13.67
Household size		
1-2 person	50	16.67
3-4 person	152	50.67
5-6 person	79	26.33
7 or more persons	19	6.33

1$ equals to 1,53 TL in 2009 [22].

Table 3: Some information about consumers preferring packed milk.

	Consumed packed milk (%)
Education	
Illiterate and primary school graduates	41.86
University graduates	82.30
Income	
Less than $349 and $350–$698	73.33
More than $1050	90.24
Most important choice reason	
Quality	28.64
Hygiene	28.64
Place of buying packed milk	
Supermarket	89.09
Selling point	10.91

We tried to include all socioeconomic variables in the model but the variables of gender, age, education, professional status, marital status, and milk buying place were not statistically significant. In other words, in contrast to what we expected, these variables have no statistically significant effect on the packed or unpacked milk consumption.

The level of education is related to the ability to process more complex information and make decisions [14]. We assume that education level is one of the important factors affecting milk consumption. Surprisingly, we did not find a statistically significant relationship between education level and packed or unpacked milk consumption. Sanchez-Villegae et al. [34] assess differences in cheese and milk consumption across socioeconomic groups in representative samples from several European countries. They found that there was not statistically significant an association between the level of education and consumption of milk when they pooled the estimates from different countries. Negassa [14] found that there was no difference between the households with illiterate heads and household with heads having at least primary education in terms of the likelihood to purchase raw milk. In this study, the effect of education level of the head of household on the household's likelihood to purchase butter is found to be not significant.

Household size was found out an important socioeconomic factor for the probabilities of packed and unpacked milk choice of consumers. In estimated model, household size variable was statistically important at significant level 5% and related negatively. As household size increases, tendency to consume decreases packed milk and increases unpacked fluid milk. This is the expected result of household

Table 4: Estimates of the binary probit model.

Variable	Coefficient	Std. error	z-statistic	Marginal effects
Constant	−.5489	.8840	−.621	—
GEN	.3702	.3063	1.209	.0503
AGE	−.0081	.0096	−.843	−.0604
EDU	−.2780	.3498	−.795	−.0216
PS	−.1837	.3706	−.496	−.0275
MS	−.1304	.3040	−.429	−.0192
HS	−.1416**	.0657	−2.155	−.1103
INCOME	.0007**	.0004	1.776	.1067
MILKPLACE	.326D-07	.406D-07	.803	.0222
PREFREA	3.0417*	.3086	9.857	.5515
MPRICE	−.9316*	.2719	−3.426	−.0858
Log-likelihood	−55.924	Akaike I.C.		.4395
Restricted Log-L	−179.742	Schwarz I.C.		.5630
Mc Fadden Pseudo-R^2	.6889	HQIC		.4889
X^2 $(df = 11)$	247.635	Ben./Lerman		.8912
Significance level	.00000	Cramer		.7330
Hosmer-Lemeshow X^2	25.457	Veall/Zim.		.8296
Predicted percentage correction	93.00			

Note: (***), (**), (*) denote significance at the 10%, 5%, and 1% levels, respectively.

size. According to marginal effects, for a household with larger size, the probability of consuming packed fluid milk decreased by 11.03%. This can be explained by allocation of household income to use it in other food goods due to the increase in household size. In this case, packed milk with the lower price is preferred instead of packed milk. Günden et al. [8] emphasized that households with more members could be closely correlated with budget constraints, which imply that this group's demand for unpacked milk is income- and/or price-oriented. Similar to our study results, Kilic et al. [13] found that increasing household size decreased the probability of consuming packed fluid milk compared to unpacked fluid milk. Tiryaki and Akbay [16] implied that the household size was getting bigger; the household would tend to consume unprocessed fluid milk instead of consuming processed fluid milk. Yayar [3] household size had a negative impact on the probability of packed fluid milk consumption versus unpacked fluid milk consumption. In contrast to the findings, Alviola and Capps [12] found that household size negatively affected both conventional and organic milk consumption.

Income level of households is one of the factors affecting their packed and unpacked milk consumption behavior. It is hypothesized that families with low income may consume more unpacked milk when milk prices are lower. As expected, household's income level affects the household's packed milk consumption positively. The positive and statistically significant coefficients imply that the household income increased; the household tended to consume unpacked milk instead of packed milk. As it is seen in Table 4, marginal effects of income variables indicate that households with the high income are 10.67% more likely to consume packed milk. According to our results, households preferred unpacked milk (39.54%) as a priority because of being cheaper than packed milk. It is a known fact that unpacked milk was unhygienic. Therefore, it is said that households tend to the consumption of unpacked milk because of their economic difficulties. Günden et al. [8] implied that consumers at higher income levels would tend to curtail the consumption of unpacked milk and simultaneously substitute more packed milk with increased income as the household regards the consumption of unpacked milk as "inferior good." Tiryaki and Akbay [16] found that as household income increased, then household would tend more to consume processed fluid milk instead of choosing unprocessed fluid milk. The effect of income is the largest on the probability of consuming processed fluid milk. Also, the findings of Dong and Kaiser [35], Fuller et al. [10], Zhang and Wang [36], Bus and Worsley [37], Vandermersch and Mathus [27], Hatirli et al. [2], Celik et al. [28], Jonas and Roosen [38], Yayar [3] are consistent with our research findings.

It is hypothesized if a consumer believed that packed milk was healthier and values being healthy, then he/she would likely have a positive attitude towards purchasing packed milk. Hygiene and health was a significant estimator of the consumers' milk consumption choices. There is significant and positive relationship between packed milk consumption and the estimator. This means that a household gives tendency that consuming packed milk increases but unpacked milk decreases. These results indicate that consumer awareness for safer milk consumption has increased. Marginal effects of hygiene and health are the largest on the probability of consuming packed milk. In consideration, to marginal effects the consumers who believe that packed milk is hygienic and healthy are by 55.15% more likely to prefer packed milk instead of unpacked milk. Similar studies support our study findings by Pazarlioğlu et al. [5], Akbay and Tiryaki [9], Kilic et al. [13], Günden et al. [8].

Milk price was determined as other main factors affecting households' packed and unpacked milk consumption behavior. Price was the primary reason mentioned in the survey for not purchasing packed fluid milk, as it was perceived as being quite expensive compared to unpacked fluid milk. In average, Turkish consumers have been sensitive to price of foods which they consume [13]. This variable was found out to be significant at 1% level and was related negatively. This sign indicated that consumers who were sensitive to price were less likely to consume packed milk. Households believe that packed milk price is expensive compared to unpacked milk price. The results support the hypothesis that households' milk consumption choices are related to the belief that packed milk price is expensive compared to unpacked milk price. According to the results, implied that consumers preferred price of packed milk are expensive compared to unpacked milk were less likely to consume packed milk. When milk price increased, the probability of packed milk consumption decreased 8.58%. Our study findings are supported by Kilic et al. [13] who reported the statistically significant and negative coefficients of PRICE variable for packed fluid milk equation. Hatirli et al. [2] emphasized that survey results showed that there is about twofold price difference between unpacked and processed fluid milk. Due to price concerns, many households were more likely to select unpacked and processed-unpacked fluid milk and less likely to choose processed fluid milk.

4. Conclusions

This study focused on the socioeconomic and demographic factors influencing milk consumption in Sivas, Turkey. In order to analyze the socioeconomic and demographic factors, we employed the binary probit model.

The findings of this study revealed that consumer's socioeconomic characteristics affected unpacked and packed fluid milk consumption preferences. The results from binomial probit model, household size, income, milk preferences reason, and milk price are significant and associated with packed and unpacked fluid milk consumption.

Results show that larger households are more likely to purchase packed milk. Also, results implied that the higher income level of households, the more likely the households would purchase packed milk. In addition, effects of hygiene and health are the largest on the probability of consuming packed milk. Consumers believe that packed milk is hygienic and healthy to prefer packed milk instead of unpacked milk. Also, milk price was effective factor concerning packed and unpacked milk consumption behavior. Our study findings suggest that consumers who were sensitive to price were less likely to consume packed milk and believe that packed milk price is expensive compared to unpacked milk price. The majority of consumers read the contents of packed fluid milk and are affected by safety food in their shopping preferences. Also, the most important reasons were hygiene and quality for packed fluid milk choice of consumers.

In the light of the findings, the necessary policies are needed as providing accessibility to adequate price, healthy, safety food and a mechanism reached to the level of per capita milk consumption in developed countries. In addition, we expect that our study results will benefit private and public organizations and companies in Turkey marketing strategies (e.g., pricing design, promotion strategies, etc.) for milk consumption by looking at specific consumer preferences. Despite the fact that Turkish government has prohibited selling of unpacked milk by law, unpacked milk produced and sold in unhygienic conditions by street sellers is still delivered in Turkish milk markets without any inspection. We suggest that Turkish Government should take necessary measures and regulate unpacked milk selling. Also, it is needed to establish and regulate some standards for milk market. Households who are more interested in packed milk consumption tend to have higher income and lower household size. Packed milk is slightly more expensive than unpacked milk, so price is a barrier to some consumers. Furthermore, there are opportunities to increase packed milk consumption by reducing the price. That is, households are willingness to desire packed milk consumption. So, it is suggested packed milk consumption should be promoted and encouragement.

Since the study makes use of cross-sectional data, it would be appropriate to imply the study does not include the other factors over a period of time and the socioeconomic and demographic characteristics of each member of the households in each province of Turkey. So, it may limit the ability to estimate factors affecting packed or unpacked milk consumption.

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Research Article

Food Price Inflation Rates in the Euro Zone: Distribution Dynamics and Convergence Analysis

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It is widely recognized that inflation as a monetary phenomenon is determined by money supply changes. In the short run, however, several factors may lead to inflation rate differentials among different regions in the same country or among different countries in a monetary union. This paper examines the mean reversion attitude of food price inflation rates in the Euro zone, borrowing the concepts and developments from the recent growth literature and using panel unit root tests. Additionally, in order to capture sufficiently the evolving distributional dynamics, nonparametric econometric methods are also implemented. Finally, the comovement of the inflation rates among different food subgroups is also explored. The data consist of monthly observations of the EU harmonized consumer price indices of food and three different food subgroups (meat, bread and cereals, and vegetables) for the 12 older member states of the Euro zone, covering the period from 1997 to 2010. The results do not fully support the hypothesis of the food price inflation rates convergence for the whole period under investigation. Mean reversion shows up in different time periods and in different food categories. Moreover, the analysis of distribution dynamics sheds light to different aspects of convergence and highlights processes like club formation and polarization.

1. Introduction

The subject of inflation rate convergence gained the attention of economists due to its importance for monetary and regional policies. In a monetary union, homogeneous inflation is expected to prevail due to the increased economic integration after the formation of the single currency area. Inflation rates and their convergence within the Euro area have been a major concern for policy makers, even before the advent of the single currency ([1, 2]).

Persistent differences in inflation rates within a monetary union may affect real interest rates, thus, creating important disparities in inflation expectations and increasing the likelihood of asymmetric inflationary shocks ([3]). Inflation alignment within the Euro zone is directly related to the relative price competitiveness of each country ([4–7]). The recent financial crisis and its strong impact on several Euro zone countries with higher inflation rates have strengthened the interest towards this direction.

It is widely recognized that inflation, as a monetary phenomenon, is determined by money supply changes. In the short run, however, and until the full impact of such changes is felt, other forces may play a role too, especially for small range changes of price indices. Such forces can be used to explain, at least partially, longer-term inflation rate differentials at the commodity or regional level.

The purpose of this study is to examine convergence and the distribution dynamics of food inflation rates for the twelve older countries of the Euro zone (see Table 1). The examination of food inflation is of great interest. As Walsh [8] emphasizes, food inflation is in many cases more persistent than nonfood inflation, and shocks in many countries are propagated strongly into nonfood inflation. Under these conditions, and particularly given high global commodity price inflation in recent years, a policy focus on overall inflation—excluding food prices—can misspecify inflation, leading to higher inflationary expectations, a downward bias to forecasts of future inflation, and lags in policy responses. The importance of food price inflation is further emphasized in the study of Cecchetti and Moessner [9] who report evidence suggesting that food price inflation has explanatory power for future headline inflation.

Table 1: Descriptive statistics for the "food", "bread and cereals", "meat", and "vegetables" inflation rates.

		Austria	Belgium	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	The Netherlands	Portugal	Spain
Food	M*	0.019	0.023	0.016	0.019	0.012	0.031	0.020	0.017	0.025	0.017	0.017	0.027
		(7)**	(9)	(2)	(6)	(1)	(12)	(8)	(5)	(10)	(3)	(4)	(11)
	SD*	0.021	0.020	0.034	0.020	0.024	0.025	0.018	0.035	0.016	0.029	0.028	0.025
Bread and cereals	M	0.023	0.029	0.015	0.018	0.014	0.040	0.021	0.022	0.027	0.016	0.030	0.030
		(7)	(9)	(2)	(4)	(1)	(12)	(5)	(6)	(8)	(3)	(10)	(11)
	SD	0.025	0.026	0.027	0.016	0.021	0.031	0.038	0.024	0.018	0.021	0.030	0.025
Meat	M	0.016	0.020	0.009	0.021	0.011	0.027	0.010	0.018	0.021	0.015	0.010	0.025
		(6)	(8)	(1)	(10)	(4)	(12)	(3)	(7)	(9)	(5)	(2)	(11)
	SD	0.022	0.018	0.039	0.022	0.027	0.018	0.040	0.018	0.018	0.029	0.035	0.032
Vegetables	M	0.016	0.024	0.017	0.022	0.006	0.029	0.018	0.025	0.028	0.029	0.032	0.038
		(2)	(6)	(3)	(5)	(1)	(10)	(4)	(7)	(8)	(9)	(11)	(12)
	SD	0.050	0.086	0.079	0.057	0.065	0.114	0.079	0.041	0.049	0.083	0.122	0.044

* M and SD stand for mean and standard deviation, respectively.
**The numbers in parenthesis indicate the relevance ranking for each country in the specific group.

The food price spike preceding the 2008 global financial crisis set off a number of studies on the role of food price inflation in the development of monetary policy. Catão and Chang [10] point out that the distinctive role of food in household utility and the presence of high food price volatility may have important implications for the welfare effects of different monetary policy regimes. Anand and Prasad [11] also conclude that in an environment of credit-constrained consumers, a narrow policy focus on nonfood inflation can lead to suboptimal outcomes.

In this study, both stochastic convergence (in particular the mean reversion case of β-convergence) and σ-convergence are considered. Additionally, nonparametric econometric methods are implemented to study the evolving distribution dynamics of food price inflation rates. The latter methodology allows the exploration of the entire distribution of relative inflation rates, rather than just the first two moments of the distribution, and its dynamics over time.

Most of the studies on price inflation convergence focus on price indices which are either general or refer to largely aggregated groups of commodities. Following the same approach, the data used consists of monthly estimates of the Harmonized Indices of Consumer Prices (HICPs) for the "food" group and for three specific subgroups, namely, "bread and cereals," "meat," and "vegetables." The data set covers a period from January 1997 to November 2010.

Dynamic panel data analysis and panel unit root tests according to Levin et al. [12] are used to examine stochastic convergence. Changes in standard deviation are used to examine σ-convergence, according to its concept [13]. Examination of the evolving distribution dynamics is also conducted using an alternative kernel density estimator proposed by Hyndman et al. [14] and Hyndman and Yao [15]. This estimator was introduced in the growth and income convergence analysis by Arbia et al. [16] and it is used in a similar manner in this analysis to study inflation rate distribution dynamics, since it offers certain advantages.

2. Literature Review

Throughout the literature, inflation rate differentials are often associated with the productivity catching-up process (e.g., [17]) and with monetary and fiscal factors (e.g., [18, 19]). Moreover, Dalsgaard [20] and Beck et al. [21] emphasize the role of market concentration, mergers and acquisitions, and cartel formations on the phenomenon of inflation rate differentials. Campolmi and Faia [22] and Jaumotte and Morsy [23] point out the importance of labor and product market institutions, which can generate significant and persistent inflation differentials.

Several other studies (e.g., [24, 25]) also emphasize the importance of sectoral inflation. Different sectoral inflation rates among countries provide evidence of dissimilarity in the industrial structure of the European Union (EU) which itself leads to differences in regional inflation ([26]). As Nagayasu [1] claims, in the absence of convergence in industrial structure, regional inflation rates do not converge even after the establishment of monetary union. Altissimo et al. [27] also point out the importance of the different responses of Euro-zone countries to common, Euro-area shocks, while Stavrev [28] recognizes the influence of price convergence, business cycle, and past inflation differentials for the formation of inflation differentials.

The empirical studies on inflation convergence literature deal with the issue of inflation convergence among different regions in the same country or inside a cluster of countries. Beginning with the former group, Cecchetti et al. [18] and Roberts [29] examine inflation convergence trends within USA, while Dayanandan and Ralhan [30] investigate price index convergence among Canadian districts and cities. Fan and Wei [31] investigate inflation convergence among Chinese cities and Busetti et al. [32] test for convergence among Italian regions. Moreover, Yilmazkuday [33] tests for inflation rate convergence among different Turkish regions. Finally, Nagayasu [1] examines regional inflation differential in Japan.

The cluster of countries for which inflation convergence is examined usually refers to members of the European Monetary Union (EMU) or the new members of the European Union[1]. Kočenda and Papell [34] and Lopez and Papell [35] using panel unit root test find a strong evidence of inflation convergence among EU countries. However, several other studies cast doubt on the convergence hypothesis in Europe (e.g., [19, 36]). Also, Busetti et al. [3] detect two convergence clubs, while Erber and Hagemann [37] find that there is still a considerable degree of prevail heterogeneity in the national inflation rates. However, the stochastic long-term convergence could be accomplished after a sufficiently long time period. A number of studies also focus on the examination of the inflation convergence of the new member states relative to the EMU benchmark (e.g., [38–43]). The findings are not similar among these studies but vary considerably depending on the period under investigation and the applied methodology.

According to Lünnemann and Mathä [44], even though the available international evidence focuses mainly on aggregate inflation data, the usage of more disaggregated inflation data may prove a useful complement in identifying the key drivers of aggregate inflation persistence. A disaggregate analysis may uncover inflation persistence differences and allow their categorization according to sectors. Moreover, several authors provide evidence that aggregate inflation persistence is predominantly driven by the most persistent disaggregate inflation components (e.g., [21, 45]).

In the above context, the examination of food inflation is of great interest. Weber and Beck [19] examined inflation rate convergence in two samples of European countries. Their study considers changes in HICPs for several groups of products including the "food and nonalcoholic beverages" subgroup. For the latter, β-convergence was found but the estimates of half-lives were not provided since the solution of the nonlinear expression for β-convergence that was used produced complex numbers. Even though β-convergence took place during the whole period examined, it was slower for the period after the introduction of the common currency implying also the existence of nonlinearities in the convergence process. This result is also supported by the existence of σ-convergence during the first half of the period they examined but σ-divergence for the second half of the period.

Dayanandan and Ralhan [30] used panel unit roots tests suggested by Levin and Lin [46] and Im et al. [47], and they found evidence of β-convergence for the food price index in Canada with a half-life equal to 7.4 years. Sturm et al. [48] estimated coefficients of variation for the consumer price index of several commodity groups including food commodities and for different groups of European countries. They found a variety of results for different commodity and food commodity groups, with regards to β- and σ-convergence. Results vary also with respect to country groups (EMU and non-EMU members) and time periods.

Faber and Stokman [49] found evidence of convergence for the consumer price index of food and nonalcoholic beverage products in Europe, for the period 1980–2003. In early 90s, there was a strong price level convergence for all "second-level" commodity groups including food and non-alcoholic beverages. In the study of Fan and Wei [31], panel unit root tests were used to study convergence of the food price inflation rates across 36 major Chinese cities and over a seven-year period. They found contradictory results on β-convergence based on the panel unit root test implemented and the time lag selection model. They argued that these results are stemming from the fact that high-frequency data (monthly) were used, which better capture the time period needed for price convergence.

Lünnemann and Mathä [50] analyze the degree of persistence of inflation in the EU for more than 1500 HICP sub-indices (94 HICP subindices and 17 countries or country aggregates). The results indicate a very moderate median and mean inflation persistence at the disaggregate level based on a nonparametric measure of the mean reversion.

Several authors have also provided possible explanations for the food inflation rates differentials. Fousekis [51] points at the fragmentation of the European market and claims that inflation rate differentials are not efficiently confronted by horizontal EU measures but by changes in the market structures in EU countries. Bukeviciute et al. [52] argued that food price inflation differentials are caused by the different ways and degrees in which the food supply chains of different countries absorb external shocks such as the rapid increase of energy prices. This in turn is due to different food market structures and regulatory frameworks. In this sense food price inflation differentials are a signal that the EU food market still remains fragmented.

Davidson et al. [53] show that there are a range of factors that determine retail food prices like the exchange rate, manufacturing labor costs, and oil prices. In addition, given the underlying characteristics of commodity price behavior on world markets (i.e., relatively low prices punctuated by spikes), the impact of world commodity prices on retail food price inflation will depend on the duration of the shock. Given the expectation that world commodity prices are likely to be higher and more volatile in the future, understanding the dynamics of commodity price (and other) shocks on domestic retail prices is an important issue for macroeconomic policy.

A large part of the empirical studies on the subject of inflation convergence follows the introduction and development of quantitative methods in the area of economic growth and convergence. Consequently, the concepts of stochastic convergence and σ-convergence have dominated the relevant literature (e.g., [34–36, 38]). Recently, another methodological tool, the distribution dynamics analysis, borrowed from the economic growth literature, has also been introduced in the analysis of inflation rates differentials. The study of Cavallero [54] presents an example of this alternative approach. After the decomposition of the EU-12 inflation series into trend and cyclical component, Cavallero [54] concludes that inflation trends converged, although the convergence process was not constant over time. Especially the launch of the EMU and the introduction of a single currency have boosted convergence. Moreover, although inflation cycles converged in the long run, they still lack synchronization over short time horizons. In search for an economic explanation for cyclical inflation dynamics, he suggests that country-specific labor market institutions are likely to affect inflation outcomes especially in high inflation countries.

Additionally, Nath and Tochkov [55] examine the distribution dynamics of inflation rates in ten new EU members relative to the EMU accession benchmark inflation over the period 1990–2009 using nonparametric methods. Over the entire sample period, they detect a general shift in the new EU members' inflation distribution toward the EMU benchmark along with intradistributional convergence. However, this process is not uniform. In the early years, it was equally likely for new EU members' inflation rates to move toward or away from the benchmark. The resulting multimodal distribution gave way to a unimodal distribution in the years leading up to the EU accession, accompanied by a marked shift toward the EMU benchmark. In more recent years, the emergence of a bimodal distribution signaled the stratification of relative inflation in new EU members into two convergence clubs, which has intensified since the start of the global economic crisis.

3. Data and Descriptive Statistics

Monthly data on HICPs for the "food" group and the "bread and cereals," "meat," and "vegetables" subgroups have been used in the analysis. Inflation rates are computed as annual percentage changes of the price index as follows:

$$\pi_t = 100(\ln P_t - \ln P_{t-1}) = 100(p_t - p_{t-1}), \qquad (1)$$

where π_t denotes the food price inflation rate in period t, P_t represents the price index at period t, and p_t is the natural logarithm of P_t. Table 1 provides some descriptive statistics—mean (M) and standard deviation (SD)—of the monthly data for the "food," "bread and cereals," "meat," and "vegetables" groups.

On average, Greece and Spain have the highest food price inflation rates during the period under investigation, while Finland and Germany have the lowest. Even though there are many similarities in the relevant rankings of the countries, in each subgroup, some significant differences can also be observed. Finland and Germany possess high rankings in all the categories, while Greece and Spain possess low ranking in all categories. On the other hand, Portugal is the second in the "meat" group but the tenth in the "vegetables" group. Moreover, Austria ranks the second in the "vegetables" group but the seventh in the "bread and cereals" group.

These statistics illustrate the high degree of complexity in the data. Apart from economic policies (EMU or national) other country and product specific factors, such as market structures, may be contributing to the observed inflation "heterogeneity" between countries and products.

Figures 1 and 2 provide some additional insight on the inflation rates within the Euro-zone. In Figure 1, each dot represents a country's inflation rate at a specific time (monthly observation). The white line represents the cross-country average inflation rate. Consequently, each graph illustrates the dispersion of the inflation rates at a specific month and additionally depicts the comovements of inflation rates. As we can see in Figure 1, there is a significant comovement of the inflation rates in each group. However, in the case of the "vegetables" group, this comovement is less obvious, while there is also a significant dispersion of the inflation rates. Additionally, Figure 1 reveals that the evolutions of the inflation rates of the groups under consideration are characterized by a high degree of seasonality, with the exception of the "bread and cereals" group. In the latter case, there is a remarkable shift in the inflation rates that corresponds to the "food spike" of the 2007-2008 period.

Figure 2, shows the number of times (monthly observations) that each country has been included in the "high," "medium," or "low" inflation group. The "high" inflation group includes the four countries with the highest inflation rates; the "low" inflation group includes the four countries with the lowest inflation rates, while the rest of the countries are included in the "medium" inflation group.

It is obvious that even countries with low average food inflation (e.g., Germany and Luxemburg) have in some occasions been placed in the "high" inflation group. This reflects the complexity of the data and indicates the presence of the "leapfrogging" phenomenon. The latter refers to cases where countries with high (or low) relative inflation rates move towards the mean and end up with a low (or high) relative inflation rate. This phenomenon is common in the economic convergence studies (see Magrini [56]).

4. Methodology

4.1. Stochastic Convergence. The concept of stochastic convergence was firstly introduced in the growth literature by Bernard and Durlauf ([57, 58]). According to the authors, stochastic convergence is not the outcome of a negative relation between initial income and growth during a predetermined time period, as β-convergence is. It is the outcome of the relationship between the long-term income estimates of two economies, subject to the initial conditions. Thus, giving the available information at initial period t, $\Im_t$ economies i and j converge stochastically if (Bernard and Durlauf [57]):

$$\lim_{T\to\infty} E\left(y_i(t+T) - y_j(t+T) \mid \Im_t\right) = 0. \qquad (2)$$

In the stochastic convergence study researchers usually apply either time series or panel data unit roots tests for the examination of the mean reverting behavior. Several studies use this analysis to examine the mean reverting behavior in price and inflation rates (e.g., [7, 16, 19, 31, 35, 40, 43, 59–62]). According to Gregoriou et al. [63], discovering that inflation differentials are characterized by a unit root implies that the idiosyncratic shocks in individual countries' inflation rates have persistent effects. This finding raises issues on whether EMU really constitutes an optimal currency area that can be effectively managed by the ECB. In addition, it raises questions on whether the member countries have truly converged during the pre-Euro-zone period.

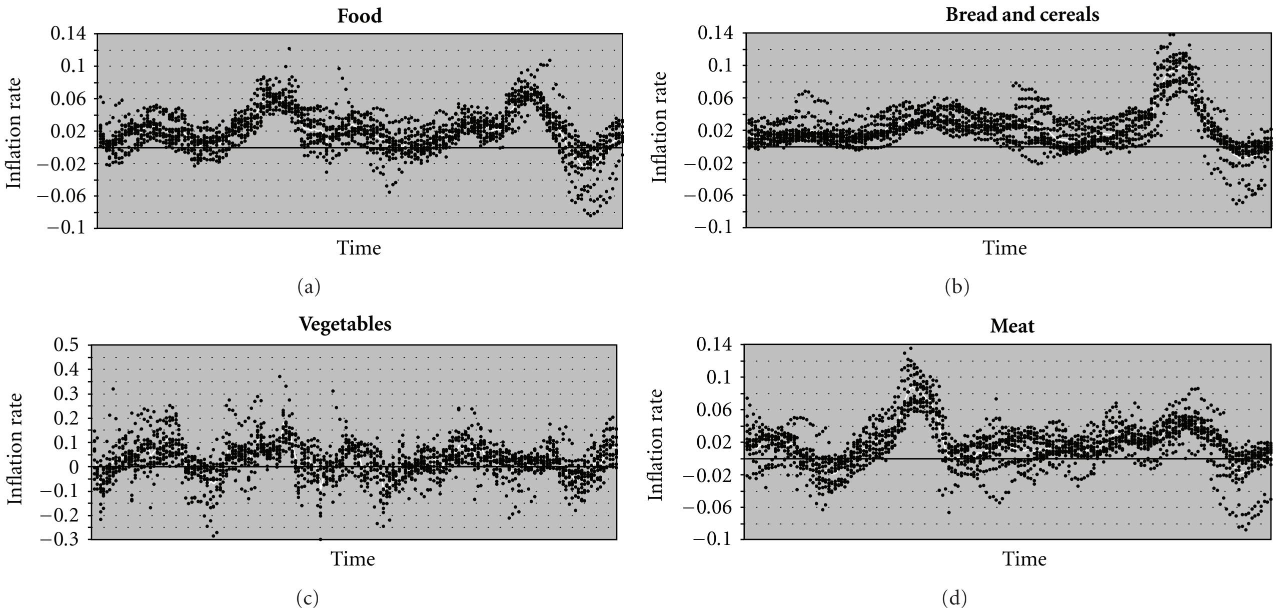

Figure 1: Evolution of the “food,” “bread and cereals,” “meat,” “vegetables” inflation rates. Each dot for each month (horizontal axe) represents a country observation on the inflation rate (vertical axe) of this group.

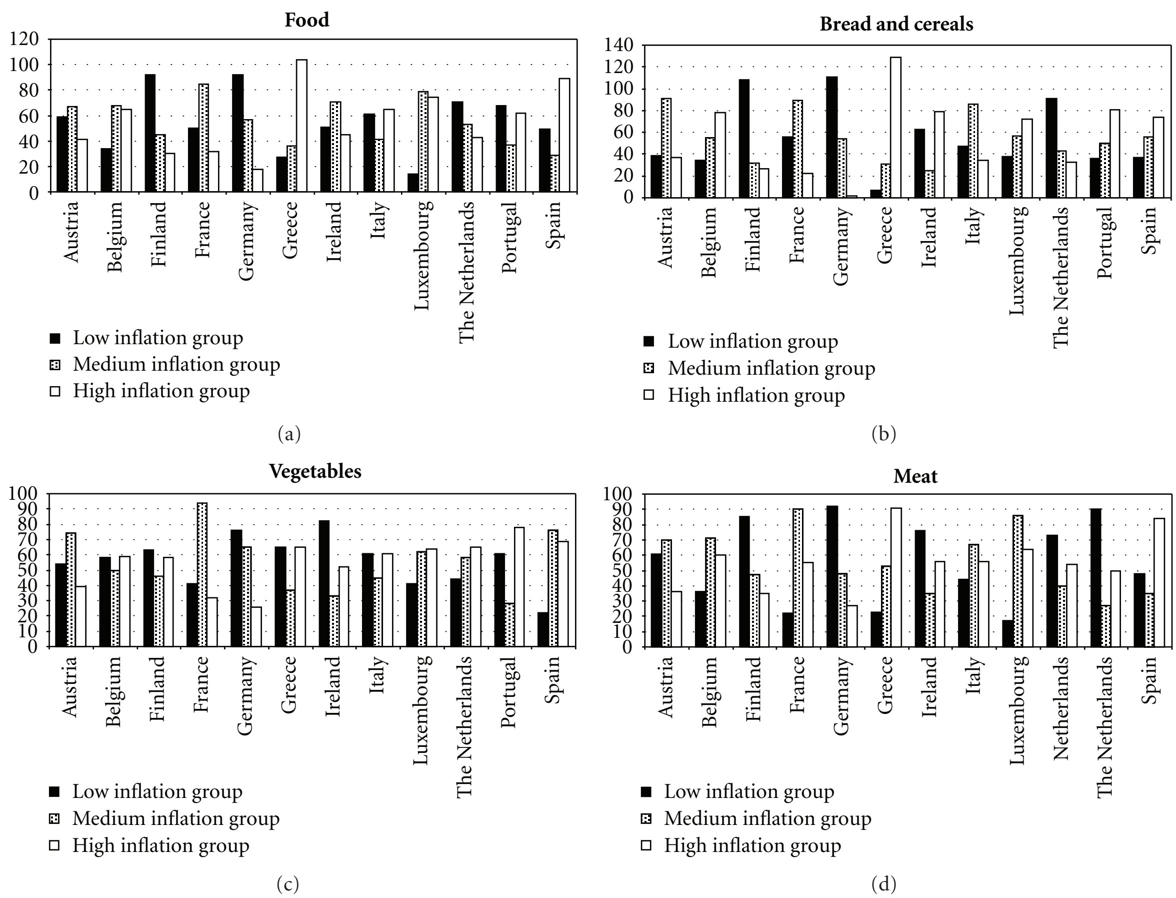

Figure 2: Times that each country has been included in the “high,” “medium,” and “low” food inflation rate category.

On the other hand, if inflation differentials are only temporary, ECB can effectively implement and communicate its policies without exacerbating the differences that exist between EMU countries. Therefore, the degree of persistence of inflation differentials is of primary importance in order to establish whether the economic area exhibits imbalances that require structural interventions, or whether the asymmetries are just temporary phenomena which in the long run eliminate themselves [63].

Bernard and Durlauf ([57, 58]) use time series unit root tests to explore the issue of stochastic convergence. The major problem associated with this group of tests is their low power, especially in small samples. The use of panel unit root tests has alleviated this problem to a great extent by exploiting both cross- and time-series variation [64]. In this analysis the Levin et al. panel unit root test (LLC) [12] is implemented[2]. The LLC test has been widely used in the inflation convergence literature (e.g., [10, 43, 59, 60, 62]).

Let $i = (1, 2, \ldots, N)$ denote the countries and let $t = (1, 2, \ldots, T)$ represent the time index. Then, the test for food inflation convergence is based on the following equation:

$$\Delta\pi_{i,t} = a_i + b\pi_{i,t-12} + \theta_t + \sum_{j=1}^{k_i} \varphi_{i,j}\Delta\pi_{i,t-j} + \varepsilon_{i,t}, \tag{3}$$

where Δ denotes the annual, month to corresponding month, change of $\pi_{i,t}$, $b = \rho - 1$, θ_t represents a common time effect, and $\varepsilon_{i,t}$ is assumed to be a stationary idiosyncratic shock. The inclusion of lagged differences in the equation serves to control for serial correlation. Their respective number is determined using the Akaike Information Criterion (AIC) and the Schwarz Information Criterion (SIC). The inclusion of a common time effect is supposed to control for cross-sectional dependence caused by an external shock. To take control of this effect, the variable is transformed by subtracting the cross-sectional mean leading to

$$\Delta\tilde{\pi}_{i,t} = a_i + b\tilde{\pi}_{i,t-12} + \sum_{j=1}^{k_j} \varphi_{i,j}\Delta\tilde{\pi}_{i,t-j} + \varepsilon_{i,t}, \tag{4}$$

where $\tilde{\pi}_{i,t}$ is computed as

$$\tilde{\pi}_{i,t} = \pi_{i,t} - \frac{1}{N}\sum_{j=1}^{N} \pi_{j,t}. \tag{5}$$

The examination of the mean reverting behavior is implemented by testing the null hypothesis that the common b's[3] equals zero against the alternative hypothesis that they are all smaller than zero. The rejection of the null hypothesis implies stationarity, that is, inflation rates exhibit mean reverting behaviour. Thus, any shock that causes deviations from equilibrium will eventually die out. The speed at which this occurs can be directly derived from the estimated value[4] of ρ (denoted $\hat{\rho}$) using the half-life formula: $t_{\text{half}} = \ln(0.5)/\ln(\hat{\rho})$. In addition to the analysis for the total period and in order to get a rough indication of nonlinearities in the convergence process, we also implement the LLC panel unit root test, in three distinct time periods. The first period starts from January 1997 and finishes at December 1999, just before the creation of the Euro-zone. The second period is the largest one and covers all the years up until the beginning of the global financial crisis at August 2008. The last period covers the period from September 2009 to November 2010. If the results, concerning the existence of convergence and the value of ρ differ among the subperiods under investigation then as Goldberg and Verboven [65] and Berka [66] argue, we have an indication of nonlinearity in the convergence process.

4.2. Distribution Dynamics. Despite the information on the transition towards a steady state that stochastic convergence contains, it does not provide an insight on the dynamics of the entire cross-sectional distribution. It does not conclude on certain conclusions on rising, declining, or stationary dispersion of the cross-section distribution over time and any method that cannot differentiate between distribution convergence, divergence, and stationarity is of limited use [16]. The concept of σ-convergence approach, which refers to the evolution of the overall cross-regional dispersion, is also an insufficient solution since it does not offer information on the intradistribution dynamics. A constant dispersion can coexist with very different dynamics of the distribution ranging from crisscrossing and leapfrogging to constant ranking and no changes in distribution at all [56].

The distribution dynamics analysis overcomes the above limitations as it examines the evolution of the entire distribution over time [19]. It enables researchers to simultaneously detect and analyze shifts of the distribution of inflation rates relative to the mean, intradistributional convergence, and stratification into different convergence clubs [55]. This methodology has been firstly introduced in the economic growth literature by Quah [67].

The idea behind the distribution dynamics approach is to find a law of motion that describes the evolution of distribution over time. One of the techniques most commonly used in this analysis involves the calculation of stochastic kernels (see [64]). This approach is based on the estimation of the conditional density of a variable Y given a variable X. In our case, X refers to the absolute deviation of a country's food inflation from the average at month t, while Y refers to the absolute deviation of a country's food inflation rate from the average at month $t + 12$ (transition period equal to 12 months). Thus, the conditional density function describes the probability of a country to move to a certain level of inflation deviation from the cross-sectional mean at time $t + 12$ given its current inflation rate deviation (time t).

The traditional stochastic kernel estimator (see, among others, [16]) is defined as

$$\hat{f}_\tau(y \mid x) = \frac{\hat{g}_\tau(x, y)}{\hat{h}_\tau(x)}, \tag{6}$$

where

$$\hat{g}_\tau(x, y) = \frac{1}{nab}\sum_{i=1}^{n} K\left(\frac{\|x - X_i\|_x}{a}\right)\left(\frac{\|y - Y_i\|_y}{b}\right) \tag{7}$$

is the estimated multiplicative joint density of (X, Y) and

$$\hat{h}_\tau(x) = \frac{1}{na}\sum_{i=1}^{n} K\left(\frac{\|x - X_i\|_x}{a}\right) \quad (8)$$

is the estimated marginal density. In the above equations, a, b are bandwidth parameters controlling the smoothness of fit, $\|\cdot\|_x$ and $\|\cdot\|_y$ are Euclidean distance metrics on spaces X and Y, respectively, and $K(\cdot)$ is the Epanechnikov kernel function.

The conditional density estimator can be rewritten as

$$\hat{f}_\tau(y \mid x) = \frac{1}{b}\sum_{i=1}^{n} w_i(x) K\left(\frac{\|y - Y_i\|_y}{b}\right), \quad (9)$$

where

$$w_i(x) = \frac{K(\|x - X_i\|_x / a)}{\sum_{j=1}^{n} K\left(\left\|x - X_j\right\|_x / a\right)}. \quad (10)$$

This estimator is in fact the Nadaraya-Watson kernel regression estimator. Equation (8) shows that the conditional density estimate at $X = x$ can be obtained by the sum of n kernel functions in Y space weighted by the $\{w_i(x)\}$ in X space. Using $w_i(x)$, the estimator of the conditional mean is given as

$$\hat{m}(x) = \int y \hat{f}_\tau(yx)\,dy = \sum_{i=1}^{n} w_i(x) Y_i. \quad (11)$$

Hyndman et al. [14] noticed that when the conditional mean function has an exacerbate curvature and when the points utilized in the estimation are not regularly spaced, the above estimator is biased. In order to correct this bias, they propose an alternative estimator whose mean function has better bias properties than the traditional kernel regression, as well as a smaller integrated mean square error (for further details on this alternative estimator, see the Appendix). For the bandwidth selection, we follow the Hyndman and Yao [15] proposed algorithm.

In addition to the reduced bias estimator, Hyndman et al. [14] proposed two new ways to visualize the conditional densities, namely, the "stack conditional density" and the "high density region" (HDR) plots. The former was introduced for the direct visualization of the conditional densities, which is considered as a sequence of univariate densities. Thus, it provides better understanding than the conventional three-dimensional perspective plots. The HDR plot consists of consecutive high density regions. A high density region is defined as the smallest region of the sample space containing a given probability. These regions allow a visual summary of the characteristics of a probability distribution function. In the case of unimodal distributions, the HDRs are exactly the usual probabilities around the mean value. However, in the case of multimodal distributions, the HDR displays multimodal densities as disjoint subsets in plane.

The "stacked conditional density" plots present the location of the univariate conditional densities relative to the x-axis which refers to time t and, unlike the HDR plots, is the vertical axis. If the mass of the distribution concentrates parallell to x-axis line at zero point, it is an indication that any existing deviation in time t almost disappears at time $t + \tau$ (inflation convergence trend). On the other hand, if the mass of the distributions is located on the 45° degree line (when t and $t + \tau$ axes are similarly scaled), the deviations at time t still exist at time $t + \tau$ (inflation persistence). In the examination of the HDR plots, the existence of multiple modes in the conditional densities is also of great importance. If there are more than one peaks in a univariate conditional density, this implies that from a certain inflation rate deviation in time t, countries tend to end up in two (or more) different point masses of inflation deviations.

When examining the "high density region" plots, we observe whether the 25% or the 50% HDRs are crossed by the 45-degree diagonal (again t and $t + \tau$ axes should be similarly scaled) or if they are crossed by the horizontal axis. If the majority of the 25% or 50% HDRs are crossed by the diagonal, strong convergence trend is present. If the majority of the 75% HDRs are crossed by the diagonal, weak convergence trend is present. On the other hand, if the majority of the 25% or 50% HDRs are crossed by the x-axis, there is a strong persistence of inflation differences among countries. Finally, if the majority of the 75% HDRs are crossed by the x-axis, weak persistence prevails in inflation distribution. The 25%, 50%, 75%, and 90% are shown to be beginning with the darker shaded region and moving towards the lighter respectively. Arbia et al. [16] emphasized also the importance of analyzing central points like modes, the values of y, where the density function takes on its maximum values. When, in particular, the distribution function is bimodal, the mean and the median are only "compromise" values between the two peaks. The highest modes for each conditional density estimate are superimposed as bullets on the HDR plots.

5. Results

Table 2 summarizes the findings from the stochastic convergence analysis. For the entire period under investigation, stochastic convergence is only statistically significant in the "vegetables" product group and only when the SIC criterion for the determination of the number of lags is applied. The values of ρ's and the corresponding half-lives are only reported in cases where the unit root hypothesis is rejected at a 95% level of significance.

In the first subperiod, "bread and cereals" is the only group where no convergence evidence appears. On the other hand, the general "food" group, as well as the "meat" and the "vegetables" subgroups, appears to have strong convergence trends. However, in the cases of "food" and "meat" groups, the convergence is only supported when the lags selection is based on the SIC criterion. In the second period, there is no inflation convergence evidence in the "bread and cereals" and "meat" subgroups. Stochastic convergence only appears in the general "food" group as well as in the "vegetables" subgroup and only when the number of lags is determined by the SIC criterion. Finally, in the last subperiod (global financial crisis), stochastic convergence appears everywhere

Table 2: Unit root tests for food and eleven food product subgroups' inflation rates.

Categories		Total period			1997M01–1999M12			2000M01–2008M09			2008M10–2010M11		
		ρ-adj	t-stat	adj. 1/2 life	ρ-adj	t-stat	adj. 1/2 life	ρ-adj	t-stat	adj. 1/2 life	ρ-adj	t-stat	adj. 1/2 life
Food	S*		−0.51		**0.89**	**−2.14**	**5.74**	**0.91**	**−1.37**	**7.56**		−1.02	
	A*		5.62			−1.12			3.53		**0.92**	**−1.70**	**8.61**
Bread and cereals	S		0.49			−0.67			−0.32		**0.79**	**−5.12**	**3.00**
	A		6.12			−0.67			5.44		**0.79**	**−5.14**	**3.00**
Meat	S		2.23		**0.90**	**−2.26**	**6.84**		−0.72		**0.94**	**−1.89**	**11.64**
	A		7.27			−1.39			5.40		**0.94**	**−1.99**	**11.15**
Vegetables	S	**0.8**	**−8.86**	**3.06**	**0.81**	**−2.64**	**3.22**	**0.77**	**−8.28**	**2.70**		−1.04	
	A		1.19		**0.79**	**−2.78**	**2.96**		0.28			−0.92	

* S, A: Schwarz and Akaike information criterion for the selection of the lags number, respectively.

with the exception of the "vegetables" group. Unlike the second subperiod under investigation, mean reversion in the "food" group is present, only when the analysis is implemented using the AIC criterion for the lags selection.

To summarize, the results of the stochastic convergence analysis are rather mixed. There are no similar convergence patterns among groups or among time periods. However, for the entire period under investigation, the general conclusion is the absence of convergence, with the notable exception of the "vegetables" group. Moreover, it is important to mention that the implementation of the AIC or the SIC criterion is crucial for the estimation of the statistical significance of the estimated ρ's.

Figure 3 presents the results of the σ-convergence analysis. It presents the cross-section, countrywise, inflation rate dispersion in terms of standard deviation from January 1997 to November 2010. As can be observed for the "food" and for the "bread and cereals" groups, there was an increase in dispersion, which was totally counterbalanced by the last few monthly observations. On the other hand, the "vegetables" group, regardless of the seasonalities of the inflation rate dispersion, presents a downward trend which is steady during the period under investigation. Finally, the results for the "meat" group are similar to the "food" group, but with almost no increasing trend. Both the "food" and "meat" groups present a high increase in their inflation rates during the year 2008. Moreover, the "bread and cereals" group suffers a sharp increase in year 2007. This may be related to the rapid increase in some agricultural commodity prices and energy prices, which were observed during the second half of 2007.

A closer look at the above figures indicates that σ-convergence analysis provides similar results with the β-convergence analysis, especially when the total period is under investigation. Another important implication from the above figures is the rapid decrease in the inflation rates dispersion that was observed in the last few months of the period under investigation. This is the main reason for the significant convergence trends that are provided by the stochastic convergence analysis in the third subperiod.

Turning now to the results of the distribution dynamics analysis, Figure 4 presents the "high density regions" and the "stack conditional density" plots for each group under investigation. It can be seen that for most of the product groups the mass of the distributions in the HDR plots concentrates around a line, close to the parallel of the x-axis which crosses the zero point on the vertical axis. This implies that the existing deviations at month, t, are significantly reduced at time $t + 12$. This is an indication of strong inflation convergence. Thus, in general, countries with relatively higher or lower food price inflation rates are expected to move back towards the mean in a one-year period. It is important to emphasize that the above results demonstrate the argument in favor of the convergence hypothesis, better than the previous results.

Although the trend of reversion to the mean appears in each group, each case presents several different characteristics. The degree of mean reversion is not similar across groups. The "meat" group appears with the most obvious mean reversion trends. On the other hand, the mass of the distribution of the "vegetables" group is less obviously concentrated to the parallel of the x-axis which crosses the zero point on the vertical axes. In the other two groups ("food" group and "bread and cereals" group) there are still obvious mean reversion trends but they are restricted in cases where the absolute values of the inflation deviations in the initial period are relatively low in absolute values.

Another important characteristic of the distribution dynamics analysis is the presence of multimodality cases, in different frequencies among product groups. The presence of multimodalities indicates that, in some cases, a low or a high inflation rate deviation does not result in a common point mass after the transition period, but to two or more point masses. These cases do not appear in the same "areas" of each product group plot and do not show the same sharpness. However, according to Figure 2, multimodalities mostly appear in the edges, that is, when the initial deviation of the inflation rate has a high absolute value (either positive or negative). In these cases, the distributions of the inflation rate deviation in the next period ($t + 12$) tend to be multimodal. It is important to mention that the presence of multimodalities is more common in the subgroups distributions than in the distribution of the general "food" group.

Another interesting result from the nonparametric analysis is the existence of threshold points in our sample. A closer look at the plots reveals that after a certain point of inflation deviation (either negative or positive), the mass of

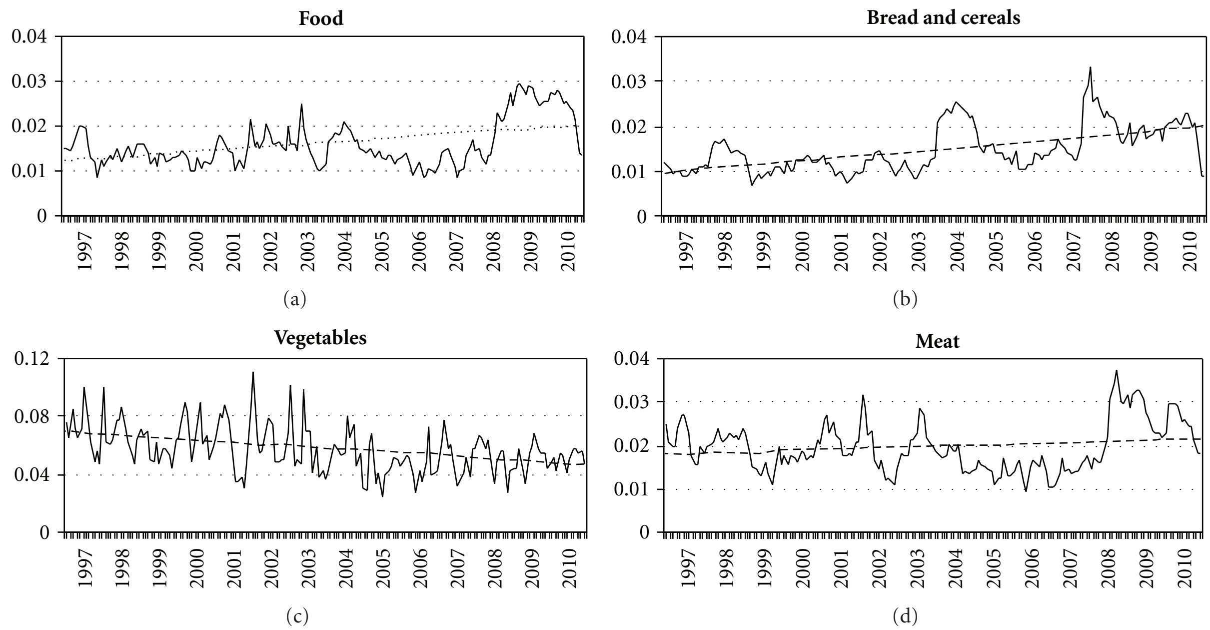

Figure 3: Inflation rate dispersion for "food," "bread and cereals," "vegetables," and "meat" product groups.

the conditional distribution does not remain close to zero, but near to the opposite point of inflation deviation. In the case of "meat" group, for example, when the inflation deviation is greater than 0.06 or lower than –0.08, the mass of the next year inflation deviation is concentrated around −0.06 and 0.02, respectively. In the other groups, threshold points also exist but they are "one sided," that is, cases of initial negative or positive values of inflation rate deviations from the mean end up with positive or negative values of inflation rate deviations from the mean, respectively, after the transition period. As in the case of multimodality, thresholds mostly appear in the distributions of the subgroups.

For a further investigation of the distribution of food inflation rates in the Euro-zone, the results of the distribution dynamics using stochastic kernels are accompanied with a Markov transition probability matrix (Table 3). Following Cavallero [54], three states are considered for the construction of this matrix. The first state represents low inflation countries (with respect to the areawide mean, henceforth, L-state); the second state stands for countries with inflation performances in line with the areawide mean, therefore it represents the "convergence" state (henceforth, C-state); the third state represents high inflation countries (with respect to the areawide mean, henceforth, H-state).

Each cell in a given row of the matrix in Table 3 shows the probability of a transition from the initial state to one of the three states; hence, row probabilities add to one. The values along the diagonal represent the cases where relative inflation remains in the same interval (state) from one period to the next and are thus indicative of inflation persistence. As in the continuous case, probabilities are estimated for transitions over 1-year horizon.

Estimated transition probabilities close to 1 along the main diagonal point to persistence in EU-12 inflation rates, while large offdiagonal values imply high mobility. The final raw of each matrix reports the ergodic distribution and represents the long-run steady state that the system could eventually reach if nothing structural were to change.

The probabilities for annual transition along the diagonal of the first matrix (referring to the general "food" group) of Table 3 are lower than those off the diagonal. This is an indication of inflation convergence during the period under investigation. It is also important to mention that the two lowest values occur in the upper-right and the lower-left cells (about 20%). This fact suggests that the countries with high and low relative inflation in the initial state are less likely to move to the low or to the high inflation state, respectively. Furthermore, the fact that the highest values occur in the second column of the matrix (44%–51%) suggests that most countries tend to concentrate on the "convergence" state, that is to an inflation rate close to the average. The estimated ergodic distribution confirms this trend in the long run.

As far as the "meat" group is concerned, the similarities with the general "food" group are remarkable. The values in each cell and the ergodic distributions are similar. In the other two subgroups, there are both similarities and differences with the general "food" group. Two similarities are mainly observed. The first refers to the fact that the highest values are still observed in the second column. The second similarity refers to the structure of the ergodic distribution. These similarities suggest that the mass of the distributions is concentrated on the mean in the long run, and it has similar structure with the long-run distributions of the "food" group.

On the other hand, the transition probability matrix that refers to "bread and cereals" group appears to have the highest persistence as the diagonal elements of the matrix are higher than those off the diagonal. The lower-right cell has

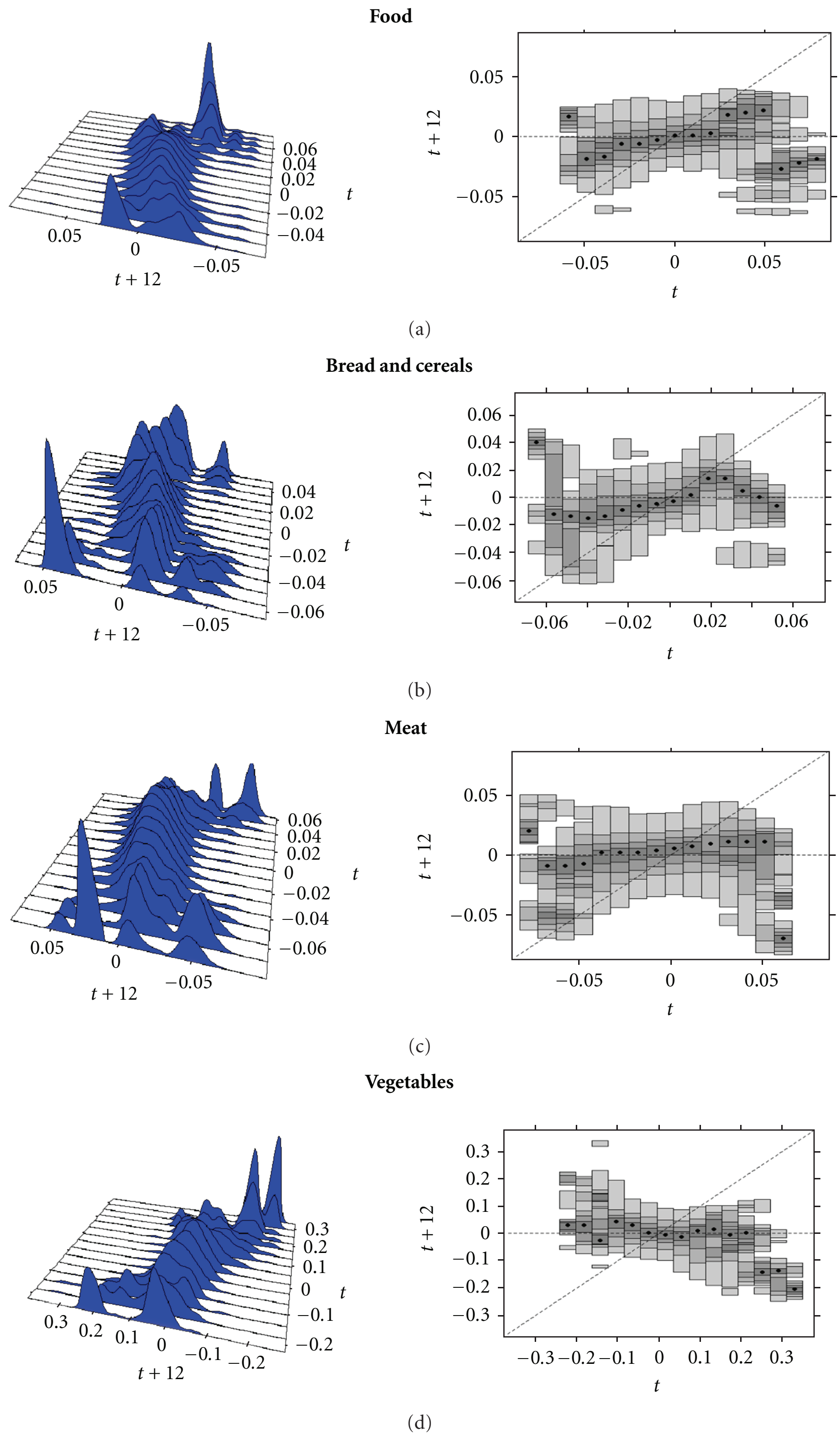

Figure 4: Intradistribution dynamics of annualized inflation rate transitions. "Stacked density" plot (left-hand side panel) and "high density region" plot (right-hand side panel).

the highest value (54%), indicating that the countries that initially belong to the higher state are more likely to stay in it than to move to another state and especially to the lower inflation state (14%). The probabilities for a country that initially belongs to the lower or to the "convergence" state to move to the high inflation state are also very low (12% and 18% resp.).

Finally, the transition matrix that refers to the "vegetables" group seriously deviates from the other matrices. Among the diagonal elements, the upper-left and the

Table 3: Markov transition probability matrices and ergodic distributions for "food", "vegetables", "bread and cereals", and "meat" groups.

		State in period $t+1$			Number of transitions
		L-state	C-state	H-state	
Food					
Grid $(-\infty, -0.008402, 0.00920669, +\infty)$, states: 3					
State in period t	L-state	0.3246	0.4749	0.2004	310
	C-state	0.2497	0.5106	0.2397	682
	H-state	0.2036	0.4412	0.3552	247
	ergodic	*0.2570*	*0.4834*	*0.2596*	
Vegetables					
Grid $(-\infty, -0.031727, 0.0333225, +\infty)$, states: 3					
State in period t	L-state	0.1589	0.4393	0.4018	381
	C-state	0.2249	0.5469	0.2282	700
	H-state	0.4049	0.4336	0.1615	256
	ergodic	*0.2541*	*0.4906*	*0.2553*	
Bread and cereals					
Grid $(-\infty, -0.008490, 0.00914554, +\infty)$, states: 3					
State in period t	L-state	0.4215	0.4559	0.1226	269
	C-state	0.2350	0.5831	0.1818	738
	H-state	0.1435	0.3161	0.5404	305
	ergodic	*0.2597*	*0.4808*	*0.2595*	
Meat					
Grid $(-\infty, -0.009169, 0.01217942, +\infty)$, states: 3					
State in period t	L-state	0.3363	0.4374	0.2264	302
	C-state	0.2493	0.4895	0.2612	563
	H-state	0.2279	0.4338	0.3382	231
	ergodic	*0.2667*	*0.4604*	*0.2729*	

lower-right cells are those with the lowest value (about 16%). These results suggest that there is a very low persistence in the low and high inflation states, as only 16% of the countries that belong to these states will remain in them after the transition period. Moreover, there is almost equal chance of moving to the other two inflation states. This is relevant to the findings of the distribution dynamics analysis about the threshold points in the sample. On the other hand, the fact that the centric cell has the highest value (58%) indicates that the "convergence" state presents the highest persistence (among all the groups under consideration). Thus, countries with food inflation that is close to the average tend to remain in this state after one-year transition.

The above findings indicate that despite the similarities among the "food" group and the three subgroups, there are also important differences. The fact that the majority of the 25% and 50% HDRs are crossed by the horizontal axis in each group indicates strong inflation convergence trends. However, the distribution of inflation deviation in each product group has its own characteristics and calls for special treatment. A policy for the elimination of inflation differentials among Euro-zone should focus in each product group, in order to efficiently handle its distinct market structure (e.g., geographical separation of the market, differences in which the food subgroup supply chains can absorb external shocks and differences in competitive pressures) and thus to deal with the elimination of inflation differentials.

The results of the analysis also indicate that countries with small inflation deviations from the mean tend to keep this level of deviation after the transition period. On the other hand, the trend of reversion to the mean does not characterize the inflation evolution in all cases. It is usual that countries with high—in absolute values—initial inflation deviation keep these high levels on inflation deviation, after the transition period. Commonly, these countries go from the lower to the higher state of inflation deviation or vice versa ("leapfrogging" and "crisscrossing" phenomena). These findings have an important implication for the EU policy. They suggest that the EU policy should mainly focus in specific countries where high levels of inflation persist, like Greece and Spain. The elimination of food inflation in this group of countries could lead to a higher inflation convergence trend.

6. Summary and Concluding Remarks

This study explores the inflation convergence and the distribution dynamics of food inflation rates for EU-12. The examination of food inflation is of great interest for the researchers and for the planning of monetary and regional policy schemes. Especially, after the runup in food prices and the global financial crisis, a narrow policy that is only focusing on the general inflation may be misleading. Shifting the focus from the general inflation index to the disaggregated "food" indices can reveal productwise and countrywise characteristics that are not apparent by the examination of the general inflation index. Apart from the "food" group, the inflation rates are also examined for three subgroups: "meat," "vegetables," and "bread and cereals". The data set covers a period from January 1997 to November 2010.

For the examination of food inflation convergence, both stochastic convergence and σ-convergence analyses are implemented. Additionally, nonparametric methods are also applied to study the evolving distribution dynamics of food price inflation rates, using an alternative conditional density estimator and Markov transition matrices. These methods allow the exploration of the entire distribution of relative inflation rates and its dynamics over time.

The examination of stochastic convergence as mean reversion took place for three different subperiods, in order to find some evidence of nonlinearities in the convergence process. Our results show that during the whole period there is no mean reversion for the overall "food" product group whereas the only subgroup where stochastic convergence appears is the "vegetables" group. The situation appears different for the three subperiods. In addition to the panel unit root tests applied, half-lives for the overall and individual products were estimated. The lack of stochastic convergence for the whole period is consistent with the finding of σ-divergence which as a general rule prevails. The different findings of econometric analysis indicate the existence of strong nonlinearities in the convergence process. The latter supports the use of nonparametric methods to examine the existence of convergence.

The application of nonparametric methods and the use of an alternative kernel density estimator with visualizations show that, in general, countries deviating from the mean tend to move backwards to it, after one-year transition period. Hence, unlike the findings of the parametric research, a more detailed nonparametric investigation of distributions supports in general the existence of convergence. Multi-modalities and threshold effects in several cases were also detected.

The findings of the distribution dynamics analysis indicate that despite the similarities among the inflation rates of the "food" group and the three subgroups, there are also important differences. The presence of those differences calls for the examination of disaggregated indices in order to capture the maximum available information about the food markets in the Euro-zone and thus to extract consistent policy implications.

To conclude, the empirical evidence from this study emphasizes the necessity of the EU policy to insist in the elimination of inflation deviations. The results also indicate that in order to sufficiently deal with this issue, the suggested policy measures should not be horizontal (applying to all markets and countries), but they should focus on specific group of products and in specific countries that present higher level of inflation.

Appendix

The alternative estimator of the conditional density that has been proposed by Hyndman et al. [14] is given by the following equation:

$$\hat{f}_{\tau}^{*}(y \mid x) = \frac{1}{b}\sum_{i=1}^{n} w_i(x) K\left(\frac{\|y - Y^*\|_y}{b}\right), \tag{A.1}$$

where $\hat{f}_{\tau}^{*}(x) = e_i + \hat{r}(x) - \hat{l}(x)$, $\hat{r}(x)$ is the estimator of the conditional mean $r(x) = E(Y \mid X = x)$, $e_i = y_i - \hat{r}(x)$ and $\hat{l}(x)$ is the mean of $\hat{f}_{\tau}^{*}(e \mid x)$. Instead of estimating $\hat{l}(x)$ by the Nadaraya-Watson smoother, many alternative smoothers with better properties could be applied. In this way, an estimator of the conditional density with lower mean-bias properties can be produced. Moreover, as Hyndman et al. [14] showed, the modified estimator has a smaller integrated mean square error than the standard kernel estimator.

Hyndman et al. [14], proposed a local linear density estimator with lower bias. Let

$$R(\beta_0, \beta_1; x, y) = \sum_{i=1}^{n}\left\{K\left(\frac{\|y - Y_i\|_y}{b}\right) - (\beta_0 - \beta_1(X_i - x))\right\}^2 \times K\left(\frac{\|x - X_i\|_x}{a}\right). \tag{A.2}$$

Then, $\hat{f}_{\tau}^{*}(y|x) = \beta_0$ is a local linear estimator, where $\hat{\beta} = (\beta_0, \beta_1; x, y)$ is that value of β which minimizes $R(\beta_0, \beta_1; x, y)$. The fact that the above estimator is not restricted to be nonnegative leads Hyndman and Yao [21] to propose an alternative estimator, the local parametric estimator, which is based on the following modified $R(\beta_0, \beta_1; x, y)$:

$$R(\beta_0, \beta_1; x, y) = \sum_{i=1}^{n}\left\{K\left(\frac{\|y - Y_i\|_y}{b}\right) - \exp(\beta_0 - \beta_1(X_i - x))\right\}^2 \times K\left(\frac{\|x - X_i\|_x}{a}\right). \tag{A.3}$$

This local linear density estimator can be combined with the mean-bias-correction method of Hyndman et al. [14] in order to force the density function to have a mean equal to any prespecified smoother (see [68]).

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Endnotes

1. Notable exemptions are (among others) the studies of Lee and Wu [69] and Borio and Filardo [70] that deal with the issue of global inflation rate convergence and the study of Kishor and Ssozi [71], who investigate the issue of inflation convergence within the East African Community (EAC).

2. Levin et al. [12] suggest a three-step procedure to implement LLC test. In step 1, separate ADF regressions for each individual in the panel are carried out and two orthogonalized residuals are generated. The test allows for different lags in each individual. Step 2 requires estimating the ratio of long-run to short-run innovation standard deviation for each individual. This ratio was obtained using the quadratic spectral kernel ([72]) and the Newey and West ([73] automatic bandwidth selection. The final step includes the estimation of the pooled t-statistics.

3. According to Lopez and Papell [2], while it would be desirable to allow for heterogeneous rates of convergence (different b's), the choices are problematic. Several tests that average t-statistics across the members of the panel have been developed. The alternative hypothesis for these tests, however, is that $\rho_i < 0$ for at least one i, which is not economically relevant for investigating convergence among a group of countries.

4. According to Nickell [74], the estimates for β are biased downward for finite samples. So, following Cecchetti et al. [18], we apply Nickell's formula to correct this downward bias.

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Research Article

Demand for Fresh Vegetables in the United States: 1970–2010

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This paper analyzes a demand system for eight major fresh vegetables in the USA using the most recently available dataset (1970–2010). A first-differenced Linear Approximate Almost Ideal Demand System (LA-AIDS) is applied to estimate price and expenditure elasticity of demand, imposing homogeneity and symmetry restrictions. We find that not only are consumers responsive to changes in own-prices but they also respond significantly to changes in prices of other fresh vegetables that are consumed together. Conditional budget share allocation to lettuce, cabbage, and celery has declined, while the share of the consumer dollar going to tomatoes, peppers, and onions has increased over the period. Except for cabbage, all own-price elasticity estimates are negative, less than unity in absolute value, and statistically significant. About half of the 56 cross-price elasticities are negative and significant, indicating high, albeit asymmetric, complementarities among these fresh vegetables. Expenditure elasticities are positive and significant for all but one of these eight vegetables. Over the period under consideration, demand and expenditure elasticities remained fairly stable.

1. Introduction

The demand for fresh produce in the United States continues to increase yearly due, in large part, to consumer awareness about the linkages between diet and health. Per capita consumption of fresh vegetables increased roughly 12% between 1989 and 1999, compared to 9.9% for all fresh fruits and vegetables [1]. Rising incomes and the changing demographic makeup of the USA population has also contributed to increased demand for fresh produce. Studies have shown that consumption of fresh fruits and vegetables is positively correlated with incomes [2]. The demand for specialty and ethnic fresh fruits and vegetables is growing, spurred by increases in Hispanic and Asian populations, who tend to have more fresh-produce-based diets than the rest of the population. According to the USA Census Bureau [3], Hispanics and Asians combined now make up about 21% of the USA population, up from 16% in the year 2000. Estimates show that a typical Hispanic household spent about $408 on fresh produce in 1998, compared to $292 for a white household and $217 for an African American household [2].

A number of authors have estimated the demand elasticities for fresh vegetables in the United States. Notable among them are You et al. [4, 5] and Henneberry et al. [6]. You, Huang, and Epperson (hereafter YHE) used data on per capita annual consumption of eight fresh vegetables from 1960 to 1993 while Henneberry, Piewthongngam, and Qiang (hereafter HPQ) used data on consumption of fourteen major vegetables from 1970 to 1992. A considerable amount of health information has become available to consumers since these two studies were published. Consumers' attitudes to consumption of fresh vegetables may have changed as a consequence of this health awareness. The current paper contributes to the literature by empirically determining what changing patterns have occurred in the demand for fresh vegetables. We achieve this by using an extended dataset over the period 1970–2010 to estimate the demand for fresh vegetables in the USA.

YHE [4] found that demand for major fresh vegetables in the USA was generally price inelastic over the period 1970–1993. Their study also found that “[t]he majority of the estimated cross-price elasticities were statistically insignificant, indicating that for the eight fresh vegetables studied, generally the demand relationship were neutral.” Expenditure effects were found to be highly elastic for five of these vegetables, with the exception of tomatoes, cabbages, and celery, which had insignificant or inelastic effects. YHE [5] found that demand for fresh fruits and vegetables responds significantly to changes in own-price, but not to changes in income. Thus, they concluded that income was not a significant determinant of consumer demand for fresh vegetables and fruits in the USA The current study presents evidence that these fresh vegetables exhibit more complementarities than previously thought, and that demand for these vegetables shows high responsiveness to changes in income, contrary to the findings of YHE [5].

The objective of the present paper is to analyze the effects of prices and expenditures on demand for fresh vegetables in the USA using more recent data. Estimates of price and expenditure elasticities are derived to investigate changes in demand and consumption patterns of major fresh vegetables consumed in the United States over the period of 1970 through 2010. Eight fresh vegetables, originally covered by YHE [4], including, cabbages, carrots, celery, cucumbers, lettuce, onions, peppers, and tomatoes are covered in this study. These eight account for about 80% of all fresh vegetables consumed in the USA Much like YHE [4] and HPQ [6], we apply the Linear Approximate version of the Almost Ideal Demand System (LA-AIDS) proposed by Deaton and Muellbauer [7] to estimate demand elasticities for these major fresh vegetables.

The link between diet and health has been the subject matter of intense research in the medical profession. Epidemiological studies have drawn links between the consumption of high fat diets and coronary heart diseases [8, 9]. On the other hand, it has been established that diets rich in fiber, such as fruits and vegetables, are negatively correlated with the risk of coronary heart diseases [10]. Since the 1990s a lot of health awareness information has become available to consumers, thus, changing their attitudes to consumption of fresh vegetables. Capps and Schmitz [11] study the impact of health and nutritional awareness on food demand in the USA They found that consumers do consider health and nutritional information, usually obtained from the news media and medical personnel, in their choice of diets, particularly, with regard to consumption of food that may be high in fat and cholesterol.

As more people have access to fresh fruits and vegetables through local food systems, demand for fruits and vegetables can be expected to increase. According to the USDA [12], farmer markets have seen an exponential growth in the USA, from 1,755 in 1994 to 7,175 in 2011, an increase of more than 300%. This means that more people now have access to fresh fruits and vegetables and this should reflect in increased consumption. This has also been attributed to growing interest of consumers in obtaining fresh and healthy produce.

The rest of the paper is organized as follows: Section 2 discusses the theoretical underpinnings of demand systems and Section 3 examines two-stage budgeting and weak separability. In Sections 4 and 5 we present the empirical analytical methods and data, while Section 6 discusses the results. Finally, Section 7 draws conclusions based on findings of the study.

2. Theoretical Demand Systems

Two approaches have generally been followed to estimate demand for any type of commodity. The first is a utility maximization approach in which consumers are assumed to choose a bundle of goods that give them maximum satisfaction given their budget. Thus, the problem facing the consumer is to solve the following constraint maximization function which specifies utility as a function of quantities consumed (direct utility) subject to the budget constraint:

$$\begin{aligned} \max \quad & U = U(Q), \\ \text{St.} \quad & P'Q = Y. \end{aligned} \tag{1}$$

Alternatively, consumers could be assumed to maximize an indirect utility function given by

$$V(P, Y) = \max[U(Q) : P'Q = Y], \tag{2}$$

where $V(P, Y)$ is the maximum attainable level of utility at given prices and income.

The solution to either (1) or (2) yields a system of demand functions

$$\begin{aligned} Q^* &= \phi(P, Y), \\ \lambda^* &= \lambda(P, Y), \end{aligned} \tag{3}$$

where Q^* is the set of Marshallian or uncompensated demand functions. The above approach is known as the primal preference approach. Under duality utility theory, demand functions may also be derived from the dual problem (expenditure minimization) given by

$$\begin{aligned} e(P, U) &= \min PQ, \\ \text{such that } U(Q) &\geq U, \end{aligned} \tag{4}$$

the solution of which gives the expenditure minimizing bundle, $h(P, U)$, described as Hicksian or compensated demand functions [13].

The second approach to estimating demand is the systems approach which posits a demand system consisting of goods that belong to the same subgroup in a multistage budgeting framework. Two of the most commonly used demand systems are the Rotterdam model and the Almost Ideal Demand System (AIDS) model. According to Alston and Chalfant [14], the AIDS model has been used much more often than other demand systems such as the linear

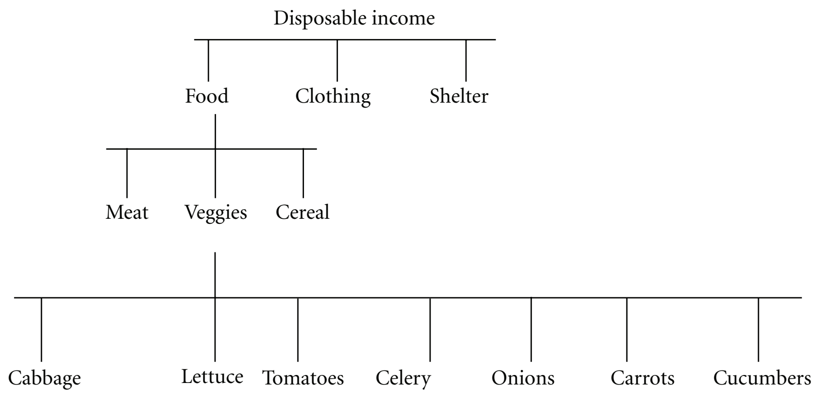


FIGURE 1: Multistage budgeting.

(or quadratic) expenditure system, or even the Rotterdam model. The popularity of the AIDS demand system has been attributed to two critical properties; first, "it is as flexible as other locally flexible functional forms (such as the Translog) and has the added advantage of being compatible with aggregation over consumers" [14]. Secondly, the AIDS system, in its Linear Approximate form (LA-AIDS), is relatively easy to estimate and permits testing of theoretical restrictions (such as homogeneity and symmetry).

The Rotterdam model was proposed by Barten [15] and Theil [16] and it is also considered as a locally flexible functional form. It has identical data requirements like the AIDS model but has been used less often, probably because of its earlier perceived restrictive nature. However, the two models do not often give the same results. For cases of incongruent outcomes using these models in demand studies, see Alston and Chalfant [17, 18], and Brester and Wohlgenant [19].

3. Two-Stage Budgeting and Weak Separability

Two-stage budgeting assumes that consumers allocate their disposable incomes to various commodities in two successive stages. Stage 1 involves allocating incomes to broad groups (e.g., food, shelter, and clothing). In stage 2 the budget of each group, such as food, is further allocated across successively disaggregated bundles of commodities (e.g., vegetables, meats, and cereal). Figure 1, adapted from Goddard [20], illustrate a multi-stage budgeting process.

Two-stage budgeting is advantageous to estimating the demand system in that at each stage one only needs information about prices and quantities on commodities within that group. For example, in Figure 1, to estimate the demand functions for the vegetables group, we need information only on prices and quantities of vegetables. According to Phlips [21], "a subset of demand equations inside a branch can be estimated using only the prices of goods and total expenditures on goods in the branch." This does not, however, imply that prices of goods outside the vegetables branch and total income are not important to the consumer's decision-making process, but rather, what it means is that prices and income in other branches (say meat and cereals) enter the vegetables branch only through their effect on the budget allocated to that branch.

A necessary and sufficient condition for two-stage budgeting is weak separability of the utility functions. Weak separability implies that commodities can be partitioned into a number of sub-groups, such that the "marginal rate of substitution between any two goods i and j belonging to the same group is independent of the quantities consumed of goods outside the sub-group" [21, 22]. We assume weak separability of the fresh vegetables group. HPQ [6] found that fresh vegetables are weakly separable from fresh fruits and other food commodities.

4. Analytical Methods

Following YHE [4], we use the Almost Ideal Demand System (AIDS) model proposed by Deaton and Muellbauer [7] to estimate demand elasticities for fresh vegetables in the United States. The Linear Approximate version of the AIDS (LA-AIDS) model is presented as follows:

$$w_i = \alpha_i + \sum_{j=1}^{m} \gamma_{ij} \ln p_j + \beta_i \ln\left(\frac{x}{P}\right), \quad i = 1, 2, 3, \ldots, m, \tag{5}$$

where w_i denotes the expenditure share of commodity i, p_j is the price of the jth commodity, and x is the total expenditure on all m commodities in the subgroup. Finally, P is the Stone's geometric price index, defined as:

$$\ln P = \sum_{j=1}^{m} w_j \ln p_j. \tag{6}$$

The theoretical restrictions of this demand system require;

$$\begin{gathered} \sum_i \alpha_i = 1, \quad \sum_i \gamma_{ij} = 0, \quad \sum_i \beta_i = 0, \quad \text{adding-up}, \\ \sum_j \gamma_{ij} = 0, \quad i = 1, 2, 3, \ldots, m, \quad \text{homogeneity}, \\ \gamma_{ij} = \gamma_{ji} \quad \text{Symmetry}. \end{gathered} \tag{7}$$

YHE [4] notes that the adding-up conditions are automatically satisfied, but homogeneity and symmetry need to be imposed during estimation of the system. To avoid singularity of the variance-covariance matrix in the estimation of this system, one of the equations is arbitrarily dropped. The coefficients of the dropped equation are then recovered by using the adding-up conditions.

4.1. Misspecification Tests. Misspecification testing, especially of functional form and autocorrelation, is very important in the context of systems estimation as it is in single equation estimation [23]. In the present paper, we have employed a semi-log functional form often used in the empirical literature. The LA/AIDS model follows a semi-log functional form which is known to be consistent with the empirical data on household budgeting behavior [7]. Autocorrelation, however, does pose a problem in many time series studies, and the present paper is no exception. Therefore, we devote the remainder of this subsection to describe the methods and results of our autocorrelation tests. The usual test of autocorrelation most authors use is the Durbin-Watson (DW) test. However, the DW test is only good for testing equation-by-equation autocorrelation and does not take into account residual correlations across equations. For this reason, we employ a system-wide autocorrelation test in addition to the single-equation tests to test for autocorrelation in the residuals.

We first estimate the model in (5) and test for autocorrelation in per capita consumption of fresh vegetables. The tests of autocorrelation used are the DW test, Harvey single-equation LM test, and Harvey overall system LM test. The test results show that the model in levels exhibits autocorrelation both in single equations and in the system as a whole (see results of the autocorrelation tests in Table 2). The null hypothesis for this test is no autocorrelation in the residuals. Notice in Table 2 that the model in levels shows smaller P values indicating rejection of the null hypotheses, while the first-differenced model has larger P values indicating no autocorrelation. Thus, we find that the problem of autocorrelation is resolved by estimating the model in first differences. This confirms what earlier researchers found concerning autocorrelation in the data, that is, differencing the data can achieve stationary parameter estimates. McGuirk et al. [23] and Eales and Unnevehr [24] noted that, generally, estimating the AIDS model in differences gets rid of autocorrelation problems. Therefore, we reestimate the LA/AIDS model in levels (5) as a first-differenced LA-AIDS model as follows:

$$\Delta w_i = \alpha_i + \sum_{j=1}^{m} \gamma_{ij} \Delta \ln p_j + \beta_i \Delta \ln\left(\frac{x}{P}\right),$$
$$\Delta \ln P = \sum_{j=1}^{m} \Delta w_j \Delta \ln p_j, \tag{8}$$

where Δ is the first-difference operator (for a given series Y, $\Delta Y = Y_t - Y_{t-1}$). Significant intercepts (α_i) in (8) are interpreted as time trends in expenditure shares of each commodity i. Upon estimating (5) or (8), demand and expenditure elasticities can be recovered as follows:

$$\eta_i = \frac{\beta_i}{w_i} + 1 \text{ (income elasticity)}, \tag{9}$$

$$\varepsilon_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{w_i} - \frac{\beta_i w_j}{w_i} \text{ (uncompensated price elasticity)}, \tag{10}$$

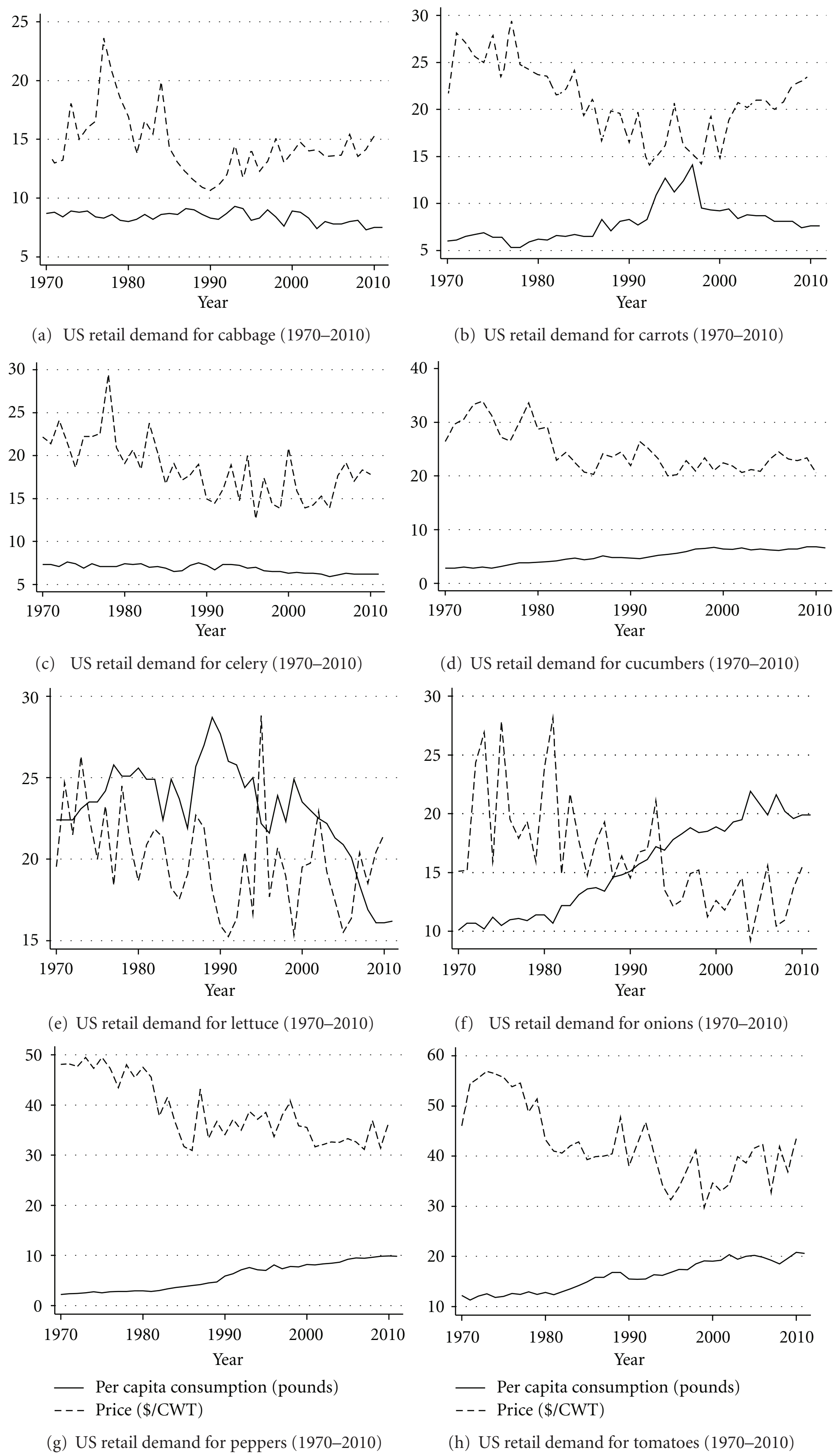
where δ_{ij} is the Kronecker delta, equal to unity for $i = j$ and zero otherwise.

As part of the misspecification tests, we have compared the static models outlined above to two dynamic models. In the first of the dynamic models, which is referred to as a general dynamic model, we included all lagged dependent variables as intercept shifters in all equations. In the second case only the lagged dependent variable of each respective equation was included as intercept shifters. In both cases, almost all the parameters of the lagged variables were statistically insignificant (results not reported). Further comparative diagnostic tests comparing the static models and dynamic models were also performed. Both the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) rejected the dynamic models in favor of the static models.

5. Data and Study Period

The data used to estimate the models are extracted from the Vegetables and Melons Yearbook jointly maintained by the USDA Economics, Statistics, and Market Information System and the Albert R. Mann Library, Cornell University. The dataset consists of US per capita annual consumption and retail prices of eight major fresh vegetables, covering the period 1970–2010. These are cabbages, carrots, celery, cucumbers, lettuce, onions, peppers, and tomatoes. Two factors guide our choice of the study period of 1970–2010. First of all, there has been a significant improvement in knowledge regarding the linkage between eating healthy foods (such as fresh vegetables) and reduced incidence of coronary heart diseases. As a consequence, we anticipate that using more recent data will accurately depict recent changes in consumption patterns of fresh vegetables. Second of all, the literature shows that there have been very few studies on demand for fresh vegetables in the USA during the period of 1970–2010. Two of the studies were conducted during an almost overlapping period: You et al. [4] covered the period 1960–1993, while Henneberry et al. [6] covered 1970–1992. There are no similar studies, to the best of our knowledge, that extends beyond the 90s into the 2000s.

Preliminary exploratory data analysis was performed to determine trends in per capita consumption over time. Figures 2(a)–2(h) plot the relationships between per capita consumption of each vegetable type and their respective retail prices. Over the period of 1970–2010, most of the fresh vegetables saw declining retail prices, but in the late 2000s prices started to creep up, especially for cabbages (Figure 2(a)), carrots (Figure 2(b)), and tomatoes (Figure 2(h)). As prices decreased, the consumption of



(a) US retail demand for cabbage (1970–2010)

(b) US retail demand for carrots (1970–2010)

(c) US retail demand for celery (1970–2010)

(d) US retail demand for cucumbers (1970–2010)

(e) US retail demand for lettuce (1970–2010)

(f) US retail demand for onions (1970–2010)

(g) US retail demand for peppers (1970–2010)

(h) US retail demand for tomatoes (1970–2010)

Figure 2: US per capita consumption of major fresh vegetables.

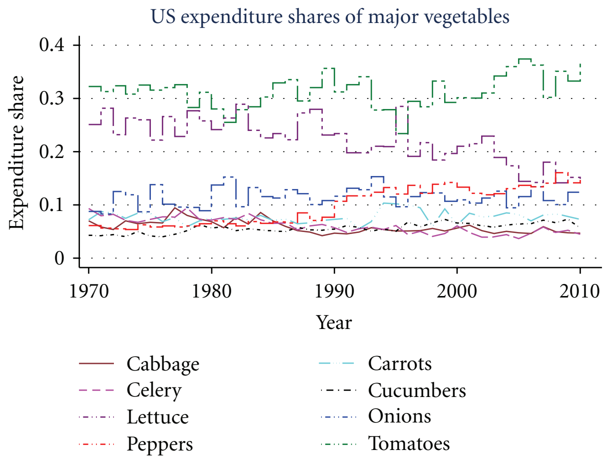


Figure 3: Expenditure shares.

Table 1: Per capita annual consumption of fresh vegetables in the USA (pounds).

Commodity	Period					
	1970s	1980s	1990s	2000	2005	2010
Cabbage	8.6	8.6	8.5	8.9	7.8	7.5
Carrots	6.2	6.8	10.4	9.2	8.7	7.6
Celery	7.2	7.1	6.9	6.3	5.9	6.2
Cucumbers	3.1	4.5	5.6	6.4	6.2	6.8
Lettuce	23.8	25.0	24.4	23.5	20.9	16.1
Onions	10.8	13.0	17.3	18.9	20.9	19.9
Peppers	2.6	3.7	7.2	8.2	9.2	9.9
Tomatoes	12.2	14.6	16.8	19.0	20.2	20.8
Subtotal of 8 veggies	74.4	83.2	97.1	100.2	99.7	94.8
All fresh veggies	90.5	103.1	128.2	146.8	148.1	143.6

Table 2: Harvey LM tests of single-equation and overall system autocorrelation.

Equation	LA/AIDS model in levels		First-differenced LA/AIDS Model	
	Statistic	P value	Statistic	P value
Cabbages	0.009	0.922	1.546	0.203
Carrots	6.230	0.012	0.258	0.611
Celery	2.560	0.109	0.494	0.482
Cucumbers	6.054	0.014	0.057	0.811
Lettuce	9.153	0.002	1.077	0.299
Onions	7.452	0.006	1.892	0.169
Peppers	11.150	0.000	0.102	0.749
Tomatoes	1.534	0.215	0.471	0.492
Overall system	42.608	0.000	5.426	0.608

Note: Null hypothesis tested: No autocorrelation.

most of these vegetables generally tended to increase, in line with the law of demand. Tomatoes (Figure 2(h)), onions (Figure 2(g)), cucumbers (Figure 2(d)), and peppers (Figure 2(f)) saw the most significant increases in per capita consumption. Per capita consumption of lettuce significantly decreased over the period, while cabbage, celery, and carrots stayed constant.

Using the two-stage budgeting approach, conditional expenditure shares were computed for each of these vegetables. Figure 3 presents plots of these conditional expenditure shares over the period 1970–2010. Most of the expenditure shares have stayed constant while a few registered modest increases or declines over the period. In particular, the expenditure shares of tomatoes and peppers increased, while lettuce, cabbage, and celery saw a decline in share of budget allocation, and the remaining vegetables had stable budget share allocations. The conditional budget shares indicate that a dollar allocated to these eight vegetables in 1970 were broken down as follows: (cabbage: ¢7, carrots: ¢8, celery: ¢8, cucumbers: ¢5, lettuce: ¢25, onions: ¢10, pepper: ¢5, and tomatoes: ¢32). In 2010, the share allocation of the consumer dollar was (cabbage: ¢5, carrots: ¢7, celery: ¢4, cucumbers: ¢6, lettuce: ¢14, onions: ¢12, pepper: ¢15, and tomatoes: ¢37).

6. Results and Discussion

Table 1 presents a decadal comparison of per-capita consumption of each vegetable type from 1970s to the 2000s. Consumption of cucumbers, onions, peppers and tomatoes has been increasing through the decades. The demand for cabbages, carrots, celery, and lettuce has held steady or decreased over the decades. Overall, the total consumption of these eight fresh vegetables has been steadily increasing from 1970 until 2000. The decline in consumption of these eight fresh vegetables from 2000 to 2010 could be attributed to the uptick in prices during that period (Figures 2(a)–2(h)). On the whole, however, total consumption of all fresh vegetables has been increasing over the entire period of 1970–2010. This may be a reflection of health consciousness on the part of consumers.

In order to derive demand elasticity estimates for these fresh vegetables, we fitted the data using the Linearly Approximated AIDS model. The LA-AIDS model in levels, (5), was estimated to determine the presence or otherwise of serial correlation in the random error terms (see Table 4). We tested for homogeneity and symmetry restrictions in all equations, results of which are presented in Table 3. Testing each of these restrictions at the 5% level, we find that homogeneity and symmetry cannot be rejected (Table 3). Adding-up is automatically satisfied, thus, there was no need to impose it. To avoid singularity of the variance-covariance matrix, we dropped the tomatoes equation from the analysis. The coefficients in the tomatoes equation were then recovered using the adding-up conditions. It was found, using Durbin-Watson Statistics, that all the equations exhibited low to moderate autocorrelation (Table 4). The DW tests corroborate those of the Harvey LM test presented in Table 2. The coefficient of autocorrelation (rho) along with corresponding Durbin-Watson Statistics range from 0.013 (DW = 1.87) for the cabbage equation to a high of 0.465 (DW = 0.95) for the pepper equation (Table 4). Therefore, the first-differenced LA-AIDS model, (8), which

Table 3: Tests of homogeneity and symmetry restrictions.

Null Hypothesis	Asymptotic t-value	P value
Homogeneity does not hold in cabbage equation	1.80	0.071
Homogeneity does not hold in carrots equation	−1.28	0.205
Homogeneity does not hold in celery equation	−1.30	0.199
Homogeneity does not hold in cucumbers equation	0.27	0.790
Homogeneity does not hold in lettuce equation	−0.63	0.535
Homogeneity does not hold in onions equation	−0.98	0.336
Symmetry between cabbage and carrots	−0.88	0.378
Symmetry between celery and cabbage	2.08	0.035
Symmetry between cucumbers and cabbage	1.25	0.219
Symmetry between lettuce and cabbage	−1.35	0.128
Symmetry between onions and cabbage	0.24	0.818
Symmetry between pepper and cabbage	−0.19	0.856
Symmetry between celery can carrots	−1.82	0.068
Symmetry between cucumbers and carrots	−1.60	0.111
Symmetry between lettuce and carrots	0.32	0.756
Symmetry between onions and carrots	−0.91	0.372
Symmetry between pepper and carrots	−2.16	0.028
Symmetry between cucumbers and celery	2.51	0.009
Symmetry between lettuce and celery	0.55	0.593
Symmetry between onions and celery	1.79	0.073
Symmetry between pepper and celery	−1.64	0.102
Symmetry between lettuce and cucumbers	1.95	0.050
Symmetry between onions and cucumbers	−0.78	0.447
Symmetry between pepper and cucumbers	−0.78	0.447
Symmetry between onions and lettuce	−1.28	0.204
Symmetry between pepper and lettuce	−1.06	0.299
Symmetry between pepper and onions	1.39	0.168

Table 4: Parameter estimates for eight fresh vegetables using LA/AIDS model (in levels).

Elasticity of	Price coefficients									
	Cabbages	Carrots	Celery	Cucumbers	Lettuce	Onions	Peppers	Tomatoes	Income coeff.	Rho [DW]
Cabbages	0.0616 (12.79)	−0.0218 (−4.01)	0.0014 (0.24)	−0.0090 (−1.05)	−0.0074 (−1.33)	−0.0025 (−0.73)	−0.0062 (−0.72)	−0.0199 (−2.72)	−0.089 (−7.01)	0.013 [1.87]
Carrots	−0.0117 (−1.61)	0.0468 (3.82)	−0.0199 (−1.51)	−0.0212 (−1.10)	−0.0009 (−0.08)	−0.0095 (−1.21)	0.0569 (2.91)	−0.0030 (−1.83)	0.0247 (0.86)	0.367 [1.19]
Celery	0.0009 (0.21)	−0.0167 (−3.29)	0.0542 (9.89)	−0.0051 (−0.63)	−0.0073 (−1.41)	−0.0014 (−0.44)	0.0036 (0.45)	−0.0310 (−4.54)	−0.1054 (−8.89)	0.242 [1.48]
Cucumbers	0.0062 (1.14)	0.0040 (0.66)	−0.0005 (−0.07)	0.0502 (5.15)	−0.0156 (−2.47)	−0.0063 (−1.60)	−0.0135 (−1.38)	−0.0324 (−3.90)	0.0434 (3.01)	0.357 [1.20]
Lettuce	−0.0035 (−0.11)	−0.0934 (−2.52)	−0.0182 (−0.46)	0.0027 (0.05)	0.1563 (4.14)	0.0106 (0.45)	0.0093 (0.16)	−0.1207 (−2.43)	−0.3636 (−4.22)	0.424 [1.00]
Onions	−0.0098 (−1.16)	0.0120 (1.26)	−0.0034 (−0.33)	0.0018 (0.12)	−0.0283 (−2.90)	0.0824 (13.57)	−0.0248 (−1.65)	−0.0204 (−1.59)	0.0856 (3.86)	0.411 [1.13]
Peppers	−0.0115 (−0.58)	0.0318 (1.42)	−0.0035 (0.15)	0.0198 (0.56)	−0.0429 (−1.87)	−0.0358 (−2.51)	0.0671 (1.90)	0.0169 (0.56)	0.3090 (5.91)	0.465 [0.95]
Tomatoes	−0.0265 (−1.46)	0.0372 (1.81)	−0.0101 (−0.46)	−0.0392 (−1.23)	−0.0538 (−2.57)	−0.0373 (−2.86)	−0.0917 (−2.84)	0.2376 (8.62)	0.0953 (1.99)	0.174 [1.42]

Note: Numbers in parentheses are t-ratios, Rho: first-order autocorrelation coefficient, Durbin-Watson statistics in square brackets.

corrects for autocorrelation was estimated using Zellner's [22] Seemingly Unrelated Regression (SUR).

As in other studies we estimated the Rotterdam model using our dataset for the purpose of selecting the model that fits the data best. However, the Rotterdam model did not produce satisfactory results. That is to say that all the own-price elasticities turned up positive and statistically insignificant. Based on these unexpected elasticity signs, we rejected the Rotterdam model in favor of the AIDS model. Alston and Chalfant [18] show, using data on Canadian meat demand, that the AIDS and Rotterdam models do not always yield similar results. Thus, we present demand elasticity estimates based on the first-differenced LA-AIDS model. The parameter estimates of the first-differenced LA-AIDS model with homogeneity and symmetry restrictions imposed are presented in Table 5. All the own-price coefficient estimates are statistically significant; cross-price effects are mostly negative and significant, while only two expenditure coefficients are significant.

Using the elasticity formulas in (9) and (10) we derived the uncompensated price and expenditure elasticities at the mean expenditure share of each commodity. Table 6 presents these uncompensated demand elasticities. With the exception of cabbage, all own-price elasticities are negative and statistically significant at the 5% level. Moreover, the estimates show that, with the exception of cabbage, all the vegetables have inelastic demand over the period 1970–2010. The estimated own-price elasticities are carrots: −0.29, celery: −0.10, cucumbers: −0.99, lettuce: −0.37, onions: −0.20, peppers: −0.16, and tomatoes: −0.44. These estimates, although pretty close, do not exactly equal those of YHE (carrots:−0.40, celery: −0.12, cucumbers: −0.30, lettuce: −0.34, onions: −0.29, peppers: −0.13, and tomatoes: −0.36) and HPQ (carrots: −1.65, onions: −0.29, tomatoes: −0.23, cucumbers: −0.73, and green peppers: 0.84) who used data over 1960–1993. Except that of peppers, all expenditure elasticities are statistically significant at the 5% level. HPQ [6] found that most of these vegetables are income elastic or "luxuries," however, our results show that only two of these vegetables are considered "luxury" commodities by consumers, based on income elasticity greater 1 (carrots: 2.35, lettuce: 1.39). The others are "normal" goods with income elasticities less than 1 (cabbages: 0.93, celery: 0.75, cucumbers: 0.84, onions: 0.77, and tomatoes: 0.69).

All the cross-price elasticities that are statistically significant are negative, indicating complementarities in the consumption of these fresh vegetables. Close to half of the 56 cross-price elasticities are significantly different from zero, which is in contrast to YHE [4] where the majority of cross-price elasticities were not significant. For example, the cross-price elasticities show that there is a high degree of complementarity between carrots and lettuce (−0.50), carrots and tomatoes (−0.59), lettuce and tomatoes (−0.38), and cucumbers and tomatoes (−0.47). Our results further show that these cross-price elasticities are not symmetric. So for example, the change in demand for lettuce with respect to a change in price of tomatoes is −0.38, while the change in demand for tomatoes given a change in price of lettuce is only −0.04. In other words, while lettuce is a strong complement with tomatoes, one cannot say that tomatoes are a strong complement with lettuce. Put differently, if the price of tomatoes goes down by 1%, then consumers increase their demand for lettuce by 0.38%. However, if the price of lettuce goes down by 1%, consumers do not significantly change their demand for tomatoes. The same can be said about the relationship between carrots and lettuce, carrots and tomatoes, and cucumbers and tomatoes.

With changing consumer attitudes towards their choice of diets, we thought it was worthy of consideration to estimate these demand and expenditure elasticities over time to observe what changes there has been with regards to consumption of fresh vegetables. Thus, Table 7 presents the demand elasticities estimated at mean expenditure shares of different years. Similarly, Table 8 presents the expenditure elasticities over time. It can be inferred from Table 7 that the demand elasticities for most of these vegetables have remained fairly stable over the period under consideration. Table 8 shows that the expenditure elasticities have also generally remained constant throughout the period.

The effect of consumers' income on demand for fresh vegetables is implicitly accounted for in the LA/AIDS model. AIDS models typically include an expenditure (income) effect. Our estimated expenditure elasticities show that consumer demand for fresh vegetables does respond to changes in aggregate expenditures (income effect). Generally, almost all the eight vegetable types have elastic demand with respect to expenditure. This corroborates the assertion that higher income people do patronize fresh produce more than the lower income people [2].

6.1. Limitations of the Study. The major limitation of the present study is an inability to perform the analyses at a more disaggregated level such as state, county, or even the individual-level. This is primarily due to lack of disaggregated data. While data on per capita consumption of fresh vegetables is readily available at the national level, the same cannot be said about the state or county levels. Future research may explore ways of generating micro data to analyze the demand for fresh vegetables. Our inability to directly control for health information in this study is a serious limitation that we propose to undertake in future research: a health information index that captures consumers' awareness of the importance of consuming fresh vegetables should be incorporated in the analysis. This will help to explain the changing patterns in per capita vegetables consumption resulting from a heightened awareness of the linkage between diet and health.

7. Conclusion

Consumers have become increasingly more conscious of what they eat, as information on diet-related illnesses, such as coronary heart diseases, obesity, hypertension, and strokes, has filtered through the news media. The impact of this heightened awareness of diet-health relationship can be expected to lead to increases in demand for "healthy" foods such as fruits and vegetables and decreases in the

Table 5: Parameter estimates for eight fresh vegetables using a first-differenced LA/AIDS model with homogeneity and symmetry restrictions.

Elasticity of	Price coefficients									
	Cabbages	Carrots	Celery	Cucumbers	Lettuce	Onions	Peppers	Tomatoes	Income coeff.	R-Sq
Cabbages	0.0643 (17.21)	−0.0128 (−4.66)	−0.0020 (−0.86)	−0.0028 (−1.02)	−0.0161 (−5.17)	−0.0074 (−3.75)	−0.0064 (−1.64)	−0.0167 (−3.75)	−0.0035 (−0.20)	0.92
Carrots	−0.0128 (−4.66)	0.0633 (11.55)	−0.0066 (−2.89)	−0.0040 (−1.66)	−0.0157 (−3.12)	−0.0051 (−1.76)	−0.0061 (−1.46)	−0.0129 (−1.95)	0.1049 (3.29)	0.82
Celery	−0.0020 (−0.86)	−0.0066 (−2.89)	0.0538 (18.32)	−0.0009 (−0.36)	−0.0103 (−3.51)	−0.0046 (−2.50)	−0.0092 (−2.66)	−0.0202 (−5.54)	−0.0149 (−1.06)	0.93
Cucumbers	−0.0028 (−1.02)	−0.0040 (−1.66)	−0.0009 (−0.36)	0.0574 (12.95)	−0.0135 (−4.75)	−0.0076 (−4.24)	0.0005 (0.12)	−0.0291 (−7.23)	−0.0085 (−0.61)	0.87
Lettuce	−0.0161 (−5.17)	−0.0157 (−3.12)	−0.0103 (−3.51)	−0.0135 (−4.75)	0.1586 (16.93)	−0.0216 (−5.54)	−0.0246 (−4.65)	−0.0568 (−7.09)	0.0848 (1.64)	0.92
Onions	−0.0074 (−3.75)	−0.0051 (−1.76)	−0.0046 (−2.50)	−0.0076 (−4.24)	−0.0216 (−5.54)	0.0876 (29.23)	−0.0126 (−3.83)	−0.0288 (−6.12)	−0.0256 (−1.04)	0.96
Peppers	−0.0064 (−1.64)	−0.0061 (−1.46)	−0.0092 (−2.66)	0.0005 (0.12)	−0.0246 (−4.65)	−0.0126 (−3.83)	0.0789 (9.47)	−0.0205 (−2.86)	−0.0390 (−1.40)	0.77
Tomatoes	−0.0167 (−3.75)	−0.0129 (−1.95)	−0.0202 (−5.54)	−0.0291 (−7.23)	−0.0568 (−7.09)	−0.0288 (−6.12)	−0.0205 (−2.86)	0.1117 (14.76)	−0.0982 (−4.03)	0.91

Note: Numbers in parentheses are t-ratios.

Table 6: Demand elasticity estimates (at sample mean shares) computed from first-differenced LA/AIDS model with homogeneity and symmetry restrictions.

Elasticity of	Price of								
	Cabbages	Carrots	Celery	Cucumbers	Lettuce	Onions	Peppers	Tomatoes	Expenditure elasticity
Cabbages	**0.107** (**1.10**)	−0.219 (−2.44)	−0.030 (−0.11)	−0.048 (−0.86)	−0.261 (−3.78)	−0.113 (−3.42)	−0.097 (−1.17)	−0.271 (−2.44)	0.931 (4.37)
Carrots	−0.245 (−4.02)	**−0.297** (**−3.56**)	−0.172 (−2.13)	−0.127 (−1.65)	−0.503 (−4.69)	−0.218 (−4.38)	0.209 (0.74)	−0.589 (−5.05)	2.346 (6.19)
Celery	−0.019 (−0.65)	−0.096 (−3.04)	**−0.100** (**−2.56**)	−0.001 (−0.55)	−0.110 (−1.16)	−0.054 (−0.55)	−0.123 (−1.64)	−0.251 (−3.77)	0.754 (2.92)
Cucumbers	0.044 (0.07)	−0.059 (−1.67)	−0.006 (−1.76)	**−0.995** (**−20.41**)	−0.214 (−2.59)	−0.125 (−2.29)	−0.025 (−0.16)	−0.467 (−6.17)	0.839 (3.28)
Lettuce	−0.095 (−2.48)	−0.102 (−0.88)	−0.069 (−2.65)	−0.085 (−1.07)	**−0.366** (**−5.63**)	−0.143 (−5.28)	−0.151 (−0.24)	−0.379 (−5.16)	1.385 (6.90)
Onions	−0.048 (−0.70)	−0.026 (−0.30)	−0.030 (−0.69)	−0.057 (−0.40)	−0.143 (−1.45)	**−0.202** (**−4.15**)	−0.092 (−2.21)	−0.183 (−2.94)	0.772 (2.94)
Peppers	−0.038 (−1.69)	−0.030 (−2.92)	−0.068 (−1.54)	0.027 (1.23)	−0.167 (−0.73)	−0.087 (−0.17)	**−0.155** (**−2.47**)	−0.089 (−1.16)	0.602 (0.66)
Tomatoes	−0.016 (−0.11)	0.009 (−1.22)	−0.025 (−0.43)	−0.057 (−1.59)	−0.039 (−1.21)	−0.019 (−0.40)	−0.003 (−2.63)	**−0.443** (**−5.07**)	0.687 (3.27)

Asymptotic t-ratios in parentheses.

consumption of "unhealthy" foods. With this in mind, this study sought to investigate trends in per capita consumption of fresh vegetables in the United States, using recent data on eight fresh vegetables which make up 80% of the vegetable portion of most households. This is not the first of its kind, but the current study utilizes a more recent dataset, 1970–2010, which previous studies, notably YHE [4] and HPQ [6], did not have access to. We adopted a systems approach to demand analysis, in which the LA-AIDS model was estimated by Zellner's seemingly unrelated regression method.

Table 7: Demand elasticities estimated at the expenditure shares of different years.

Commodity	Period 1970s	1980s	1990s	2000	2005	2010
	Uncompensated own-price elasticity					
Cabbage	−0.077 (−1.67)	0.033 (0.07)	0.256 (2.93)	0.134 (1.35)	0.358 (4.00)	0.382 (4.27)
Carrots	−0.277 (−3.20)	−0.230 (−2.47)	−0.339 (−4.29)	−0.094 (−0.63)	−0.331 (−4.11)	−0.242 (−2.65)
Celery	−0.298 (−8.24)	−0.195 (−4.94)	0.063 (0.57)	−0.089 (−2.22)	0.492 (5.93)	0.221 (3.05)
Cucumbers	0.253 (2.86)	0.068 (1.08)	−0.030 (−0.03)	−0.126 (−1.59)	−0.098 (−1.14)	0.012 (0.41)
Lettuce	−0.459 (−7.06)	−0.449 (−7.01)	−0.336 (−5.14)	−0.329 (−5.03)	0.016 (−0.60)	−0.047 (−0.27)
Onions	−0.112 (−1.44)	−0.244 (−5.39)	−0.245 (−5.39)	−0.170 (−3.22)	−0.212 (−4.33)	−0.268 (−6.07)
Peppers	0.377 (1.51)	0.178 (0.47)	−0.332 (−5.16)	−0.369 (−5.90)	−0.382 (−6.17)	−0.424 (−7.09)
Tomatoes	−0.547 (−5.11)	−0.534 (−4.50)	−0.526 (−4.32)	−0.532 (−4.54)	−0.604 (−7.34)	−0.597 (−7.08)

Asymptotic t-ratios in parentheses.

Table 8: Elasticities estimated at the expenditure shares of different years.

Commodity	Period 1970s	1980s	1990s	2000	2005	2010
	Expenditure Elasticity					
Cabbage	0.943 (5.05)	0.936 (4.62)	0.922 (3.94)	0.929 (4.31)	0.915 (3.69)	0.914 (3.63)
Carrots	2.381 (6.13)	2.459 (6.01)	2.276 (6.31)	2.684 (5.71)	2.290 (6.28)	2.438 (6.04)
Celery	0.809 (4.18)	0.780 (3.44)	0.709 (2.26)	0.751 (2.85)	0.590 (1.15)	0.665 (1.74)
Cucumbers	0.804 (2.53)	0.833 (3.13)	0.848 (3.51)	0.863 (4.04)	0.859 (3.89)	0.842 (3.36)
Lettuce	1.335 (7.43)	1.340 (7.42)	1.400 (6.73)	1.404 (6.70)	1.589 (5.48)	1.605 (5.40)
Onions	0.745 (2.40)	0.784 (3.21)	0.785 (3.21)	0.762 (2.75)	0.775 (2.98)	0.792 (3.37)
Peppers	−1.581 (−1.78)	−0.159 (−0.40)	0.689 (1.57)	0.708 (1.93)	0.714 (2.08)	0.735 (2.44)
Tomatoes	0.689 (3.29)	0.677 (3.03)	0.670 (2.61)	0.675 (3.05)	0.738 (4.42)	0.733 (4.27)

Asymptotic t-ratios in parentheses.

The results show that the demand for these vegetables is generally inelastic, both with respect to own-prices as well as cross-prices. The results show significant complementary, but asymmetric, relationship between these fresh vegetables than previously found by YHE [4], which suggests that most of these fresh vegetables tend to be consumed together. Expenditure elasticities are positive and statistically significant. Over time, the demand and expenditure elasticities have remained stable during the period 1970–2010.

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Research Article

Economic Risks of Aflatoxin Contamination in Marketing of Peanut in Benin

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Aflatoxin (AF) is a human health, nutrition, and financial risk to many people in the developing world. AF contamination in peanut is caused by the fungi: *Aspergillus flavus* and *Aspergillus parasiticus*. AF is a potent carcinogenic toxin that also causes millions of dollars of financial losses to people in Africa. The fungus producing the AF can be reduced to an acceptable level by proper drying, sorting, storage, and cleaning of peanut. Government intervention and regulation can also encourage market participants to reduce AF contamination. In this paper, we examine the financial risk associated with sorting, and storing of peanut and peanut products along the marketing chain. Study results show that the prices paid for peanut, prices received, the costs of sorting and storage are dominant factors in reducing AF levels in peanut. Practices such as drying, sorting, and storing, however, pose financial risks to market traders of peanut. Unless government intervenes by requesting an AF-reduced peanut and provides assistance for market liberalization where market participants consider quality in trading decisions, suppliers of peanut will be reluctant to adopt AF-reducing techniques.

1. Introduction

Aflatoxins (AFs) are naturally occurring mycotoxins that are produced by species of fungus: *Aspergillus flavus* and *Aspergillus parasiticus.* AFs are some of the most potent toxic substances found in foods and feeds [1]. Numerous studies have also linked AFs to various diseases, such as cancer of the liver and hepatitis B and C. High levels of AF were detected in children with kwashiorkor in Sudan [2], in Durban, South Africa [3] and in Nigeria [4]. AFs are ubiquitous but are more commonly found in warm and humid climates and affect about one-quarter of the global food and feed crop output [5, 6]. The fungi associated with AF production are found on peanut, maize, yams, cassava, and cereals that form the basic staples of the African diet. According to Cardwell et al. [7], AF contamination of agricultural crops causes annual losses of more than $750 million in Africa. In the USA, it was reported that income losses due to AF contamination cost an average of more than US $100 million per year to US producers [8]. According to FAO [9], developing countries account for approximately 95 percent (%) of world peanut production. Groundnut (or peanut) (*Arachis hypogaea* L.) is one of the most important crops in West Africa because it is not only a useful crop for rotation but also a cash crop.

Recent studies have linked AF contamination in foods to environmental conditions, poor processing, and lack of proper storage facilities in developing countries [10]. Contamination is usually most frequent and serious at the storage and processing level along the marketing chain. The AF contaminated peanut is tainted and cannot be marketed and must be thrown away. Awuah et al. [11] stated that about 5 to 15% of peanut in Ghana were discarded during sorting. Pre- and postharvest management strategies employed to reduce AF in food result in lower supply but better product quality.

In spite of the studies that have outlined the losses due to and the recommended practices to reduce the losses due to AF, there is little written on the effects of AF on the financial returns of production and marketing of peanut.

Hence, these questions must be raised. What are the financial and marketing risks associated to peanut AF contamination during postharvest handling in Benin? We examine the effects of AF contamination of peanut on the net revenues of market participants and the associated risks of adopting techniques to reduce AF levels in peanut marketed in Benin.

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, guavas, bananas, coconuts and peanut. Peanut is grown as a protein source and consumed throughout the country as part of the basic staple. All of the peanuts produced are marketed locally and are contaminated with varying levels of AF [12, 13]. AF levels acceptable by the World Health Organization (WHO) standard can be attained by proper postharvest handling. The post-harvest handling methods that are likely to have the greatest impact in reducing AF levels are drying, sorting and storage. However, each method employed for lowering AF levels is accompanied by additional costs to market participants. Processors and consumers may wish to avoid these costs based on their perception of the product's safety, the price, and the effects of lowering AF on their net revenues. To determine who will bear the cost can be explained by a simple microeconomic model.

Figure 1 represents a partial equilibrium model for peanut in which food regulation to improve food safety is observed, or suppliers voluntarily agree to improve the quality of peanut. The market demand (D_o) and the supply (S_o) curves determine the equilibrium price (P_E) and quantity (Q_E). In this market, farmers or market participants sort their peanut to improve quality. The sorting of peanut results in a reduction of the quantity supplied which forces the supply curve (S_o) upward 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 perceive that the sorted nuts are of better quality, and hence they are willing to pay a higher price. However, if buyers perceive sorting of nuts as an indication that the peanuts are contaminated with AF, the demand curve (D_o) may shift to the left (D_1) resulting in a much lower price P_2 and quantity Q_2. Hence perceived lower quality results in a lower price and smaller quantity marketed.

Regulation requires pre- and postharvest control (appropriate drying sorting, and storage structures). If consumers are aware of AF problem and its market consequences, they will be willing to pay a higher price for a safer food supply. Thus, supply will shift to the left (Figure 1). Unnevehr [14] indicates that with consumers' awareness of a safer food product they are willing to buy more at a higher price. Mitchell [15] noted that consumers of milk in the USA purchased larger quantities of milk when they perceived the product as safe.

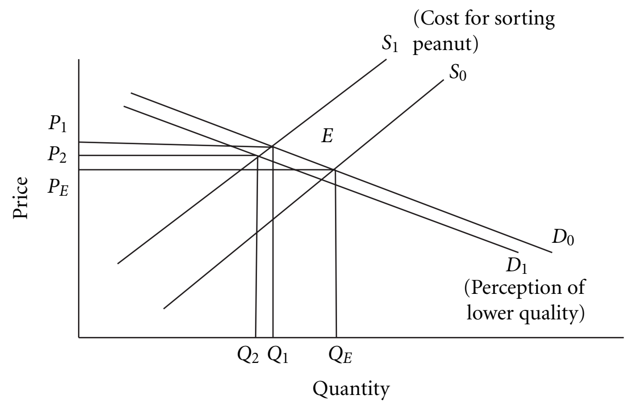


Figure 1: Market impact of food safety regulation.

1.1. Factors Affecting AF Contamination during Postharvest

1.1.1. Drying. At harvest, moisture content in groundnut is generally high and leads to development of aflatoxigenic fungi. It is recommended to dry peanut immediately down to 8% [16] in order to avoid production of AF during storage. In Benin, the most commonly used moisture reduction method for groundnut is sun drying. Farmers spread the nuts on the floor usually for one to three days. Paz et al. [17] reported that delayed drying can lead to a rapid increase in AF from 14.0 ppb at harvest to 93.8 ppb, if maize is not dried for 5 days after the harvest. This was confirmed by Hell et al. [18] who found that postharvest contamination with AF in Benin increased when harvesting took more than 5 days and drying was delayed. Attah et al. [19] indicated that drying peanut to less than 10% moisture reduced AF contamination to the WHO acceptable level.

1.1.2. Storage. Another important postharvest factor affecting AF contamination is storage conditions. Grain crops may be attacked by fungi in the field which can then develop rapidly during storage when conditions are suitable for producing mycotoxins [20]. It is recommended that grain crops should be stored in a clean, sanitized room with low humidity and temperature and adequate air circulation. The relationship between the length of storage and the level of AF has been investigated [21].

1.1.3. Sorting. AF production is optimal in regions with high temperatures. Smallholder farmers in Benin use their own houses to store their product. The ambient temperature in Benin is about 81°F. Contamination is more acute in warm, humid climate. In order to eliminate those with possible contamination, groundnut should be sorted before or after storage to remove defective or burrowed, contaminated grain. Awuah et al. [11] found that age, education, and gender influenced sorting of peanut. Women are more likely to sort peanut than men.

1.1.4. Food Policy on Groundnut. The risk of contamination by AFs is an important food safety concern for field crops [5]. 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 the world export market. The WHO has set a maximum level for AF

Table 1: Definition of parameters (inputs) used for risk models.

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

at 20 parts per billion (ppb) in human food and 100 ppb in animal feed. Likewise, the Food and Drug Administration sets a tolerance limit for groundnut at 15 ppb. The European Union has set stricter standards; any food products with a concentration of AF greater than 4 ppb cannot be marketed [5].

We investigate the effects of AF on peanut net revenues by examining the use of postharvesting techniques of reducing AF levels. We also examine the key variables that affect cost of reducing AF levels and the risks associated with the application of each of the recommended techniques. Various scenarios were examined at the market vendor, processors and stockers' level to analyze the costs, returns, and risks related to the reduction of AF levels in peanut.

2. Method

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 (southeast), and Abomey-Bohicon (south).

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, Benin. Market participants were individually interviewed on their crop handling, sorting, storage practices, and household revenues. Moreover, information on the economic and financial aspects of processing, storage, and marketing of peanut was also collected.

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 AF contamination on market participants' net revenues from the storage, processing, and trading of peanut. A Monte Carlo simulation was used in the risk analysis, using 10,000 iterations. Parameters used for @RISK are defined in Table 1. Standardized coefficients of regressions were obtained to determine the factors that pose the greatest risk to market participants in the postharvest handling of peanut to reduce AF contamination. The standardized coefficient refers to how many standard deviations a dependent variable will change, per standard deviation increase in the predictor variable. Cumulative probability distribution of net present values (NPVs) for market participants was used to evaluate the level of risks associated with certain actions to reduce AF levels.

3. Results

3.1. Sociodemographics. Most of the market participants were above 36 years old (Table 2). Stockers and vendors represented 53.3% and 51.1% of individuals, respectively, between the age group of 36 to 55 years while processors comprised of 48.1%. A large percentage (77.8% vendors, 100.0% processors, and 64.4% stockers) of the market participants were female, and most had no formal education. A large number of processors and stockers had between 0 and 15 years of experience while vendors had 44.4% having between

Table 2: Sociodemographics characteristics for vendors, processors, and stockers peanut, by region ($N = 45$).

	Vendors		Processors		Stockers	
	Number	%	Number	%	Number	%
Age groups						
Under 35	11	24.4	17	32.7	11	24.4
36–55	23	51.1	25	48.1	24	53.3
over 55	11	24.4	10	19.2	10	22.2
Gender						
Female	35	77.8	52	100.0	29	64.4
Male	10	22.2	0	0.0	16	35.6
Education						
No formal education	32	72.7	34	65.4	31	68.9
Primary school	10	22.7	15	28.9	12	26.7
Secondary school	2	4.5	3	5.8	2	4.4
Years of experience						
0–15	20	44.4	51	56.7	25	55.6
16–30	20	44.4	34	37.8	14	31.1
Over 30	5	11.1	5	5.6	6	13.3
Land ownership						
Owner	27	60.0	63	70.0	21	46.7
Renter	18	40.0	27	30.0	24	53.3
Income levels						
\$0–\$525.21	17	37.8	57	63.3	14	31.1
\$525.21–\$1,000.42	18	40.0	25	27.8	22	48.9
\$1,000.42–\$2,000.84	8	17.8	8	8.9	6	13.3
Over \$2,000.84	2	4.4	0	0.0	3	6.7
AF knowledge						
Yes	10	22.2	10	11.1	9	20.0
No	35	77.8	80	88.9	36	80.0

Source: survey data.
N: the number of observations ($N = 45$).
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.

0 and 15 years. The incomes vendors received from peanut were modest, 77.8% having a lower income 1,000 CFA (US \$3.00) per 100 Kg bag, while processors had 91.1%, and stockers had 80.0%. Most market participants had no knowledge of AFs. The percentage varied from 77.8% for vendors to 88.9% for processors.

3.2. Storage and Sorting Practices

3.2.1. Vendors. Based on survey responses, only retailers said that they are likely to sort peanut. Approximately, 80.0% of market vendors purchase sorted peanut and 20.0% do not purchase sorted peanut (Table 3). However, 91.1% of vendors said that they always checked and sort the nuts before marketing. About 31.7% report that they sell the spoilt nuts at a lower price, and 68.3% state that they just discarded them.

3.2.2. Processors. About 74.4% of the processors surveyed stated that they purchased sorted peanut, while 21.1% do not purchase the sorted nuts and do not plan to do so in the future (Table 3). One reason given for buying sorted nuts was the expected price would be higher for sorted nuts and higher quality nuts generated quick sales. About 90% of them sort peanut before processing it into paste, oil, or other products, 7.78% do not sort the nuts before processing them but are willing and plan to do it in the future. Only 2.2% refused to sort before processing. In addition, of 81 respondents who sort peanut before processing, 41.9% reported that they discard the spoilt nuts, usually throw them away, burn them, or use them as charcoal. However, the remaining consumed them, used them as animal feed, or sell them at a lower price. About 89.5% of the processors mention that they usually store peanut for a period of 6 months.

3.2.3. Stockers. There is little difference in the decision made by the stockers to sort peanut. About 66.7% indicated that they always purchase sorted peanut, and only 33.3% purchase nonsorted peanut. Among those who do not purchase sorted peanut, 80% intend to buy the cleaned nuts and only

Table 3: 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
Autoconsumption	—	—	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 produce, sell, and/or transform peanut.

20% are not likely to do it. About 53% of peanut stockers, who state that they sort peanut before selling, are those who also produce, sell, and/or process peanut. The remaining (46.7%) only specializes 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.

3.3. Financial Analysis of Effects of AF on Peanut

3.3.1. Enterprise Budgets for Market Vendors. Budgets for market vendors in Benin are presented in Table 4 based on the assumption that consumers consider all nuts the same and pay the same price. The first budget concerns vendors who purchase nonsorted peanut and do not sort before selling; the second budget shows costs and net returns for those who purchase nonsorted 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 are willing to pay a higher price for improved food safety.

Table 4 displays the estimated costs and returns for market vendors who sell only unshelled peanut (wholesalers) and those who sell only shelled peanut (retailers). 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. Since the costs of sorting are transferred from farmers to vendors, labor costs for traders increase by \$13.00, resulting in higher variable costs (\$626.00), and consequently, smaller net returns of \$155.70. It is, therefore, less profitable for vendors who purchase nonsorted nuts to use their own labor to sort the peanut. The third case, in Table 4, shows a budget where the decision makers (wholesaler) purchase already-sorted peanut at a higher price and decide to sort again. Vendors receive lower net returns than in the last case because they pay a higher price for the product and incur additional costs for sorting. Higher purchasing price for clean peanut leads to an estimated loss of net returns of \$62.30.

Results are similar for retailers; it is not profitable in terms of net revenue to sort peanut before selling. Gross revenue for 4,500 kg decreases from \$756.00 to \$726.80 when sorting takes place. In addition, the purchase of a better quality product at a higher price results also in smaller net returns of \$118.10. Break even prices range from \$0.11 to \$0.13 for the wholesalers and \$0.12 to \$0.14 for the retailers.

3.3.2. Enterprise Budgets for Processors. Results from enterprise budgets for processing peanut are shown in Table 5. Fol-lowing the assumptions that AF increases with storage time, costs and returns for nonsorted 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 (\$705.60) and net returns (\$236.14). When the sorted peanut was stored for a period greater than or equal to 3 months, labor costs increased (\$174.58), generating lower net returns of \$168.58. Because of peanut's lower quality after 6 months of storage, processors have to throw away 5% of the peanut which results in lower net returns (\$147.42).

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. It is observed that net

Table 4: Estimated costs and returns budget for vendors (wholesalers) under the following assumptions. (1) Vendors purchased nonsorted peanut and do no sort before marketing. (2) Vendors purchased nonsorted peanut and sort before marketing. (3) Vendors purchased sorted peanut at a higher price and do not sort before marketing.

		Wholesalers			Retailers		
	Unit	(1)	(2)	(3)	(1)	(2)	(3)
		Value	Value	Value	Value	Value	Value
Unshelled peanut	kg	5,500	5,225	5,500	4,500	4,275	4,500
Price	$	0.147	0.15	0.15	0.168	0.17	0.17
Revenue	$	808.5	783.8	825.0	756.0	726.8	765.0
Variable costs							
Quantity purchased	kg	5,500	5,500	5,500	4,500	4,500	4,500
Price	$	0.105	0.105	$0.126	0.11	0.11	0.13
Purchasing costs	$	577.5	577.5	$693.0	495.0	495.0	585.0
Labor hour	hour	28.5	54.0	28.5	68.5	87.0	68.5
Labor costs	$	7.63	20.63	7.63	34.5	43.75	34.5
Material and equipment	$	28.89	27.84	28.89	23.63	22.58	23.63
Total variable costs	$	614.0	626.0	729.5	553.1	561.3	643.1
Income above variable costs	$	194.48	157.8	95.5	202.9	165.4	121.9
Fixed costs							
Repair and maintenance	$	1.0	1.0	1.0	2.5	2.5	2.5
Depreciation equipment	$	1.13	1.13	1.13	1.23	1.21	1.23
Total fixed costs	$	2.13	2.13	2.13	3.73	3.71	3.73
Total costs	$	616.2	628.1	731.7	556.9	565.0	646.9
Net returns	$	192.4	155.7	93.4	199.1	161.7	118.1
Break-even price (per kg sold)							
To cover variable expenses	$	0.111	0.12	0.133	0.118	0.126	0.139
To cover total expenses	$	0.112	0.12	0.133	0.119	0.127	0.14

Peanut is sold to vendors at the farm gate price, which is 50 FCFA per kg ($0.105).
Wholesalers are vendors selling unshelled peanut in local and neighbors' villages at 70 FCFA ($0.147) per kg.
Retailers are vendors who sell only shelled nuts; price of shelled peanut is higher than the unshelled nuts: 80 FCFA ($0.168) per kg.
In the third case (3), the purchased cost of 1 kg of peanut already sorted is 60 FCFA = $0.126.
Material and equipment are considered as variable costs because they are renewed every year.

returns above all costs drop for processors who sort peanut 3 months after harvest ($137.38) and also for processors with peanut stored for more than 6 months ($116.22).

3.3.3. Enterprise Budgets for Stockers. Results are displayed in Table 6. Two types of storage practices are studied; traditional stockers are stockers who store peanut in *banco* buildings, on the floor, in plastic bags, on hay, or on the top of the roof of their house, while the improved storage facilities are built of bricks and have storage racks. Average income for peanut stockers using the traditional method is $735.00 for 1,000 kg of stored peanut, at a total cost of $10.70 and net returns of $724.30. Stockers using the improved method, however, generate revenues of $1,051.00 per month, total costs of $12.93, and net returns of $1,038.07. 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 [22]. Results based on this assumption are also presented in Table 6. For less than 3 months of storage, revenue decreases to $720.30 with the same variable costs ($8.18) and reduced net returns of $709.60. After 6 months of storage, traditional stockers' income lowers to $698.25 (Table 6). Net returns are therefore reduced by $22.05. We note that as peanut quality is lowered due to storage time, stockers' revenue is also reduced from $1,029.98 to $998.45, resulting in a decrease in net returns from $1017.35 to $985.82.

3.4. Risk Analysis for Market Vendors. Probability distribution for net returns for wholesalers who do not sort peanut is presented in Figure 2. 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, purchasing price, and sorting. Coefficients are −0.753 and −0.228, respectively. Figure 2(b) shows similar results when market vendors purchased sorted peanut at a high price and sell it without further sorting. Purchasing price is the most important contributing variable in

Table 5: Estimated costs and returns for processing peanut, using 2,400 kg of whole grain peanut per month, under the following assumptions. (i) Case 1: peanut is normally purchased at $0.15 per kilogram and sold at $7.35 a bassin of peanut butter. (ii) Case 2: peanut is purchased at different price due to storage length and sorting.

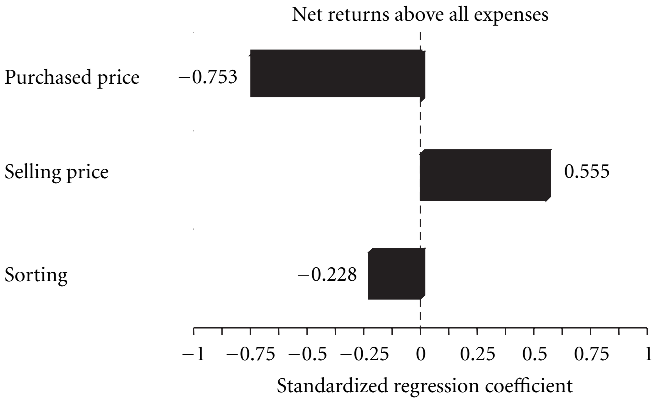
		Case 1			Case 2		
	Unit	Not sorted	Sorted		Not sorted	Sorted	
			3 months	6 months		3 months	6 months
		Value	Value	Value	Value	Value	Value
Peanut butter (1 kg @ $7.35)	kg	96.00	95.04	92.16	96.00	95.04	92.16
Revenue	$	705.60	698.54	677.38	705.60	698.54	677.38
Whole grains	kg	2,400	2,400	2,400	2,400	2,400	2,400
Unshelled nuts price	$	0.147	0.147	0.147	0.126	0.16	0.16
Purchasing costs	$	352.8	352.8	352.8	302.4	384.0	384.0
Labor hours	hour	186.0	258.0	258.0	186.0	258.0	258.0
Labor cost	$	114.08	174.58	174.58	114.08	174.58	174.58
Material and equipment	$	0.63	0.63	0.63	0.63	0.63	0.63
Total variable costs	$	467.51	528.01	528.01	417.11	559.21	559.21
Income above variable costs	$	238.09	170.53	149.37	288.49	139.33	118.17
Repair and maintenance	$	1.00	1.00	1.00	1.00	1.00	1.00
Depreciation equipment	$	0.95	0.95	0.95	0.95	0.95	0.95
Total fixed costs	$	1.95	1.95	1.95	1.95	1.95	1.95
Total costs	$	469.46	529.96	529.96	419.06	561.16	561.16
Net returns	$	236.14	168.58	147.56	286.54	137.38	116.22
Break-even price (per kg sold)							
To cover variable expenses	$	4.87	5.56	5.73	4.50	5.93	5.18
To cover total expenses	$	4.89	5.58	5.75	4.52	5.95	5.20

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

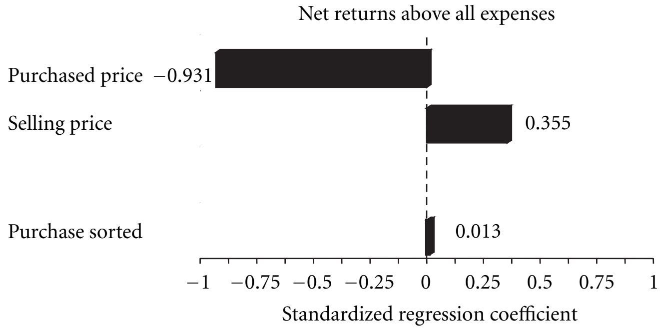
Table 6: Estimated costs and returns for peanut storage activities under the following assumptions. (i) No treatment is done for stored peanut in the traditional storage method. (ii) Decision maker authorize customers (farmers, vendors, or processors) to sort peanut. (iii) Peanut is stored for less than 3 months and more than 6 months.

		Traditional method			Improved method		
	Unit	Normal	3 months	6 months	Normal	3 months	6 months
		Value	Value	Value	Value	Value	Value
Peanut stored	kg	1,000	980	950	1,000	980	950
Price	$	0.735	0.735	0.735	1.051	1.051	1.051
Revenue	$	**735.00**	**720.30**	**698.25**	**1,051.00**	**1,029.98**	**998.45**
Labor hour	hour	6.67	6.67	6.67	3.67	3.67	3.67
Labor costs	$	2.63	2.63	2.63	2.94	2.64	2.64
Material and equipment	$	6.25	6.25	6.25	6.25	6.25	6.25
Total variable costs	$	8.88	8.88	8.88	9.19	8.89	8.89
Income above variable costs	$	726.12	711.42	689.37	1,041.81	1,021.09	989.56
Repair and maintenance	$	1.00	1.00	1.00	2.00	2.00	2.00
Depreciation equipment	$	0.82	0.82	0.82	1.74	1.74	1.74
Total fixed costs	$	1.82	1.82	1.82	3.74	3.74	3.74
Total costs	$	10.70	10.70	10.70	12.93	12.63	12.63
Net returns	$	724.30	709.60	687.55	1,038.07	1,017.35	985.82
Break-even price (per kg sold)							
To cover variable expenses	$	0.01	0.01	0.01	0.01	0.01	0.01
To cover total expenses	$	0.01	0.01	0.01	0.01	0.01	0.01

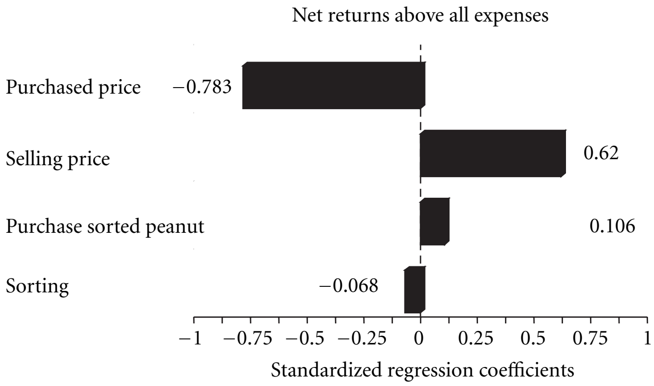
Percent of quantity rejected in 2% for peanut stored less than 3 months and 5% for peanut stored after six months.



(a) Assumption: vendors purchase unsorted peanut and sort before marketing



(b) Assumption: vendors purchase sorted peanut at a high and no sorting before marketing



(c) Assumption: vendors purchase sorted peanut at a lower price ($0.09) due to storage time, and they sort again for marketing

Figure 2: Tornado graphs of regression of net returns for peanut vendors in Benin.

the model. Purchasing already sorted peanut at a higher price causes net returns to decrease by 0.93 standard deviation. As selling price increases by one unit, net returns increase also by 0.355. In addition, coefficient for the variable purchase sorted peanut is positive (0.013). By purchasing already-sorted peanut, vendors avoid the cost of sorting which is shifted to the sellers. In Figure 2(c), 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 show that purchasing price is the most dominant variable (−0.783) influencing traders' net returns. When the variable purchase price of sorted peanut increases by one standard deviation, net returns also go down by 0.783; results also show that the 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 made by the vendors. 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 3, based on assumptions used to generate previous budgets in Table 4. Vendors in option A are those who purchase unsorted peanut and do not sort again before selling; vendors in option B are those who purchase non-sorted peanut and sort before selling; vendors in option C; are those who purchase already-sorted peanut and do not sort the product again before selling. There is a risk transfer from buyers (vendors) to sellers when vendors purchase already sorted peanut.

No change in labor cost is noted for the vendors in options A and C. Figure 3 shows that there is a probability of 18% NPV for all options are less than zero and then become positive, but option A is less risky than option C, and finally than option B. For all levels of discounted profits, option A would be considered the most efficient set and would be the most rational. In option A, the market vendor may use family members' labor to sort and enforce high-quality control.

3.5. Risk Analysis for Processors. Results from regression sensitivity analysis for net returns are shown in Figures 4(a), 4(b), and 4(c) 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 0.91 for sorted peanut stored more than 6 months. However, when

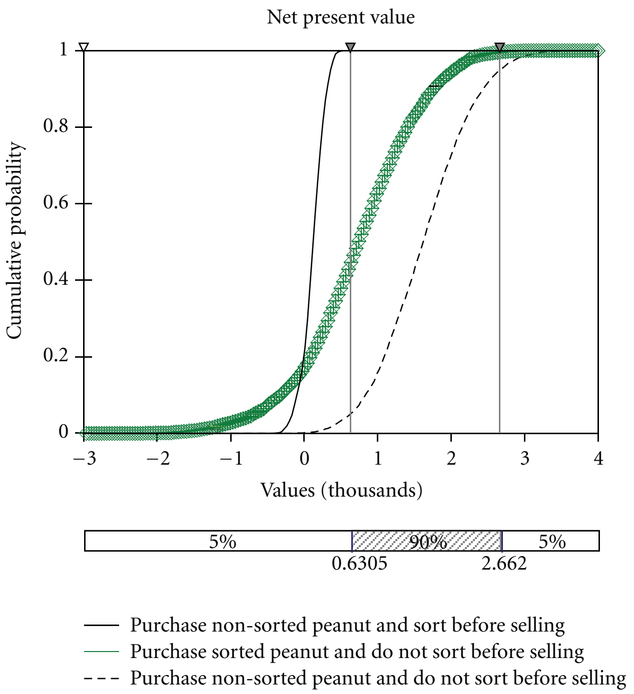


Figure 3: Cumulative probability distribution of net present values for vendors, discounted at 6% and using the assumptions shown in Table 4. (Assumptions: option A: vendors purchase unsorted peanut and do not sort before selling, option B: vendors purchase non-sorted peanut and sort before selling, option C: vendors purchase sorted peanut and do no sort again before selling.)

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 negative effect on processors net returns.

Cumulative distributions of the NPV for processors, as price vary due to sorting and storage, are presented in Figure 5. 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 5), which is smaller than the other options ($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 close and almost at the same points. However, we can observe that it is more profitable for the same level of risk for processors to sort peanut stored for a period of less than 3 months.

3.6. Risk Analysis for Stockers. Tornado graphs in Figure 6 show the factors influencing 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 1%, net returns will also increase by 0. 99 standard deviation. In addition it is shown that net returns are negatively influenced by sorting (−0.059) and storage (−0.022).

Another comparison is made between stockers who use the traditional storage method and those who use the improved method for peanut conservation. Figure 7 shows that with a probability of 80%, stockers who use treatment to improve peanut quality obtain a higher NPV ($12.6) compared to those with a traditional storage method ($8.4). Hence, we can conclude that for the same level of risk, stockers who use the improved method have a higher NPV than those using the traditional method.

4. Discussion and Conclusion

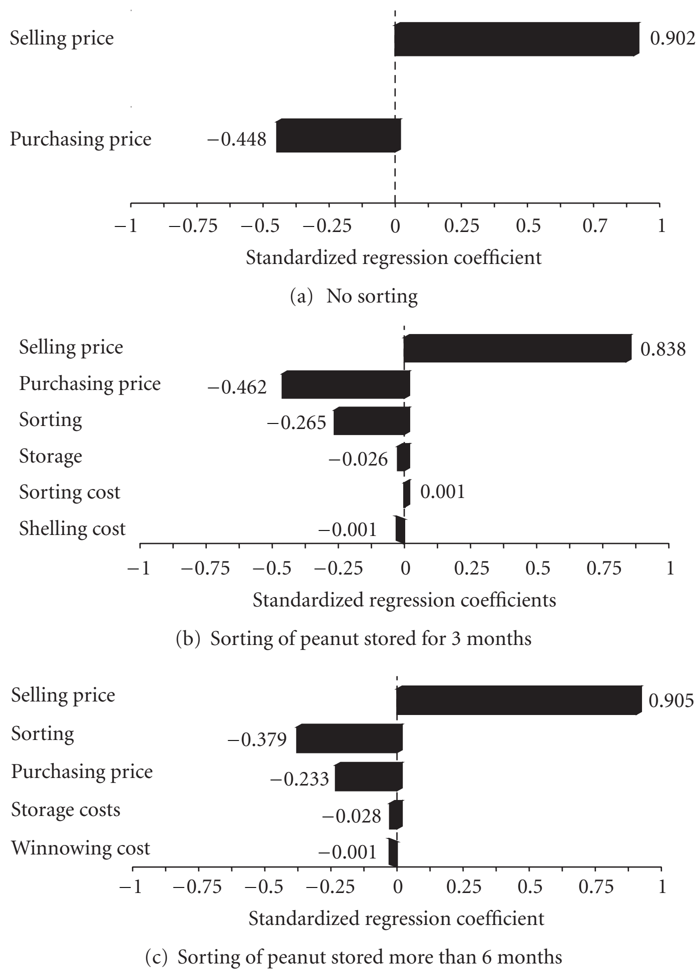
This study summarizes the results of the effects of AF contamination on the financial and economic risks during post-harvest handling of peanut in Benin. Answers originating from surveyed market participants show that the majority of the respondents do not have any information on AF contamination of peanut and its harmful health effects to human and animals. Jolly et al. [23] also note similar responses for Ghanaian market participants. It also shows clearly that most of them are unable to identify AF contaminated nuts, but only signs of spoilage like discoloration or insect damage. Jolly et al. [24, 25] observed that the knowledge of AF was low among market participants in Ghana and Benin. Hence market participants must be educated to identify poor quality peanut if they are to sort in order to reduce AF levels.

The budget analysis shows that AF contamination lowers the net revenue of market participants since the tainted nuts were discarded in an effort to improve quality. The dominant factors influencing the revenues are purchase price and sorting. This is confirmed by the regression analysis. For market participants to participate in an AF reduction program, they would have to be given a price incentive for the sorting, labor cost increased and the rejection and discard of AF-contaminated nuts. Consumers should also be educated about the negative effects of AF so that they can encourage suppliers to sell a better product by offering a higher price for an AF-free product.

Enterprise budgets and risk analysis were developed and conducted to examine the risk of AF 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 decrease by $36.7 for 5,225 kg of nuts sold.

Risk analysis also confirms that it is more risky for market participants to either purchase already-sorted peanut before selling or purchase nonsorted and sort the nuts themselves before selling. A comparison made between costs and returns for peanut stored for less than 3 months and those from peanut stored more than 6 months indicates that net returns after 6 months are the smallest due to lowered peanut quality.

Budgets were developed for the processors to compare the costs and returns when they do not sort peanut and when they do at different storage times. Results show that sorting increases costs and risks of sorting peanut. Moreover,



(a) No sorting

(b) Sorting of peanut stored for 3 months

(c) Sorting of peanut stored more than 6 months

Figure 4: Tornado graphs for processors' net returns above all expenses, based on the budget in Table 5.

when sorting is done for a period of more than 6 months, net returns decrease further ($147.42). Similar findings for stockers indicate that sorting peanut reduces net returns for storing 980 kg of peanuts from $1,038.07 to $1,017.35.

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 product. 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 a key factor to increase market participants' willingness to sort peanut [11]. Jolly et al. [25] also emphasized increasing market participants' awareness of AF problem to encourage them to sort peanut.

Risk analysis for sorting shows it would be less risky if the buyer purchases the unsorted nuts and then sort the nuts himself/herself. 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. [11] that young and older unemployed individuals are often engaged in 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 for all intermediaries. The decisions to sort by the market intermediary negatively influence 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 influences 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/her net returns. Therefore, sorted nuts should command a higher 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 AF contamination of peanut is significantly influenced by drying, sorting, and storage. However, price of purchase, selling price, and costs of storage are significant contributors to business net revenues and unless government provides an economic incentive for producing quality peanut, suppliers will be hesitant to adopt measures to reduce AF levels.

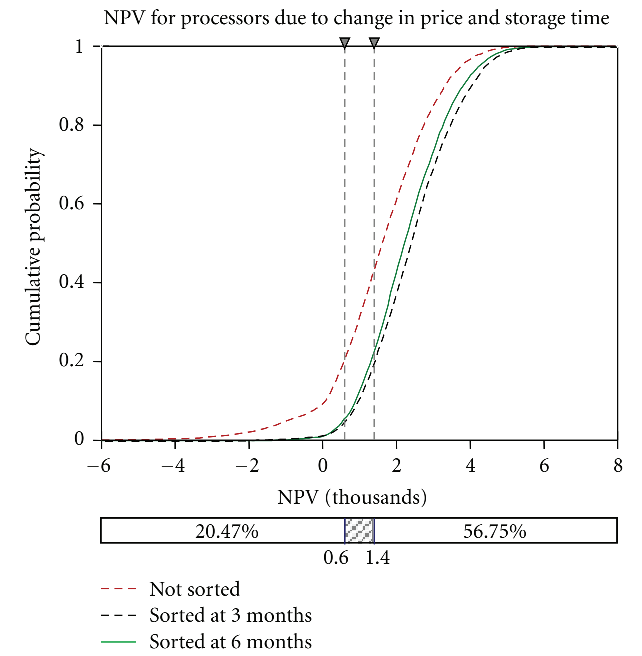


Figure 5: Cumulative probability distribution for the net present values of processors, as price changes due to sorting and storage time.

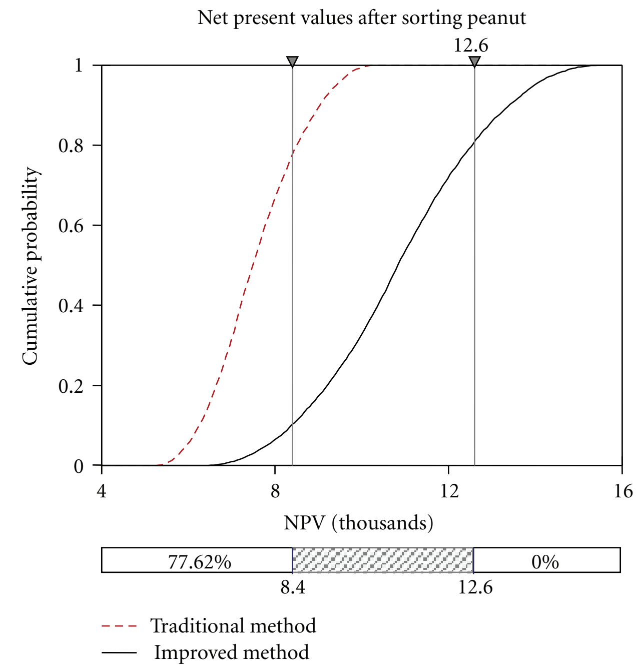


Figure 7: Cumulative probability distribution for the net present values for each method of storage when sorting is done.

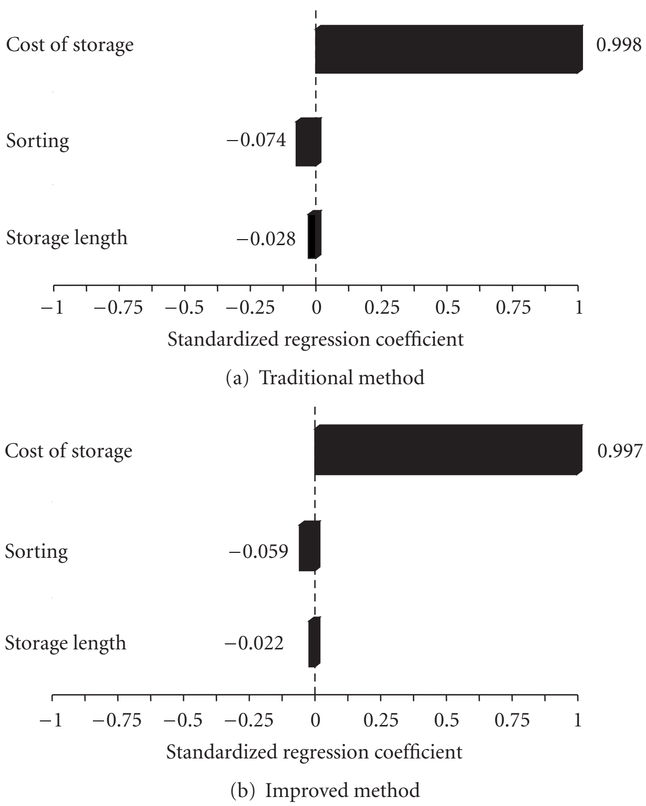


Figure 6: Tornado graphs for stockers' net returns.

Any measure to reduce peanut AF levels must be explained to the population of Benin so that they appreciate the course of action to be taken to reduce AF contamination in peanut.

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