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Table of Contents

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SENSITIVITY OF WELFARE EFFECTS ESTIMATED BY AN EQUILIBRIUM DISPLACEMENT MODEL: A PRODUCTIVITY GROWTH FOR SEMI-SUBSISTENCE CROPS IN A SUB-SAHARA AFRICAN MARKET WITH HIGH MARKET MARGIN

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Abstract

Conventionally-used Equilibrium Displacement Model (CEDM) has various unrealistic assumptions, despite its common application to the ex-ante estimation of welfare effects from agricultural productivity growth. In particular, CEDM assumes a) linear supply curve; b) productivity growth represented as parallel shift in supply curve; c) zero market margin. The application of CEDM may be questionable, particularly for assessing the impact of productivity growth in semi-subsistence crops in poor countries, where distribution of benefits to the lower income population is as important as the size of total benefits. An alternative EDM is developed which replaces a) with constant elasticity form, b) with pivotal shift and drop restriction of c). A detailed theoretical discussion is provided on how unique characteristics of cassava production in rural Sub-Saharan Africa (SSA) allow approximation of its supply curve into constant elasticity form, and also why a pivotal shift may be appropriate for cassava productivity growth in SSA given the characteristics of the most dominant disease for cassava. Estimated welfare effects are then compared between CEDM and AEDM for the case of cassava in Benin. Results indicate that CEDM can provide significant bias in both total welfare gains and the pro-poor nature of such productivity growth.

JEL Codes: D13, D31, D81, O33, Q11, Q16

Keywords: Equilibrium displacement model, Cassava, Supply curve, Market margin, Pro-poor technology, Sensitivity analysis

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Introduction

Agricultural productivity growth is essential for poverty reduction and welfare improvement in Sub-Sahara Africa (SSA). Productivity for subsistence crops like cassava can be pro-poor because poverty is prevalent among its producers in the world (Nweke, Spencer, and Lynam, 2002; Johnson, Masters, and Prekel 2006). Growth in cassava production in SSA has been significantly slow due to various diseases, particularly cassava mosaic disease (CMD) (Calvert and Thresh, 2001; Thresh et al., 1994). Recent development in biotechnology such as developing genetically modified (GM) CMD-resistant cassava holds significant potential for large scale productivity growths of these subsistence crops. The equilibrium displacement model (EDM) is often used to estimate *ex-ante* welfare effects for such productivity growth and how benefits are distributed among different population groups (Hayami and Herdt, 1977; Norton, Ganoza, and Pomareda, 1987; Qaim, 2001; Andreu et al. 2006).

The literature, however, often employs an EDM (called conventional EDM [CEDM]) with several questionable assumptions. Major key assumptions for CEDM are (a) the linear supply curve, (b) productivity growth as expressed by a parallel shift in supply curve, and (c) zero market margins (in which producers and consumers face a single price).[1] While (a) and (b) have been questioned inappropriate for biological productivity growth (Lindner and Jarrett, 1978; Rose, 1980) and tend to overestimate the effects from productivity growth (Voon and Edwards, 1991), CEDM has often been used given its parsimony.

When applying CEDM to the productivity growth of semi-subsistence crops like cassava, however, consequence of assumptions under CEDM can become even more problematic. First, the supply curve of cassava for low-income SSA farmers reflects important roles of cassava as food of last resort, relative stability of its productivity compared to other crops, higher risk associated with other economic activities than cassava production and farmers' risk aversion. Supply curve in constant elasticity form, as is discussed later, better captures such key characteristics than linear supply curve. In addition, characteristics of major disease like CMD for cassava suggest that productivity growth from varieties resistant to such disease may be better expressed by a pivotal shift in the supply curve. Second, assumption of (c) is highly questionable, compared to more commercial crops or crops with a more integrated market. Market margins are significantly high and have complicated structures in Sub-Saharan Africa (SSA) agricultural markets (Barrett, 2008), particularly for bulky crops like cassava. Third, for semi-subsistence crops like cassava, the distribution of gains is as important as the aggregate gains due to its potentially pro-poor nature. The estimated distribution of gains is expected to be even more sensitive to the violation of assumptions under CEDM.

There is a great need to assess the consequence of joint violations of the aforementioned three assumptions in CEDM, particularly when it is applied to semi-

[1] Another implicit assumption in CEDM is a perfectly inelastic home consumption. The relaxation of the perfectly inelastic home consumption assumption, however, has relatively small effects on estimated welfare and is thus excluded from the subsequent discussion, although it is included in the actual estimation of AEDM.

subsistence crops like cassava. This article therefore empirically assesses how CEDM can bias the estimated distribution of benefits from cassava productivity growth. More specifically, this article first discusses why a constant elasticity form better captures the key characteristics of cassava supply curve in SSA. This article then modifies CEDM into a model with alternative assumptions (called alternative EDM [AEDM])—namely, (a) a supply curve in constant elasticity form; (b) productivity growth as expressed by a pivotal shift in the supply curve; (c) non-zero market margins with structures indicated by Barrett (2008). This article empirically compares CEDM with AEDM, using the Benin Small Farmer Dataset (Benin dataset, hereafter)(IFPRI, 2004).

The results in this article indicate that, in the particular case of cassava producers in Benin and certain assumptions, CEDM may significantly overestimate the aggregate benefit of cassava productivity growth, while underestimating the benefit for low-income producers who belong to the higher farmgate price zones because of their proximity to a major consumption market.[2] The latter finding is important because CEDM can understate how pro-poor the cassava productivity growths are. Thus, the use of a more data-intensive, less-restrictive, and realistic, but also labor-intensive, model, as described in this article, is worthwhile when assessing the pro-poor nature of cassava productivity growth in Benin.

This article contributes to the literature by improving our understanding of how CEDM with unrealistic assumptions may provide a significantly different picture of how large and pro-poor the welfare effects are from biological cassava productivity growth in SSA countries. The results also provide important insights into how the impact of public plant-breeding research should be evaluated, and how they may be sensitive to the nature of productivity growth and market structure peculiar to the SSA countries.

Cassava Supply Curve for Low-Income Farmers in SSA

Empirical estimation of a supply curve often relies on various assumptions regarding the shape of the curve at the lower price ranges. It is difficult to obtain the exact shape of a supply curve as they are not usually observed. Important theoretical reasoning can be, however, provided for various key properties of the supply curve for cassava in SSA, including Benin, and why it is better represented by a constant elasticity form with elasticity less than unity, than linear supply curves, as well as why productivity growth is better represented by its pivotal shift than a parallel shift.

[2] Although they sell cassava at a higher farmgate price, these producers are still low income because their production costs are high and their production is small.

Marginal cost (MC) of cassava production in semi-subsistence farming in a partial equilibrium framework.

Supply curve is derived from the marginal cost (MC) of production. Crop is produced up to the point where MC equals its farmgate price.[3] For a highly commercial production where all inputs are bought with cash, MC is determined straightforward.

Semi-subsistence cassava production is, however, unique in a sense that inputs are usually not purchased at observable prices but rather bear opportunity costs of allocating inputs away from other economic activities. In addition, cassava is the most important source of food for many low-income farmers in SSA, including Benin. Cassava can grow on marginalized and infertile land (Fregene and Puonti-Kaerlas, 2001) with relatively stable yield[4], and tolerate adverse weather conditions like severe drought. With these unique characteristics, the MC for cassava can be affected by at least two important factors. They are, 1) effects of relatively higher risk in other economic activities for cassava producers compared to cassava production, and 2) the importance of subsistence activities (for example, collecting water) often carried out by cassava producers. I describe first how the opportunity costs determine MC for cassava production and how the risk in other activities may lower the MC for cassava production.

For semi-subsistence farmers, MC for cassava production is the income foregone in exchange for marginally increasing cassava production. The opportunity costs of marginally increasing cassava production can be derived in the following way. Increasing cassava production by dq unit from the initial production q^* requires increasing the use of input factors k from x_k^* by dx_k so that $\sum_k \left(f_k \big|_{q=q^*} \cdot dx_k \right) = dq$ where f_k is marginal productivity of k for cassava production measured at $q = q^*$. In the mean time, dx_k unit of k can, if used for alternative activities (for example, wages earning labor), generate income $\frac{\partial \pi}{\partial x_k} \cdot dx_k$ in which $\frac{\partial \pi}{\partial x_k}$ is the maximum marginal increase in income that can be generated from other activities (π) through marginal increase of k as input.[5] In a partial equilibrium framework, MC curve is derived from the initial equilibrium, and $\partial\pi/\partial x_k$ is fixed at that initial equilibrium so that $\partial\pi/\partial x_k = \partial\pi/\partial x_k|_{\pi=\pi^*}$ (= π_k^* hereafter). When producing additional dq units of cassava, farmers decide dx_k which minimize the total opportunity costs. More specifically,

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[3] As an exception, autarkic producers produce up to the point where MC equals the cash equivalent amount which farmers are willing to pay for consuming an additional cassava.

[4] CMD is insidious and reduces the yield slowly over long years (Thresh et al. 1994) instead of drastically reducing it in a particular year. The cassava yield itself is therefore still relatively stable even when affected by the CMD.

[5] Some activities, such as collecting water for own consumption, would raise utility instead of income. For such activities, π' is farmers' willingness to pay for additional units of water that can be collected by using additional units of k.

$$MC = \lim_{dq \to 0} \left\{ \frac{\min_{dx_k} \left[\sum_k \pi_k^* dx_k \right] \text{subject to} \sum_k f_k dx_k = dq}{dq} \right\} \tag{1}$$

where MC is the marginal cost corresponding to the cost-minimizing choice of dx_k.

Key properties of the supply curve for cassava

Cassava producing households in SSA are usually engaged in three types of economic activities; 1) cassava production; 2) other subsistence activities (such as collecting water); 3) other more profitable but risky activities. Cassava production bears an opportunity cost which is the maximum foregone benefits from either activity 2) or 3), and MC curve for cassava can be roughly characterized by the following key conditions; (i) MC = 0 at $q = 0$, (ii) MC > 0 at $q > 0$ with convex MC curve. In other words, cassava production usually bears positive opportunity costs at most production levels, although it can be minimal at $q = 0$.

The condition (i) is due to the following reasons. First, cassava can grow on marginalized infertile land and the opportunity cost of land for the first unit of cassava is very low in terms of value of other crops that could be grown, as most other crops cannot grow on marginalized infertile land. In addition, for most agricultural households, the use for land is almost exclusively for agricultural production. Moreover, land is owned by farmers under customary tenure in countries like Benin. Therefore, the land used for the first unit of cassava usually bears very low opportunity cost. In addition, since cassava can grow to satisfactory level with very little input, initial marginal productivity of land as well as labor at $q = 0$ can be very high.

Second, cassava is usually grown by planting stem cutting instead of cassava seeds. Unlike seeds for grains or legumes, which can also be eaten as food, cassava stem cutting is uneatable and does not bear opportunity costs as food when planted. Stem cutting can be relatively easily obtained from current plants and may not be sold at high prices, further reducing the opportunity costs of planting it.

Third, farmers' aversions to risk in activities 3) significantly biases inputs use toward cassava at $q = 0$. In rural SSA, other income generating activities which incur opportunity cost for cassava production tend to be riskier. Typically, while cassava provides stable yield under various weather conditions and thus source of food, production of other crops may be more risky. In addition, although non-agricultural activities tend to provide more stable sources of income than agricultural activities in the developed world, that may not hold or even reverse for cassava producers in rural Africa. Non-agricultural activities like wage-earning work can be risky because salaries are not paid on time, food prices fluctuate in the market, or high transaction costs are involved with working off-farm. In such cases, for a risk-averse cassava producer, MC becomes lower than when there is no such risk in other activities. To see this, we assume the case where only labor use (x_L) is marginally increased, in which case (1) can be simplified to MC = $\pi_L^* \cdot \frac{1}{f_L}$.[6] When there is risk in other activities, however, MC can be expressed as (see Appendix A),

$$MC = \left\{E\left[\pi_L^*\right] + \operatorname{cov}\left[u', \pi_L^*\right] / E\left[u'\right]\right\} \cdot \frac{1}{f_L} \tag{2}$$

in which u' is the marginal utility of income (= ∂u / $\partial \pi$), E denotes the expectation. The term

$$\operatorname{cov}\left[u', \pi_L^*\right] / E\left[u'\right] \tag{3}$$

is negative for risk-averse farmers and proportional to the marginal risk-premium (Koundouri, Nauges, and Tzouvelekas, 2006). MC for cassava production for risk-averse farmers tend to be lower than for risk-neutral farmers or those facing no risk in alternative economic activities.

As was mentioned above, cassava is often the most important reliable source of food for many farmers in rural SSA. No production of cassava (q = 0) would indicate extreme food insecurity for them. Therefore, farmers tend to be extremely risk-averse at q = 0, and they will incur significant marginal risk premium for using inputs for other activities including production of other crops. This makes (3) largely negative and therefore, lowers the MC significantly below the expected opportunity cost $E\left[\pi_L^*\right] \cdot \frac{1}{f_L}$.

Increase in q indicates improved food security, and farmers become less averse to risk in other activities, and so (3) approaches 0. We may think (3) stays significantly negative so that MC = 0 for at least up to a certain level of q given the aforementioned importance of cassava for farmers' food security. The condition (ii), however, states that MC > 0 once the first unit of cassava is produced. Such an increase in MC from 0 at small q is due to the opportunity cost of allocating resources, typically labor, from other subsistence activities 2) such as collecting water from the well or river. Water from the tap is generally not available in rural SSA, and collecting water is an important necessary activity for rural SSA farmers. These activities are as important as cassava production for farmers to meet their basic needs, and relatively less risky compared to activities 3) so that the term (3) is generally close to 0. Only when q = 0, (3) becomes significantly negative due to aforementioned extreme aversion to risk by farmers.

The conditions i) and ii), together with the decreasing returns to scale or decreasing marginal productivity that are common for cassava production in SSA, require that MC curve may be closer to constant elasticity form with elasticity less than unity. Other popular shapes of supply curves indicate the deviation from either i) or ii). Figure 1 illustrates roughly three types of MC curves that can be drawn from the information of equilibrium quantity, price, elasticity and an assumption of MC at q = 0. Superiority of constant elasticity forms to each of these shapes can be suggested by the aforementioned characteristics of cassava.

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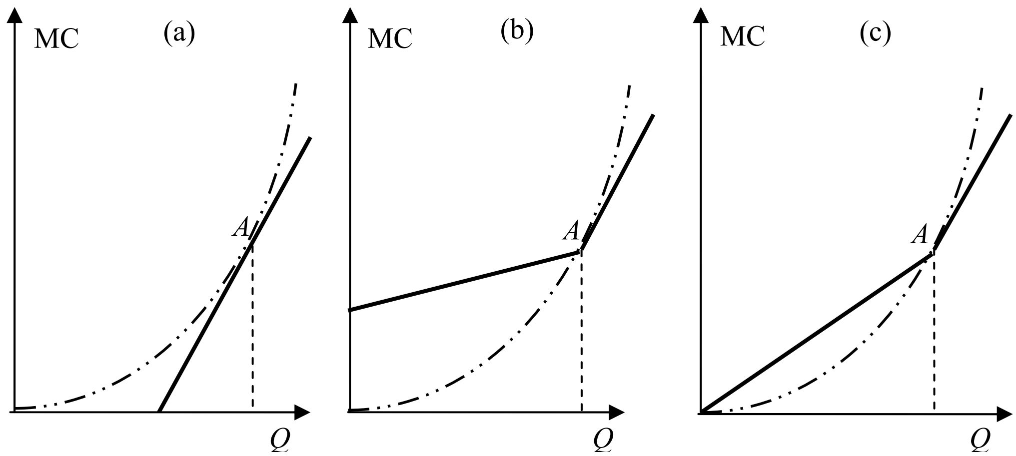
[6] However, the discussion can be generalized to the case where other major inputs such as land and seed (stem cuttings) are marginally increased.



Source: Author.

Figure 1. Inappropriate MC curves for cassava production.

Figure 1 (a) assumes zero MC for up to some positive quantity of production. This contradicts with 2) above, that any labor used for additional cassava is likely to bear opportunity costs of its use for other subsistence activities. Literature also suggests that the aforementioned constraint of linear inelastic MC curve can be relaxed as Figure 1 (b) or (c) where the MC curve below the equilibrium price are either connected to the origin or to the vertical axis. Figure 1 (b) is clearly inconsistent with the assumption of MC = 0 at $q = 0$. Figure 1 (c) satisfies MC = 0 at $q = 0$ and MC > 0 at $q > 0$. Though the difference is less intuitive, constant elasticity form (dotted line) may be still preferred to Figure 1 (c) because farmers may be particularly averse to the risk of food shortages at the low cassava production level, which makes (3) more negative and drives down the MC for small q.

Shifts in supply curve

Key insights can be obtained into how cassava supply curve shifts through a typical cassava productivity growth in SSA using the case of CMD which is its most dominant disease. A productivity growth under the GM CMD-resistant cassava is likely to be expressed by pivotal (divergent) shift instead of parallel shift in the supply curve due to the following reasons. First, the key principles of MC curve for cassava, 1) and 2), will likely to apply for GM CMD-resistant cassava because aforementioned arguments supporting 1) and 2) such as farmers' reliance on cassava as the food of last resort, risk in other activities will remain even after GM cassava is introduced. The drop in MC will be small at small q than at large q, making parallel shift less convincing.

Second, the nature of CMD and use of inputs for cassava production may also support the pivotal shift. The damage from CMD tends be random beyond farmers' control and evenly spread across the plots. An additional unit of land is equally exposed to whiteflies and the virus they carry as other plots. GM CMD-resistant cassava will raise productivity of land at equal proportions across plots. Marginal productivity of land is raised by equal proportions for all levels of q and thus, MC associated with land declines by the same proportion for all levels of q. CMD-resistant technology may also raise marginal labor productivity by the same proportion for all levels of q. As CMD is caused by virus and not pests, preventing it using labor is usually more difficult. In addition, CMD is an insidious disease, so that yield is lost little by little over long years (Thresh et al. 1994) possibly because infected planting materials tend to be disseminated among farmers (Swanson and Harrison, 1994). It is thus difficult for farmers to identify infected plants and therefore increasing labor inputs does not significantly reduce the losses[7]. In such cases, the loss from CMD increases as labor use increases. Marginal productivity of labor from GM CMD-resistant cassava may increase by relatively equal proportions at all levels of q, and thus, MC is lowered by equal proportions at all levels of q. Introduction of GM CMD-resistant cassava may lead to pivotal shift in MC curve.

Conventional EDM and Alternative EDM

The market-clearing conditions for the EDM can be expressed as

$$S_i = S_i(p_i, \tau_i, T_i, k_i; z_i) \tag{4}$$

$$D(p) = D_m(p) + \Sigma_i H_i(p_i, \tau_i, T_i) \tag{5}$$

$$\Sigma_i S_i(p_i, \tau_i, T_i, k_i; z_i) = D(p) \tag{6}$$

in which cassava production by a group i of producers (S_i) is a function of price at the market i which group i trades cassava (p_i), market margin between the farmgate price and market i (τ_i), market margin between price in market i and national average of market prices ($T_i = p_i - p$), the level of productivity growth k_i expressed as percentage reduction in production costs measured at the initial equilibrium times the percentage of producers adopting GM cassava among group i, and other production factors z_i. The aggregate cassava demand D by all consumers consists of demand by producers themselves (H_i) and by the rest of the consumers who do not produce cassava (non-cassava producers) (D_m). Supply curve S_i in the presence of nonzero τ_i is similar to the line in Figure 3 of Key, Sadoulet, and de Janvry (2000) in which supply becomes perfectly inelastic to price when the market price is in the range between 2 τ_i. In our case, H_i also has negative slope with perfectly inelastic range, and both S_i and H_i are vertically shifted up by T_i.

Given S_i , H_i and initial production, consumption and price level, we measure the Marshallian surplus for the cassava-producing households in the following way.[8] Let us

[7] If using more labor can mitigate the loss from disease, shift in production function may be more convergent and consequently, a shift in MC curve may be less divergent (parallel or convergent in certain range, particularly around the initial equilibrium).

[8] The Marshallian demand curve can be estimated with less information, like income elasticity, than can the Hicksian demand curve (Alston, Norton, and Pardey, 1998). The welfare effects using the Marshallian demand curve are biased, because it ignores the income effect caused by cassava productivity growth. However, Alston and Larson (1993) argue that bias may be larger from using the Hicksian demand curve if the Hicksian demand curve is recovered using empirically estimated elasticities which often contain errors.

define Q_i* as Q_i* = max[S_i, H_i]. Q_i* = S_i for a cassava-selling household, Q_i* = H_i for a cassava-purchasing household, and Q_i* = S_i = H_i for an autarkic household. The welfare for a cassava-producing household i (W_i) can be expressed as

$$W_i = \int_0^{Q_i^*} \left\{ \max\left[H_i^{-1}(q), p_i - \tau_i\right] - \min\left[S_i^{-1}(q), p_i + \tau_i\right] \right\} dq \tag{7}$$

in which H_i^{-1} (D_i^{-1} for non-cassava producers) is the inverse demand function and S_i^{-1} is the inverse supply function.

The expression max[$H_i^{-1}(q)$, $p_i - \tau_i$] – min[$S_i^{-1}(q)$, $p_i + \tau_i$] measures the maximum possible net benefit a cassava producer can derive from the q-th unit of cassava at hand. Because a cassava producer has Q_i* of cassava from which he can derive net benefit, his total welfare can be measured by integrating max[$H_i^{-1}(q)$, $p_i - \tau_i$] – min[$S_i^{-1}(q)$, $p_i + \tau_i$] up to Q_i*.

The productivity growth through GM affects Q_i*, p_i, $S_i^{-1}(q)$. Therefore, by extending the notation, $g \in$ [GM, No GM],

$$W_i^g = \int_0^{Q_i^{*,g}} \left\{ \max\left[H_i^{-1}(q), p_i^g - \tau_i\right] - \min\left[S_i^{-1,g}(q), p_i^g + \tau_i\right] \right\} dq \tag{7'}$$

in which subscript g indicate each function or values with GM or with No GM. The welfare effect for producer group i (ΔPW_i) is therefore

$$\Delta PW_i = W_i^{GM} - W_i^{NoGM} \tag{8}$$

and the welfare effects for non-cassava producers, (ΔCS) is

$$\Delta CS = \int_{P^{\text{GM}}}^{P^{\text{No GM}}} D_m(p)dp \tag{9}$$

Two EDM, CEDM and AEDM differ in the following ways; in CEDM, all functions S_i, H_i and D are in linear forms with slope determined by the elasticity at the initial equilibrium, market margins are zero (τ_i = T_i = 0) and the productivity growth is expressed by parallel vertical shift of S_i by k_i times initial equilibrium price. In AEDM, all functions S_i, H_i and D are in constant elasticity forms, τ_i and T_i are non-zero, and the productivity growth is expressed as shifting S_i down by k_i*100 percent pivotally around the origin.

In CEDM, thanks to the aforementioned assumptions, the welfare effects for producers (ΔPW) and consumers (ΔCS) can be expressed in closed form as (Qaim, 2001)

$$\frac{dp}{p_0} = \frac{\sum_{i=1}^{I} \varepsilon_i \delta_i k_i}{\eta - \sum_{i=1}^{I} \varepsilon_i \delta_i} \tag{10}$$

$$\Delta PW = p_0 \sum_{i=1}^{I} \left[S_i \left(\frac{dp}{p_0} + k_i \right) \left(1 + 0.5\varepsilon_i \left(\frac{dp}{p_0} + k_i \right) \right) - \frac{dp}{p_0} S_i h_i \right] \tag{11}$$

$$\Delta CS = -p_0 D \frac{dp}{p_0} \left(1 + 0.5\eta \frac{dp}{p_0} \right) - \left(-dpD \sum_{i=1}^{I} \left(h_i \delta_i \right) \right) \tag{12}$$

in which p_0 is the initial equilibrium price, ε_i is price elasticity of production (not marketed surplus) by producer i, η is price elasticity of demand (including home consumption), h_i is proportion of home consumption to production by i, δ_i is the proportion of production by i to total production, and dp is the change in equilibrium price. Total welfare effect (ΔTotal) is simply ΔTotal = $\Delta PW + \Delta CS$.

CEDM is also restricted in the following aspects. First, estimates from CEDM are proportional to p_0 (formulas (11) and (12)). Because plant breeding research is often justified based on the total benefit, the level of p_0 is critical in estimating welfare effects using EDM. Literature using CEDM generally uses farmgate prices reported by secondary sources like the Food and Agriculture Organization (FAO) or local governments as p_0 (Qaim 1999, 2001) or the average of the reported farmgate and wholesale prices (Andreu et al., 2006). The information of p_0 is, however, less accurate or simply unavailable for some developing countries and commodities.[9] For example, the estimation of p_0 for cassava is particularly difficult, because cassava is rarely traded outside the country and no border price exists as it does for crops like maize. In this article, p_0 in CEDM is estimated as the weighted average of the farmgate price for each producer group i weighted by their production reported in the dataset.

Second, when k_i is the same for all i, and $\varepsilon_d < 0$ and $\varepsilon_{si} > 0$, then CEDM tends to estimate more positive ΔPW_i for producers with larger production S_i (Appendix B). As shown in the simulation, AEDM may be less affected by the restrictions mentioned here, though it may be rather difficult to generalize the results.

As was mentioned briefly above, AEDM assumes a supply curve in constant elasticity form, which avoids the problem of zero MC for positive production quantity. Any linear supply curve with elasticity less than unity measured at the initial equilibrium has zero MC for up to some positive production quantity. By design, if elasticity is less than 1, pivotal shift provides more conservative estimates than parallel shifts (Voon and Edwards, 1991). In addition, the productivity growth is expressed as a pivotal shift in supply curve for several reasons. First, a pivotal shift in a constant elasticity supply curve assumes a proportional reduction in MC at each production quantity. For biological or yield-increasing productivity growth that does not require additional input, such as GM cassava, a proportional reduction in marginal cost may be realistic, because for each unit of output, a farmer reduces the input by the same proportion (Lindner and Jarrett, 1978; Rose, 1980). Second, farmgate price levels often differ across cassava farmers, and assuming the same reduction in MC through parallel shift in thesupply curve for all producers is questionable because the reduction in MC can be greater than the initial level of MC for some producers who have relatively low MC at the initial equilibrium production level.

Significant margins are reported to exist both between the farmgate price and the local consumption market price and among the various consumption markets within Africa (Barrett, 2008). AEDM incorporates positive market margins between the farmgate sales price and the consumption market price ($\tau_i > 0$) and between consumption

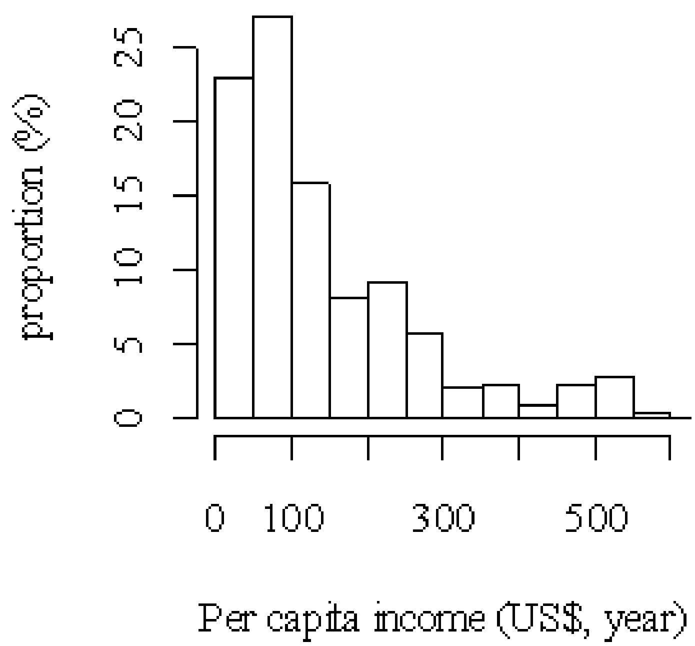
[9] For example, the FAO does not provide producer prices for cassava for Benin but does for Côte d'Ivoire, Ghana, Nigeria, and Togo.

market price ($T_i = p_i - p_0 \neq 0$). The AEDM keep these market margins constant and exogenous to productivity growth as is suggested in Alston, Norton, and Pardey (1998). The assumption of such a constant market margin is consistent with the relatively efficient inter-market price transmissions in West Africa for agricultural commodities (Kuiper, Lutz, and Tilburg, 1999; Badiane and Shively, 1998).

Empirical Application and Model Comparison

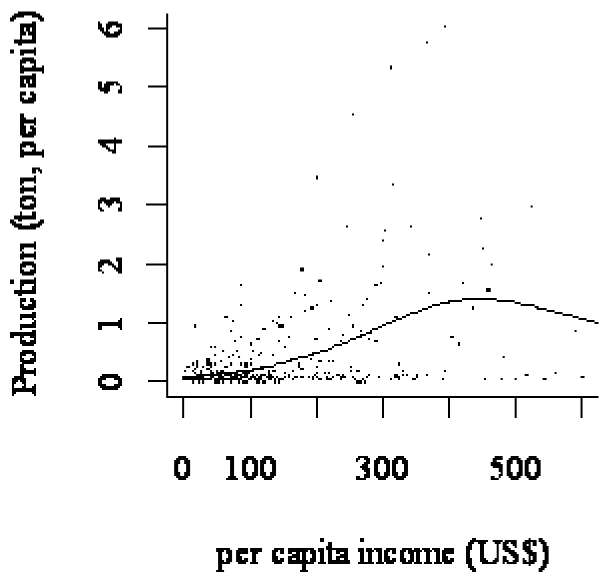
We now conduct a welfare effects estimation using both CEDM and AEDM for a hypothetical introduction of GM cassava in Benin. We then examine how the two EDMs provide different estimates of welfare effects and determine whether the two EDMs indicate differently how the welfare gains are distributed across cassava producers with different income levels.

In Benin, approximately 0.85 million tons of cassava was produced in 1997 when the Benin dataset was collected, among which around 20% were consumed by cassava producers themselves and the remaining 80% were consumed by the non-cassava producers. The majority of cassava producers belong to the lower income class, with almost 50 percent of them living under US$100 per capita (Figure 2), with lower income producers producing smaller quantity (Figure 3).



Source: IFPRI (2004)

Figure 2. Proportion of population in cassava-producing households.

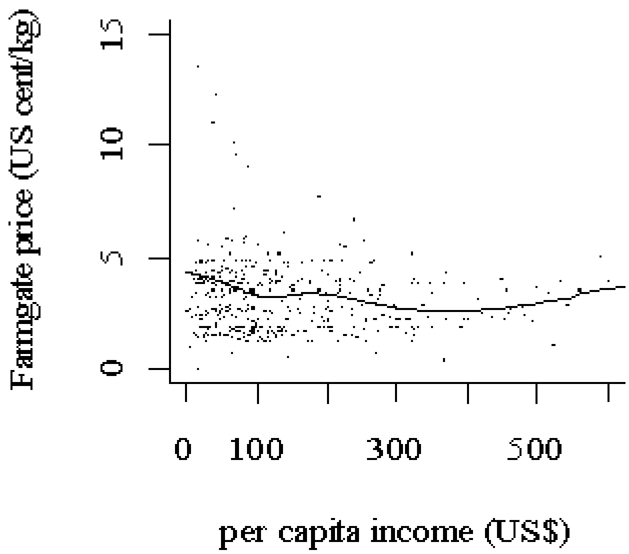


Source: IFPRI (2004) and Author.

Figure 3. Production (ton/per capita, year) by income level.

Structure and Calibration of the Models

Many recent studies using EDM deal with the uncertainty in market structures, such as supply-and-demand elasticities, by adding idiosyncratic errors to its structural parameters (Davis and Espinoza, 1998; Zhao et al., 2000). Although the choice of error terms can be arbitrary, a common approach is to use the standard deviation associated with parameters estimated in previous studies. This article therefore assigns distributions to the elasticities of production, home consumption, consumption by non-cassava producers, farmgate price and market margins based on their estimated values and standard errors. Based on the estimates from Takeshima (2008), the elasticity of cassava production and home consumption are given the truncated normal distribution with mean 0.156 and -0.578 with standard errors 0.126 and 0.162, with truncation at zero to avoid illogical signs. The elasticity of cassava consumption by non-producer is less certain, as Benin dataset does not have the information for them. This article therefore assumes the elasticity of consumption by non-cassava producers to be uniformly distributed between -0.91 (Deaton (1988) in Côte d'Ivoire) and -0.46 (Tsegai and Kormawa (2002) in Nigeria). The farmgate sales price, consumption market price and market margins between farmgate as well as between consumption markets for farmers not reporting them are estimated by the data from those who reported them (Appendix C). In the simulation, the empirically estimated standard deviations of the predicted farmgate sales price as well as market margins are also used. Estimated prices and margins vary widely (Appendix C), indicating that the welfare effects are highly heterogeneous across farmers. The lower income cassava producers tend to receive slightly higher farmgate price (Figure 4) possibly because of their proximity to the consumption market.



Source: IFPRI (2004) and Author.

Figure 4. Median of the estimated farmgate price (US cent/kilgram, fresh tuber) by income.

Percentage reduction in production costs depends on many factors. The development of GM cassava for Benin seems to be lagging behind some other African countries whose data is not available. Studies of cassava in other African countries provide some insights into the expected yield growth of several varieties of cassava (30 percent for virus-resistant cassava in Uganda,[10] while loss due to virus is up to 60 percent in Ghana (Horna, Smale, and Falck-Zepeda, 2007)). Assuming that the average loss in cassava yield in Ghana is 30 percent (which is the midpoint of 0 percent and 60 percent), a similar reduction in cost for a virus-resistant variety of cassava in Benin should be around 30 percent.

Unlike other ex-ante studies, the expected adoption path over time is simplified in this article as the purpose of this article is more to compare the estimates from CEDM with those from AEDM. Including an adoption trend may add more uncertainty to each model, making it more difficult to interpret the difference between CEDM and AEDM. More specifically, the adoption rate of GM variety is assumed to reach 100 percent in one year. This article also shifts out the demand curve horizontally by 2.5 percent which is Benin's population growth rate, from the initial demand curve, as suggested by Norton, Ganoza, and Pomareda (1987). Although the assumption of reaching 100 percent in one year may be unrealistic, it is also true that many studies also apply rather arbitrary discount factors for welfare gains when assuming specific adoption path over multiple

[10] Based on conversations at the Donald Danforth Center in Saint Louis, which spearheads the research in the development of GM cassava.

years. From these perspectives, assuming a 100 percent adoption rate in one year may not be so problematic, particularly where the comparison of CEDM with AEDM is concerned.

CEDM and AEDM are then compared to assess how the estimates from CEDM deviate from AEDM, how significant the bias is given the accuracy of parameters used to calibrate both models, and what the implications are for pro-poorness suggested by the two models. The simulation is programmed using statistical software R version 2.7.0, an open-source software developed by R Development Core Team. We have run 1,000 simulations, each of which uses different combinations of parameters drawn from the distributions specified above.

Results and Interpretations

The main results are summarized in Table 1. Table 1 shows the percentiles of estimated welfare effects from CEDM and AEDM for producers and non-producers. Table 1 says that the total welfare effects estimated by AEDM (ΔTotal_A) are above \$4.1 million for 50 percent of the time; and between \$1.5 million and \$12.8 million for 95 percent of the time, while those by CEDM (ΔTotal_C) are much higher. Similarly, the estimated welfare effects for non-cassava producers are significantly smaller in AEDM than with CEDM. Those for producers are similar in value between AEDM (ΔPW_A) and CEDM (ΔPW_C) (Table 1).

Table 1. Estimated welfare effects for each population group (million US\$)

Percentile	2.5%	**50%**	97.5%
		ΔTotal	
CEDM	13.8	**16.6**	20.1
AEDM	1.5	**4.1**	12.8
		Δ*CS*	
CEDM	9.9	**14.3**	21.7
AEDM	0.2	**1.8**	3.3
		Δ*PW*	
CEDM	-3.5	**3.0**	5.4
AEDM	0.2	**2.1**	10.4

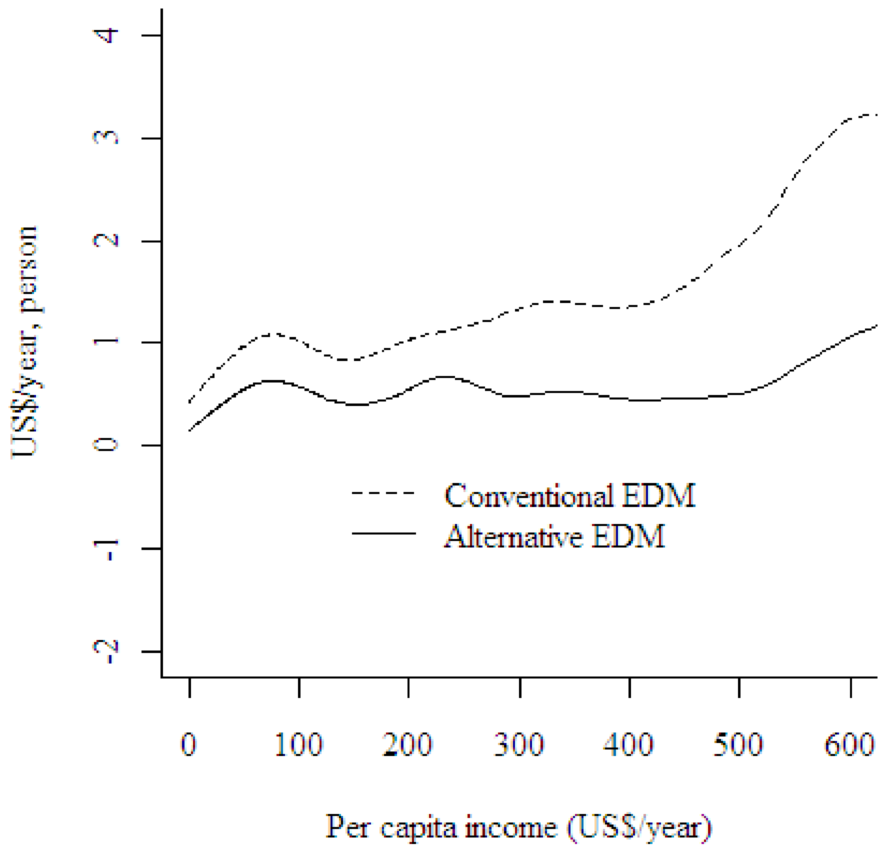
Note: US\$1 = 588 FCFA (Franc Communauté Financière Africaine) on July 1997.
Source: Author.

Three main results are of our interest. First, the difference in the estimates of total welfare effects () is sizable and robust across possible range of structural parameters. Because Benin's GDP in 1998 was approximately \$2 billion (World Bank), the ΔTotal_C and ΔTotal_A at the median are roughly 0.8 percent or 0.2 percent of GDP. The results indicate that at the median level, the difference between CEDM and AEDM can be significantly large and may lead to serious policy implications. In addition, it was found that more than 99 percent of the time, $\Delta \text{Total}_C > \Delta \text{Total}_A$. ΔTotal_C may be larger than ΔTotal_A in part because, as was mentioned by Voon and Edwards (1991), the constant elasticity form with pivotal shift often leads to more conservative estimates than are achieved with the linear form, and thus it may be predictable. The particular result obtained here is, however, still important, because how ΔTotal_C compares with ΔTotal_A depends on the empirically estimated structural parameters and their accuracy. The fact that ΔTotal_C is larger than ΔTotal_A with such a high probability provides one reason for why policy implications based only on CEDM may not be reliable and that a model such as AEDM should also be considered.

Second, the difference between ΔPW_C and ΔPW_A is smaller, as opposed to the differences in estimated welfare effects for total population and for non-cassava producers. One reason for the relatively high ΔPW is that given the same level of proportional reduction in marginal cost at the initial equilibrium, the drop in price is relatively smaller in AEDM (3.5% of the initial national average price at the median level compared to 24.9% in CEDM). Given the fact that cassava producers tend to belong to the lower income group than non-cassava producers and total population, the first and second results together indicate that GM cassava is more pro-poor when assessed under AEDM than CEDM.

Third, in AEDM, lower-income cassava producers tend to benefit relatively more compared to higher-income cassava producers. Figure 5 plots the 50th percentile of ΔPW for producers estimated from the two EDMs to see how each estimate provides different implications of how welfare gains are shared across different income levels. Figure 5 indicates that, although AEDM generally estimates slightly lower ΔPW for all producers than CEDM, AEDM indicates that the benefit for lower income cassava producers may be higher than does CEDM. Although complicated, some insights are gained by the consequences of CEDM discussed above, and how relevant characteristics of cassava producers vary across different income levels. Lower-income cassava producers in Benin tend to produce less and face higher farmgate prices (Figures 3 and 4). Earlier discussions indicated that ΔPW in CEDM tends to be more positive for cassava producers with larger production and home consumption quantities. In addition, because CEDM assumes only one price, and ΔPW in CEDM uses the relative change in equilibrium price dp/p for all types of producers, CEDM may overstate dp/p for cassava producers who have a relatively higher farmgate price when dp is the same for all producers. Thus, CEDM may underestimate the welfare gains for producers who currently face higher farmgate prices. The characteristics of lower-income cassava producers indicate that although AEDM is likely to lead to less positive welfare gains for most of the population than is CEDM, the distribution of gains suggested by AEDM. Combined with the first and second results, the third results again support that CEDM and AEDM lead to different implications of whether GM cassava in Benin is pro-poor.

Overall, the results suggest that CEDM can lead to significantly large biases in estimated total welfare gains and the wrong interpretation of the pro-poorness of cassava productivity growth as compared with AEDM, as AEDM is considered more accurate. It is also important to note that aforementioned different implications are obtained between CEDM and AEDM under fairly simple assumptions of characteristics of productivity growth, including but not limited to 100 % adoption rate and uniform productivity growth across adopters.



Source: Author.

Figure 5. Median welfare effects for producers in different income levels (CEDM and AEDM) (Smoothing spline with $\lambda = 0.01$).

The difference in the implications between CEDM and AEDM can be potentially larger if the adoption speed and productivity growth are assumed to vary across farmers. Although estimation through the AEDM requires more time and work, it is much stronger than CEDM in maintaining richness in the heterogeneity across producers, such as varying marketing margins, farmgate cassava prices, and initial distribution of incomes, and providing more accurate estimation of welfare gains and implications in pro-poorness of cassava productivity growth. While the particular results of this article apply only to the case of cassava market in Benin, the results still underscore the importance of more careful welfare effects estimations such as by AEDM than CEDM, particularly when the interest is in how the gains from productivity growth is distributed across different population groups and whether it is pro-poor.

Summary and Conclusion

Although CEDM has been commonly used for ex-ante welfare effects estimation on biological productivity growth in agriculture because of its parsimony, CEDM employs various unrealistic assumptions. Even in relatively competitive and efficient markets, the questions of linear supply curve and its parallel shift as representation of productivity growth are often challenged in the literature as unrealistic and inappropriate for biological productivity growth. An increasing number of studies apply CEDM to the case of scale-neutral productivity growth such as GM technologies for semi-subsistence crops in SSA, which raise two additional types of concerns. First, despite the common use of CEDM in ex-ante welfare effects estimations, little has been studied about the consequence of its various unrealistic assumptions. Second, the assumptions under CEDM, linear supply curve, productivity growth represented by parallel shift in the supply curve, and no market margin may jointly become more problematic if our interest is in the distribution of welfare gains from semi-subsistence crops like cassava, whose productivity growth is often justified by its pro-poor nature.

This article provides an example of how the welfare effects estimated by CEDM differ from those by more realistic AEDM, with particular focus on the distribution of such effects across producers and non-producers, as well as producers with different income levels. The findings suggest that CEDM may often provide significantly biased welfare gain estimates in terms of total size, and incorrect implications about whether such productivity growth is pro-poor. The results and discussions in the previous section indicate that the use of AEDM may be recommended over CEDM when there are good reasons to believe that the supply curve is in constant elasticity and is inelastic rather than linear, and when the nature of technology is better represented by the pivotal shift rather than the parallel shift. In addition, the use of AEDM may be recommended over CEDM when the market margins are significantly large and the relationship between the farmgate price of commodity for each producer and each producer's income level is somewhat correlated, and distribution of gains is of more important information than the aggregate gains. This is because AEDM can better translate such information into an assessment of the pro-poorness of the productivity growth at issue. Although the properties of both CEDM and AEDM still need to be more carefully analyzed, the results seem to support the accuracy of AEDM over parsimony of CEDM, particularly when analyzing the potential of public research into semi-subsistence crops like cassava as a tool for pro-poor growth in SSA countries.

Appendix A:

As was mentioned above, when only labor is used, we have MC $=\pi_L^* \cdot \dfrac{1}{f_L}$, or MC $\cdot f_L = \pi_L^*$. Since MC measures the foregone income, we have $u' \cdot \text{MC} \cdot f_L = u' \cdot \pi_L^*$. With risk on the right hand side, we have $u' \cdot \mathrm{MC} \cdot f_L = E\left[u' \cdot \pi_L^*\right] = E[u']E\left[\pi_L^*\right] + \mathrm{cov}\left[u', \pi_L^*\right]$, or $\mathrm{MC} = \left\{E\left[\pi_L^*\right] + \mathrm{cov}\left[u', \pi_L^*\right] / E[u']\right\} \cdot \dfrac{1}{f_L}$, which is equation (2).

Appendix B: Important Properties of Conventional EDM

We first start with formula (10). When $k_i = K$ for all producer groups, formula (10) can be modified as

$$\frac{dp}{p_0} = \frac{\sum_{i=1}^{I} \varepsilon_i \delta_i k_i}{\eta - \sum_{i=1}^{I} \varepsilon_i \delta_i} = \frac{\sum_{i=1}^{I} \varepsilon_i \delta_i}{\eta - \sum_{i=1}^{I} \varepsilon_i \delta_i} K \tag{10'}$$

When $\eta < 0$ and $\varepsilon_i > 0$, we have $-1 < \dfrac{\sum_{i=1}^{I} \varepsilon_i \delta_i}{\eta - \sum_{i=1}^{I} \varepsilon_i \delta_i} < 0$, or $-K < \dfrac{dp}{p_0} < 0$ from (10') because $\delta_i \geq 0$ and $\sum_{i=1}^{I} \varepsilon_i \delta_i > 0$. Therefore, we have $\dfrac{dp}{p_0} + K > 0$. For producer group i, the expression of ΔPW_i in (11) can be rewritten as

$$\Delta PW = p_0 S_i \left[\left(\frac{dp}{p_0} + k_i\right)\left(1 + 0.5\varepsilon_i\left(\frac{dp}{p_0} + k_i\right)\right) - \frac{dp}{p_0} h_i\right] \tag{11'}$$

In (iv'), because $dp < 0$, p_0, S_i, ε_i, $h_i > 0$, we have (iv') > 0 and a larger S_i leads to a larger ΔPW_i.

Appendix C: Estimation of Farmgate Price and Market Margins

In the Benin dataset, not all farmers report the farmgate sales price of cassava, and the price margin between farmgate and relevant market. This article follows Vakis, Sadoulet, and de Janvry (2003) to predict the farmgate sales price (p_i - τ_i) and τ_i for all cassava producers. More specifically, we first run regressions for those farmer groups i who report the farmgate sales price or margin between farmgate and market,

$$\ln(\text{farmgate sales price}) = x_i^f \beta^f + u_i^f \tag{13}$$

$$\ln(\text{margin between farmgate and market}) = x_i^\tau \beta^\tau + u_i^\tau \tag{14}$$

in which x_i^f and x_i^τ are exogenous factors assumed to affect the farmgate sales price and τ_i, respectively. We then obtain the predicted values of the farmgate sales price and τ_i for those who did not report them, as

$$p_i - \tau_i = \exp\left(x_i^f \beta^f\right) \tag{15}$$

$$\tau_i = \exp\left(x_i^\tau \beta^\tau\right) \tag{16}$$

The results of regression are shown in Table 2, while the distribution of the farmgate sales price, market margin and market prices are presented in Table 3. Variables for the farm gate price estimation include a regional dummy (region 2 - 6), the form of cassava for which price was reported (fresh tuber, flour or dried tuber), months of price recorded, geographical conditions (distance to paved road, passable road), and whether the price reported is the average of the farmgate and market price. Variables for the market margin include the distance to phone, square root of distance to the sales point, whether the farmer belongs to the cooperative, and level of education. When estimating the predicted value for farmgate price, month of price recorded was dropped so that the predicted price is that in December, and the farmgate price is also standardized for fresh-tuber equivalent.

Table 2. Regressions (13) and (14)

Predicted variable	Regression (13) $\ln(p_i - \tau_i)$		Regression (14) $\ln(\tau_i)$	
	Coefficient	Std.err	Coefficient	Std.err
Region 2	.076	(.383)		
Region 3	–.328	(.497)		
Region 4	.619	(.379)		
Region 5	.503	(.394)		
Region 6	.437	(.362)		
Fresh-tuber (yes = 1)	–.646***	(.193)		
Flour (yes = 1)	1.116***	(.208)		
Dried tuber (yes = 1)	.026	(.309)		
January	.139	(.157)		
February	–.366***	(.116)		
March	.189	(.119)		
April	–.171	(.121)		
May	–.079	(.127)		
June	.157	(.173)		
July	–.175	(.200)		
August	–.063	(.174)		
September	–.048	(.291)		
October	–.068	(.239)		
November	–.503	(.326)		
Distance to paved road (10km)	–.003	(.009)		
Distance to passable road (10km)	–.006	(.007)		
Distance to phone (10km)			1.483	(3.219)
Price mixed at farmgate and market (yes = 1)	.203*	(.109)		
$\sqrt{\text{Distance to sales point (10km)}}$			.309***	(.088)
Membership to cooperative (yes = 1)			–.460	(.307)
Household head education (year)			–.061	(.050)
Constant	3.397***	(.409)	.702**	(.336)
R^2	.708		.387	
Number of observations	192		53	

Note: Triple asterisk (***), double asterisk (**) and asterisk (*) denote variables significant at 1%, 5% and 10% respectively.

Table 3. Summary statistics of estimated prices, per-unit transaction cost (US cents/kilogram, fresh-tuber)

	Mean	Median	Min.	Max.
Farmgate sales price	5.22	3.47	0.28	40.09
Consumption market price	12.92	5.49	0.55	119.94
Market margin between farmgate and market	7.70	1.01	0.16	118.58

Source: IFPRI (2004) and Author.

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FOREIGN DIRECT INVESTMENT INFLOWS TO LATIN AMERICA AND THE CARIBBEAN: REMITTANCES AND MARKET SIZE

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Abstract

This paper investigates the effect of remittances in attracting foreign direct investment (FDI) to Latin America and the Caribbean (LAC). We use an unbalanced panel data set for fourteen LAC countries covering the period 1983-2003. Our results indicate a positive and significant impact of remittances on net FDI inflows to LAC, but it depends upon the level of per capita GDP in the host economy. Thus, a threshold of per capita GDP is needed for a LAC economy to benefit from the positive effect of remittances on net FDI inflows. In addition, host country demand positively influences net FDI inflows to LAC, which supports the market size hypothesis.

JEL Classification: F21, F23, F24, O54

Keywords: Foreign direct investment, Remittances, Market size, Latin America and the Caribbean

1. Introduction

Global Foreign Direct Investment[1] (FDI), as part of the world economic integration, has increased dramatically since the late 1980s. In developing countries, FDI has become one of the most important sources of development finance. FDI is associated with

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[1] The International Monetary Fund defines FDI as an investment that represents at least 10 percent of voting stocks in an enterprise operating in a country other than that of the investor. In this study, FDI is net inflows of foreign direct investment as a share of host country GDP and represents at least 10 percent of voting stock, and it is the sum of equity capital, reinvestment of earnings, and other long term and short term capital.

economic growth, so the adoption of policies aimed at attracting FDI in host countries[2] is not surprising. Positive relationships between FDI and growth are reported in Bengoa and Sanchez-Robles (2003), Campos and Kinoshita (2002), Hansen and Rand (2006), Li and Liu (2005), and Oliva and Rivera-Batiz (2002). Latin America and the Caribbean (LAC), among developing regions, has received remarkable increases in FDI inflows since the late 1990s. FDI inflows to LAC were US$27.5 billion for the period from 1992 to 1996, US$76.9 billion for the period from 1997 to 2001, US$61.0 billion for the period from 2002 to 2006 (Economic Commission for Latin America and the Caribbean [ECLAC], 2007), and US$105.9 billion in 2007 (ECLAC, 2008). The impressive increase in FDI and the benefits it drives in has motivated the study of the factors that affect its location.

The literature on the determinants of FDI is extensive. Among the issues studied are the effects of exchange rate on FDI (Barrel & Pain, 1996; Cushman, 1985, 1988; Pain, 2003); the relationship between labor costs and FDI (Culem, 1988; Cushman, 1987; Love & Lage-Hidalgo, 2000); the relationship between political factors and FDI (Haggard, 1989; Nigh, 1985; Tuman & Emmert, 2004); the effect of trade issues such as openness, trade protection and trade agreements on FDI (Agosin & Machado, 2006; Barrel & Pain, 1999; Waldkirch, 2003); and the relationship between host country market size and FDI (Barrel & Pain, 1996; Love & Lage-Hidalgo, 2000). Interestingly, many of these determinants are host country characteristics, of which market size has been one of the most influential on FDI location.

Host country market size represents the level of demand for goods and services in an economy. In the literature, the relationship between market size and FDI is usually identified as positive (Bajo-Rubio & Sosvilla-Rivero, 1994; Barrel & Pain, 1996; Billington, 1999; Culem, 1988; Cushman, 1985, 1988; Gopinath, Pick & Vasavada, 1999). It seems that economies with a larger market will be more attractive to foreign investors. Fedderke and Romm' (2006) study on the determinants of FDI into South Africa suggests augmenting market size as a strategy to attract FDI.

Measures of either gross domestic product (GDP) or gross national product (GNP) are the usual proxies for host country market size. These variables are used to capture the effect of the host country's income on FDI, so an increase in, for example, per capita GDP will increase the market size for the goods and services produced by multinational firms' (MNF) subsidiaries. However, Dornbush and Fisher (1994, p.59) argue that it is not just the level of output (GDP) that is related to consumption demand, but the money available for spending.

Workers' remittances[3] have become a very important source of external financing for many developing countries. In these countries, remittances are second to FDI as a source of external financing (World Bank, 2007, p. 54). Moreover, remittances increase the incomes of the recipient individuals. Among developing regions, the LAC region has been the largest recipient of recorded remittances (World Bank, 2007, p. 54). Hence, it is

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[2] A host country is a country that receives FDI inflows.

[3] Remittances comprise workers' remittances, compensation of employees and migrants' transfers received by individuals in a LAC country. In this study, the remittance measure represents the sum of these three items as a share of host country GDP.

likely that remittances may affect FDI inflows to LAC countries through increasing the amount of money available for spending.

There have been a large number of studies about the determinants of FDI. However, to our knowledge, there is no previous empirical research that has assessed the effect of remittances and market size on FDI. By investigating about this relationship, this paper contributes to the literature on FDI and market size. The purpose of this study is to empirically assess the effect of remittances through per capita GDP on net FDI inflows to LAC. To accomplish this task, we follow Bajo-Rubio and Sosvilla-Rivero's (1994) cost minimization approach to derive the MNF's optimal level of capital at the foreign plant.

We assess the effect of remittances on net FDI using an unbalanced panel data set for 14 LAC countries[4] which covers the period from 1983 to 2003. The econometric method used is panel generalized method of moments (GMM). Our results suggest that remittances have a positive overall effect on net FDI inflows to LAC, but only for countries in which per capita GDP is above a certain threshold. This also suggests a complementary effect of remittances and per capita GDP on net FDI inflows. Additionally, per capita GDP has a positive and significant effect on net FDI inflows.

The rest of the paper is organized as follows. Section 2 presents an overview of FDI and remittances in LAC. We then provide a review of the relevant FDI literature, followed by a description of the methodology and data. The next section presents a discussion of the results. Finally, conclusions and suggestions for further research are presented.

2. FDI and Remittances in Latin America and the Caribbean

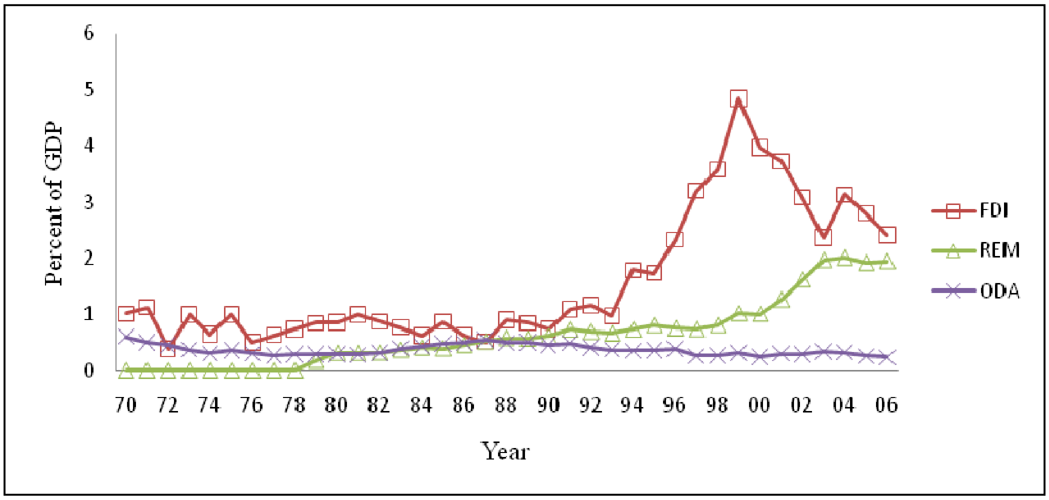
This section describes some interesting facts about FDI and remittances inflows to LAC. Figure 1 shows the evolution of net FDI inflows as a percent of GDP to LAC over the period from 1970 to 2006[5]. The first increase in net FDI inflows to LAC occurred during the period from 1977 to 1983 when LAC attracted 12 percent of global FDI (ECLAC, 2005, p.30). The second half of the 1990s shows a big surge of net FDI. At the same time, the service sectors in Brazil and in Central America and the Caribbean countries attracted large amounts of FDI (ECLAC, 2000). In Mexico, liberalizations of FDI policy regulations during the 1990s as well as the signing of the North American Free Trade Agreement (NAFTA) in 1994 were fundamental to the increase in FDI (ECLAC, 2001). Furthermore, the LAC region's economic reforms[6] of the 1990s largely influenced the boost of FDI to LAC during this decade (ECLAC, 2002, p. 37).

4 The fourteen countries included in this analysis are Barbados, Brazil, Colombia, Costa Rica, The Dominican Republic, Ecuador, Guatemala, Honduras, Jamaica, Mexico, Panama, Peru, Trinidad and Tobago, and Venezuela.

5 Figure 1 and 2 represent the countries in Latin America and the Caribbean as grouped by the World Bank, not just the 14 countries considered in this study.

6 For example, trade liberalization, liberalization of the mining and the hydrocarbon sectors, liberalization of the banking sector, privatization of public sector enterprises, and revitalization of regional integration processes.

Figure 1 also shows a decline in net FDI inflows to LAC during the period from 2000 to 2003. This decline was influenced by the slowdown of the world economy, the United States (U.S.) recession, the end of the privatization process, and the political and economic instability in Argentina, Venezuela, Bolivia, Ecuador, Colombia and Peru (ECLAC, 2002). At the same time, the reduction of U.S. demand and the revaluation of the Mexican peso hindered FDI inflows to Mexico, Central America, and the Caribbean (ECLAC, 2003). Additionally, ECLAC (2004, p. 29) reports that during the period from 1996 to 2002 57 percent of FDI inflows to LAC went to the service sector, 28 percent to manufacturing, and 15 percent to the primary sector, but since 2001 FDI in services started to decline.



Source: Own calculations using data from the World Development Indicators, online version, 2007.

Figure 1. Net FDI, remittances and ODA inflows as percent of GDP to LAC, 1970-2006

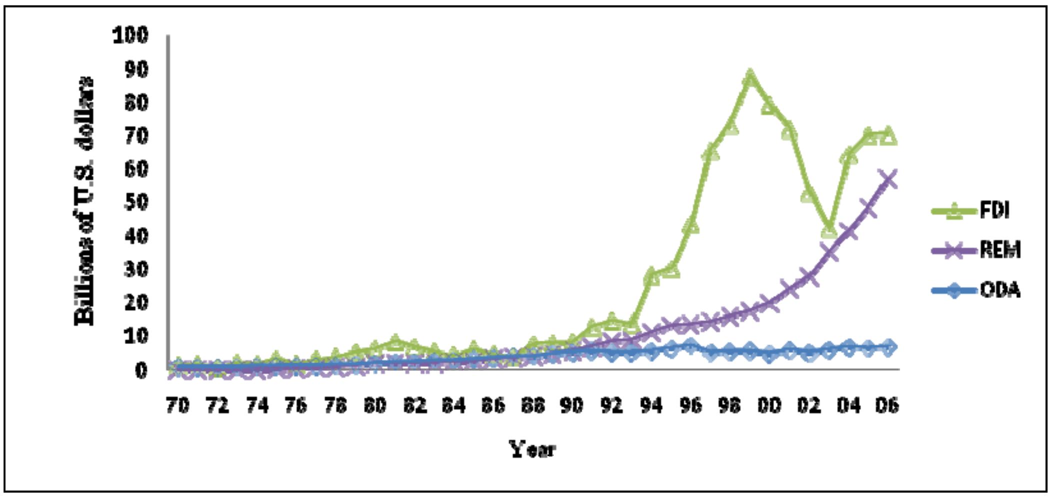
Net FDI inflows to LAC started to recover in 2004 (Figure 1). Even though net FDI inflows as a percent of GDP started to fall in 2005, net FDI inflows in billions of U.S. dollars continued the upward trend that started in 2004 (Figure 2). Among the factors contributing to this recovery were improved economic conditions and large corporate acquisitions, increased Mexican maquila activity due to the recovery in U.S. demand, as well as larger FDI inflows to Brazil[7], Chile, Colombia and Argentina (ECLAC, 2005). The increase of FDI inflows to Brazil was promoted by the rise in Brazil's domestic demand and the achievement of some important fiscal targets (ECLAC, 2004).

Furthermore, economic growth in the U.S. and in the LAC region, an increased demand for the LAC region's natural resources, and the increase in merger and acquisition transactions also contributed to the recovery of FDI in LAC (ECLAC 2006, p. 21). Also, The Dominican Republic-Central America-United States Free Trade Agreement (DR-CAFTA) that was signed in 2005 encouraged FDI in the banking and telecommunication sectors (ECLAC, 2007), as well as in the clothing sector (ECLAC,

[7] Brazil received US$18.2 billion out of the US$34.1 billion of FDI inflows to South America in 2004.

2008). ECLAC (2008, p. 25-26) also reports FDI inflows to LAC of US$105.9 billion for the year 2007, the largest amount since 1999.

Another important source of external financing in LAC is workers' remittances. LAC region has been the largest recipient of recorded remittances among developing regions and attracted US$53 billion in 2007 (World Bank 2007, p. 54). Total remittance inflows to LAC grew from US$5.7 billion in 1990 to US$57 billion in 2006 (World Development Indicators, 2007), a ten-fold increase. Figures 1 and 2 show that relative to net FDI and Official Development Assistance (ODA), remittances have become the second most important source of external financing in LAC, both in levels and as a percent of GDP. In addition, the International Monetary Fund (2005, p. 72) states that relative to non-FDI private capital inflows, exports, ODA and FDI, remittances inflows to developing countries showed a lower level of volatility over the period 1980-2003.



Source: Own calculations using data from the World Development Indicators, online version, 2007.

Figure 2**.** Net FDI, remittances and ODA inflows in billions of U.S. dollars to LAC, 1970-2006

3. Review of Literature

In this literature, market size represents the level of demand for goods and services in the host country, and it is usually proxied by a measure of either GDP or GNP. Most of this literature identifies market size as an important determinant of FDI. Cushman (1985) assesses the relationship between real exchange rate risk, expectations, and U.S. direct investment flows to five industrialized countries for the years 1963 through 1978 and finds, with one exception, a strong positive effect between foreign income and direct investment. Terpstra and Yu's (1988) analysis of the determinants of foreign investment of the twenty largest U.S. advertising agencies during the years 1972 and 1984 find host country GDP to have a significant positive effect on FDI. Bajo-Rubio and Sosvilla-Rivero (1994) study the determinants of FDI in Spain over the period from 1964 to 1989. Their results indicate the existence of a long-run relationship between real GDP and manufacturing and non-manufacturing FDI as well as for aggregate FDI. Barrel and Pain (1996) study the determinants of U.S. FDI over the period from 1971 to 1998. They use GNP level and GNP growth to proxy for host country's demand and find a significant and positive effect of host country's GNP on U.S. FDI. Billington (1999) analyzes the location of FDI both at the country level for seven industrialized countries and at the regional level for 11 regions of the United Kingdom. He reports that, at the country level, income and growth are among the significant determinants of FDI.

Recently, some research finds market size having a positive influence on FDI inflows. Blonigen and Davies (2000) assess the impact of bilateral tax treaties on both U.S. inbound and outbound FDI over the period from 1966 to 1992 and find positive and significant effects of host country's real GDP on outbound U.S. FDI. Gopinath et al. (1999) examine the determinants of U.S. FDI for the food processing industry in ten developed countries for the period 1982-1994 and find a significant positive effect of host country per capita GNP on U.S. FDI. Globerman and Shapiro (2002) investigate the effect of governance infrastructure on U.S. FDI in both developed and developing countries during the period from 1995 to 1997. They find real GDP to have a positive and highly significant effect on U.S. FDI. Li and Liu (2005) examine the relationship between economic growth and FDI on a panel of 84 countries over the period from 1970 to 1999. They use GDP as a proxy for market size in the FDI equation and estimate single equations of growth and FDI as well as a simultaneous equation system. Their results indicate, with one exception, significant positive effects of GDP on FDI.

Some of the literature about FDI in LAC also finds positive and significant effects of market size on FDI. Love and Lage-Hidalgo (2000) examine the determinants of U.S. FDI in Mexico for the period from 1967 to 1994 and find per capita GDP to have a significant positive effect on U.S. FDI. Lall, Norman and Featherstone (2003) study the determinants of U.S. FDI for a group of LAC countries over the period from 1983 to 1994. They find GDP, squared GDP and GDP growth to have significant and positive effects on FDI. Tuman and Emmert (2004) examine the political and economic determinants of U.S. FDI for a sample of 15 LAC countries over the period from 1979 to 1996. They show that the change in real per capita GDP has a positive and significant effect on U.S. FDI. Bengoa and Sanchez-Robles (2003) study the relationship between FDI, economic freedom and growth for 18 LAC countries during the period from 1970 to 1999 and report that GDP has a significant positive effect on FDI. Daude, Mazza and Morrison (2003) analyze the effects of core labor standards on bilateral FDI flows to 12 LAC countries from the U.S. and Japan during the period from 1989 to 2000. They find host country's GDP to have a significant and positive effect on FDI in ten out of 12 regressions.

Based on this literature review, it is likely that an increase in host country's GDP will increase FDI inflows. The literature also identifies GDP as host country's income which is used for acquiring goods and services; thus, an increase in host country income will raise the demand for goods and services. Moreover, under a growing aggregate demand new investments are required which promotes FDI by creating new investments and expanding existing ones as Culem (1988, p. 888) argues.

Remittances are an important source of external financing to developing countries as well as part of the recipient individuals' disposable income. Glytsos (2005) adds up remittances and GDP to construct a type of host country disposable income to capture the demand effect of remittances on consumption, investment and imports. He finds a significant positive effect of this country income on consumption. As such, it is likely that remittances raise the demand for goods and services in an economy through increasing disposable income. Therefore, it seems that remittances may raise host country's aggregate demand.

4. Methodology and Data

4.1. The model

The theoretical method used for the analysis of the net inflows of FDI to LAC follows Bajo-Rubio and Sosvilla-Rivero's (1994) cost minimization approach. It has been used in various studies of FDI (Love & Lage-Hidalgo, 2000; Marchant, Cornell, & Koo, 2002; Pain, 1993). The approach relates the undertaking of FDI by a multinational firm (MNF) to cost minimization and allows for deriving the optimal capital input for investing abroad. The model assumes that the MNF decides first on whether or not to undertake FDI which requires a decision on the output level in the foreign country. Then, for a MNF undertaking FDI, total costs are defined as a function of costs of production in both the MNF-home and MNF-foreign plants. So, total costs are given by

$$TC = c_h(q_h)q_h + c_f(q_f)q_f \tag{1}$$

where TC is total costs, c_h and q_h are unit costs and output level in the home plant, c_f and q_f are unit costs and output level in the foreign plant, subscripts h and f are for home and foreign respectively.

The constraint for total cost minimization is given by total output demand as

$$TD = q_h + q_f \tag{2}$$

Then, the Lagrangean function is defined as

$$L = c_h(q_h)q_h + c_f(q_f)q_f + \lambda\,(TD - q_h - q_f) \tag{3}$$

and the first order conditions for the cost minimization problem are given by

$$\partial L/\partial q_h = c_h'(q_h)q_h + c_h(q_h) - \lambda = 0, \tag{4}$$

$$\partial L/\partial q_f = c_f'(q_f)q_f + c_f(q_f) - \lambda = 0, \text{ and} \tag{5}$$

$$\partial L/\partial \lambda = TD - q_h - q_f = 0 \tag{6}$$

where $c_h' = \partial c_h/\partial q_h$ and $c_f' = \partial c_f/\partial q_f$. Equations (4) and (5) are marginal costs in the home and foreign plants respectively.

By equating (4) and (5) and solving for home output (q_h) and then substituting this result into equation (6), we get equilibrium output at the foreign plant. Therefore, foreign production is given as

$$q_f = \emptyset_1 \, TD + \emptyset_2 \, RUC \quad (7)$$

where $\emptyset_1 = c_h^{'}/(c_h^{'} + c_f^{'})$ and $\emptyset_2 = 1/(c_h^{'} + c_f^{'})$ which are assumed to be positive, and $RUC = c_h - c_f$ which represents relative unit costs between home and host country. Equation (7) shows that foreign plant's output is positively related to both total demand and relative unit costs.

Next, the MNF has to determine the level of inputs for producing in the foreign plant. A Cobb-Douglas production function is assumed to represent foreign production, that is

$$q_f = L_f^{\propto} K_f^{\beta} \quad (8)$$

Then, the costs associated with foreign production are given by

$$C_f = w_f \, L_f + r_f \, K_f \quad (9)$$

where *w* and *r* are real wage and real user cost of capital respectively.

Foreign plant's costs are minimized, so the Lagrangean function is defined as

$$L = w_f \, L_f + r_f \, K_f + \lambda \, (q_f - L_f^{\propto} K_f^{\beta}) \quad (10)$$

The first order conditions for the cost minimization problem are given by:

$$\partial L/\partial L_f = w_f - \lambda \propto (q_f/L_f) = 0, \quad (11)$$

$$\partial L/\partial K_f = r_f - \lambda \, \beta \, (q_f/K_f) = 0, \text{ and} \quad (12)$$

$$\partial L/\partial \lambda = q_f - L_f^{\propto} K_f^{\beta} = 0 \quad (13)$$

Dividing equation (11) by equation (12) and then rearranging yields

$$w_f \, L_f/\propto q_f = r_f \, K_f/\beta q_f \quad (14)$$

Taking L_f from equation (13) and substituting it into (14) yields K_f as

$$K_f = [(\beta/\propto)(w_f/q_f)]^{\propto/(\propto+\beta)} \, {q_f}^{1/(\propto+\beta)} \quad (15)$$

Plugging equation (7) into (15) yields the final expression for the MNF's desired capital stock (a capital stock level that solves the cost minimization problem) at the foreign plant

$$K_f^{*} = [(\beta/\propto)(w_f/q_f)]^{\propto/(\propto+\beta)} \, [\emptyset_1 \, TD + \emptyset_2 \, RUC]^{1/(\propto+\beta)} \quad (16)$$

Specifically, the MNF's desired capital stock at the foreign plant can be represented by

$$K_t^{*} = f(q_f, RUC) \quad (17)$$

where K_t^{*} would depend positively on both host country's demand (q_f) and relative unit costs (RUC) between home and host country.

Even though K_t^* in equation (17) represents the MNF's desired capital stock at the foreign plant, desired and actual capital stocks at the foreign plant are likely to differ in each time period because of adjustment costs due to delivery lags, delays due to searching for suitable investments overseas, and/or delays affecting planning permission (Barrel & Pain, 1996). Given these constraints, a partial adjustment model is an appropriate specification for net FDI inflows, which can be specified as a lag function of the difference between desired and actual capital stocks and replacement investment due to capital stock depreciation. The partial adjustment model is defined as in Bajo-Rubio and Sosvilla-Rivero (1994), Barrel and Pain (1996) and Love and Lage-hidalgo (2000) and is given as

$$FDI_t = \gamma(K_t^* - K_{t-1}) + \delta\, K_{t-1} \qquad (18)$$

where FDI_t is net FDI inflows as a share of GDP in year *t,* γ is a distributed lag function and δ is the depreciation rate of capital.

Equation (18) shows that net FDI inflows at the beginning of period t are determined by the difference between the desired capital stock in period t and the actual capital stock in period $t-1$ plus replacement capital at the foreign plant. Furthermore, equation (18) can be rewritten as

$$FDI_t = \gamma K_t^* + (\delta - \gamma)K_{t-1} \qquad (19)$$

Therefore, net FDI inflows are a function of the factors that determine the desired capital stock (equation (17)) and the lagged value of capital stock at the foreign plant.

Foreign market demand is given by q_f in equation (17). In the literature, the usual proxies used for q_f are measures of either GDP or GNP to capture the effect of the host country market on FDI. This is called the market size hypothesis[8]. It assumes a positive relationship between host country demand and the expected sales of MNF subsidiaries. Positive and significant effects of GDP on FDI are in Bajo-Rubio and Sosvilla-Rivero (1994); Filippaios, Papanastassiou and Pearce (2003); Lall et al. (2003); Love and Lage-Hidalgo (2000); and Marchant et al. (2002). Studies showing the relationship between FDI and GNP include Barrel and Pain (1996); Culem (1988); Cushman (1985, 1987, 1988). Hence, both GNP and GDP are used to capture the effect of host country income in attracting FDI, and an increase in this income is expected to increase FDI inflows.

Glytsos (2005) estimates the demand generated by remittances on consumption, investment, and imports through a type of country disposable income. He develops the following macro-econometric model:

$$C_t = \alpha_0 + \alpha_1 Y_t + \alpha_2 C_{t-1},$$

$$I_t = \beta_0 + \beta_1\, Y_t + \beta_2 K_{t-1},$$

$$M_t = \gamma_0 + \gamma_1\, Y_t + \gamma_2\, Y_{t-1} + \gamma_3 M_{t-1}, \text{ and}$$

$$Y_t = C_t + I_t + G_t + X_t - M_t + R_t$$

[8] Moosa's (2002) chapter 2 gives a description of the theories of FDI.

where C_t, I_t, and M_t represent consumption, investment and imports respectively. The identity shows that Y_t is the country's disposable income, and that remittances (R_t) are not part of GDP but part of the country's disposable income. The results show a positive and significant effect of income (Y_t) on consumption for Egypt, Greece, Jordan, Morocco and Portugal. Additionally, Taylor, Mora, and Adams (2005) report that in 2002 remittances accounted for 16 percent of rural household per capita income in Mexico. It seems that remittances through increasing disposable income may increase individuals' consumption demands in the host country.

Previous literature suggests controlling for the effects of exchange rate, imports, and inflation on FDI inflows. Regarding exchange rate effects on FDI inflows, foreign currency depreciation against the MNF's home country currency can influence FDI inflows. Host country currency depreciation gives the MNF an opportunity to capitalize its returns to a higher rate relative to host country firms (Aliber, as cited in Bajo-Rubio & Sosvilla-Rivero, 1994). Also, host country currency depreciation can stimulate foreign investment (Froot & Stein, 1991). However, some studies find strong negative effects of exchange rate on FDI (Cushman, 1985; Blonigen & Feenstra, 1996; Froot & Stein, 1991). In contrast, Waldkirch (2003) finds a positive relationship between exchange rate and FDI, while an ambiguous relationship between exchange rate and FDI is proposed by Stevens (1998). We expect exchange rate to have a negative effect on net FDI inflows[9].

The relationship between FDI and trade is not unambiguous. Under trade restriction scenarios, it is likely that FDI and trade behave as substitutes; however, in open market economies with relatively less trade restrictions, FDI and trade are more likely to be complements. Mundell (1957) studies the international movement of goods and factors and suggests that they behave as substitutes. On the contrary, Markusen (1983) presents several models that suggest that factor mobility promotes trade. In addition, complementary relationships between international flows of goods and factors are in (Billington, 1999; Brenton, Di Mauro & Lücke, 1999; Globerman & Shapiro, 1999). Barrel and Pain (1996) argue that MNFs' exports (host country imports) can promote FDI in downstream services which are consumer service facilities such as dealer networks as well as after sale repairs and maintenance outlets. They also argue that exports are jointly endogenous and include the lagged value of the MNF home country's exports in the estimated model. This study controls for host country imports lagged one period. It is expected that imports are either a complement or a substitute to net FDI inflows.

One possible proxy for host country macroeconomic stability is inflation (Barro & Sala-i-Martin, 2004, p. 520). Romer (2006, p. 550) argues that higher inflation can discourage long term investment because it can be perceived as government inefficiencies that can indicate government policies that hurt capital holders. High inflation is also tied to exchange rate volatility, political instability and other undesirable factors (Temple, 1999, p. 144). Negative relationships between inflation and investment, and between inflation and growth are in Bruno and Easterly (1998); Cukierman,

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[9] Appreciation of host country's currency against the U.S. dollar is expected to negatively affect FDI inflows.

Kalaitzidakis, Summers, and Webb (1993); and Fischer (1993). Therefore, macroeconomic instability may affect the expectations of international investors with respect to profits. Inflation is expected to have a negative impact on net FDI inflows.

The above discussion suggests that it is likely that remittances affect the desired capital stock in equation (17) through foreign market demand (q_f). Then, the model for the desired capital stock at the foreign plant should be extended to include the effects of remittances, exchange rate, imports, and inflation. The extended model is given by

$$K_f^* = f\left(q_f, REM, ER, IM, INF, w_h/w_f\right) \tag{20}$$

where q_f, REM, ER, IM, INF and w_h/w_f, denote host country demand, remittances as a share of GDP, real exchange rate, host country imports as a share of GDP lagged one period, inflation, and the ratio of home country to host country wages, respectively. Host country demand (q_f) is proxied by per capita GDP.

Then, the empirical specification of equation (19) is defined as

$$FDI_{it} = \beta_0 + \beta_1 LnGDPP_{it} + \beta_2 LnREM_{it} + \beta_3 LnGDPP_{it} * LnREM_{it} + \beta_4 LnER_{it} + \beta_5 IM_{i,t-1} + \beta_6 LnINF_{it} + \beta_7 Ln({}^{w_h}/_{w_f})_{it} + \beta_8\, LnK_{i,t-1} + a_i + \mu_t + \varepsilon_{it} \tag{21}$$

where $GDPP$ is host country per capita GDP and a proxy for host country demand; a_i denotes an unobservable country effect; μ_t denotes an unobservable time effect; and ε_{it} is the idiosyncratic error which is assumed to be independently and identically distributed with zero mean and variance σ_ε^2. Ln is the natural logarithm operator.

4.2 The Data

This study covers the period from 1983 to 2003 for a sample of 14 LAC countries. The dependent variable is net FDI inflows as share of GDP and is obtained from the World Development Indicators (WDI) CD-ROM (2006). Per capita GDP is obtained from the Penn World Tables version 6.2. Real exchange rate is constructed using data from the International Financial Statistics (IFS) CD-ROM (2007). Host country import data is obtained from the WDI CD-ROM (2006). Inflation data is obtained from the IFS CD-ROM (2007). The data used to construct the proxy for wages is obtained from the U.S. Bureau of Economic Analysis (BEA) and the U.S. Bureau of Labor Statistics. FDI stock data is obtained from the World Investment Report Annex Tables.

Remittances comprise workers' remittances, compensation of employees and migrants' transfers received by individuals in the migrant home country. Remittances data is obtained from the WDI CD-ROM (2006). Workers' remittances are private transfers from migrant workers who reside in the migrant host country for more than a year to people in the migrant home country. Compensation of employees is the income of migrants who lived in the migrant host country for less than a year. Migrant transfers are transfers from one country to another, at the time of migration, of the net worth of migrants who lived in the migrant host country for more than a year. Variable definitions and data sources and descriptive statistics are in Appendices 1 and 2 respectively.

5. Empirical Results

This section shows the results of the regressions based on the specification given by equation (21). We use panel generalized method of moments (GMM) to analyze an unbalanced panel data set because we suspect that the long panel nature of the data set makes it possible that the errors in equation (21) are no longer independent and identically distributed (iid). The errors may be heteroskedastic and autocorrelated over time for each cross section in the sample. In this situation, panel GMM allows for a robust estimation that controls for intra-cluster correlation and heteroskedasticity. It also allows for instrumental variable estimation since remittances are assumed to be endogenous. That is, remittances can be contemporaneously correlated with the errors due to reverse causality, measurement error, or omitted variable issues.

We assume weak exogeneity, so past values of remittances would be uncorrelated with the errors and used as instruments. Additionally, an exogenous instrument[10] based on the per capita GDP of the top-eight migrant receiving countries is used. The J-statistic is reported in Table 1 and suggests that the instruments are valid[11]. The Hausman test was applied to an OLS version of equation (21) and suggested that fixed effects are appropriate[12], so a full set of country dummy variables is included in the estimated model. A linear time trend is also included to control for time effects (Cameron & Trivedi, 2009, p. 267).

Table 1 shows two models. Model 1 uses the first and second lags of remittances as instruments, while model 2 uses the distance weighted per capita GDP in addition to the lagged values of remittances. The results are qualitatively the same for both models. However, given the statistical significance, the discussion of the results comes from model 2. There is a significant positive effect of per capita GDP on net FDI inflows. This result is in line with the market size hypothesis. That is, MNFs tend to be attracted to larger markets in order to exploit economies of scale. In the case of LAC, positive relationships between FDI and market size are reported in Lall et al. (2003), Love and Lage-Hidalgo (2000), and Tuman and Emmert (2004).

The results on the relationship between remittances and per capita GDP and FDI inflows suggest that remittances have a positive effect on net FDI inflows, but only for certain levels of host country per capita GDP. The coefficients on remittances and the interaction term are both significant and suggest that a threshold of host country per capita GDP is required for remittances to have a positive effect on net FDI inflows[13]. In

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[10] The instrument is based on the economic conditions of the top-eight migrant receiving countries and is adopted from Acosta, Calderon, Fajnzylber and Lopez (2007). The per capita GDP of each of these countries is weighted by the inverse of the distance of the respective countries to each LAC country.

[11] The null hypothesis states that the instruments are uncorrelated with error term. Thus, failing to reject this hypothesis suggests that the instruments are valid.

[12] The p-value of the Hausman test is 0.0001.

[13] The appropriate per capita GDP threshold is the log value of per capita GDP that makes the sum of remittances and the interaction term positive, or $log\ per\ capita\ GDP \geq (-\frac{\beta_{remittances}}{\beta_{interaction\ term}})$. But, if both estimates are positive (negative), then remittances has an unambiguously positive (negative) effect on net FDI inflows.

addition, the positive sign of the interaction term suggests that remittances and per capita GDP have a complementary effect on net FDI inflows. The estimates on remittances and the interaction term indicate that in a country with a log value of per capita GDP greater than 8.46 (a per capita GDP value of US$4,722.06) remittances positively affect FDI. In our sample, nine countries[14] pass this per capita GDP threshold. In contrast, remittances negatively affect FDI in countries with per capita GDP below this threshold. Also, note that model 1 and 2 include per capita GDP and remittances alongside their products, so the significance of the interaction term cannot be the result of the omission of any of these two factors.

Table 1. Remittances, per capita GDP and net FDI inflows as a share of GDP to Latin America and the Caribbean, panel GMM estimation, 1983-2003

Explanatory variables	Model 1	Model 2
Constant	-11.0807***	-11.0396***
	(3.73)	(3.77)
Log per capita GDP	0.6298*	0.6170**
	(1.96)	(1.97)
Log Remittances/GDP	-2.6958**	-2.6575**
	(2.21)	(2.22)
(Log Remittances /GDP)*(Log per capita GDP)	0.3188**	0.3140**
	(2.17)	(2.18)
Log real exchange rate	0.0033	0.0030
	(0.29)	(0.28)
First lag of imports	0.1403***	0.1404***
	(3.08)	(3.14)
Log inflation	0.0042	-0.0045
	(0.67)	(0.83)
Log (U.S. wage/host wage)	-0.0014*	-0.0014*
	(1.94)	(1.96)
Log first lag of foreign capital stock	-0.0107*	-0.0107*
	(1.66)	(1.67)
year	0.0028**	0.0028**
	(2.36)	(2.46)
R-squared	0.1181	0.1138
Observations	228	228
Countries	14	14
J-statistic	4.727	4.752
P-value for J-statistic	0.0941	0.1909

Notes: Asterisks indicate significance at the 10 percent (*), 5 percent (**) and 1 percent (***) levels respectively. Model 1 uses the first and second lags of remittances as instruments. Model 2 uses the first and second lags of remittances and a distance weighted per capita GDP as instruments. Values in parenthesis are t-values. Country fixed effects are not reported to save space. The p-value for the J-statistic suggests failure to reject the null hypothesis, so the instruments are valid.

In addition, in a country with a per capita GDP log value of 8.67 (the sample average and equivalent to US$5,825.5), an increase in remittances of 0.03 as a share of GDP (one

[14] Barbados, Brazil, Colombia, Costa Rica, Mexico, Panama, The Dominican Republic, Trinidad and Tobago, and Venezuela pass the threshold, or have a per capita GDP greater than US$4,722.06.

standard deviation) which is an increase of 132 percent relative to remittances' sample mean will raise net FDI by 0.09 percentage points per year. Given the same increase in remittances, but in a country with a per capita GDP log value of 9.82 (as in the case of Trinidad and Tobago's per capita GDP value of US$18,398.05), the maximum value in the sample, net FDI rises by 0.56 percentage points a year. Therefore, on average, increasing remittances has a positive impact on net FDI inflows to the LAC countries.

The positive effect of remittances on net FDI given the threshold of per capita GDP suggests that, on average, remittances strengthen the impact of market size in attracting FDI to LAC economies. It may be that by increasing disposable income and conditional on a per capita GDP threshold, remittances may raise aggregate demand in LAC economies and increase FDI inflows. Furthermore, if FDI positively affects economic growth in LAC countries as suggested in Bengoa and Sanches-Robles (2003), then remittances may indirectly contribute to growth.

The real exchange rate effect on net FDI inflows is positive but is not significant. This was not expected. The literature reports mixed results, some studies find negative relationships between exchange rate and FDI (Blonigen & Feenstra, 1996; Cushman, 1985; Froot & Stein, 1991). On the other hand, a positive relationship between exchange rate and FDI is suggested in Stevens (1998) and Waldkirch (2003).

Host country imports have a positive and highly significant effect on net FDI inflows. This suggests a complementary relationship between host country imports and net FDI inflows. Complementary relationships between host country imports and FDI are in Billington (1999) and Globerman and Shapiro (1999).

The ratio of U.S. wages to host country wages is negative and significant. This was not expected and implies that higher home country wages relative to host country wages discourage net FDI. Chakrabarti (2001) argues that, among all the potential FDI determinants, wages have been the most controversial since the literature reports host country wages negatively affecting FDI, having no effect, or having a positive effect. Positive and significant effects of host country wages on FDI are in Filippaios et al. (2003); Marchant et al. (2002); Swedenborg (2001); and Wheeler and Mody (1992).

As expected, inflation negatively affects net FDI but it is not significant. Negative relationships between inflation and FDI for developing countries are in Schneider and Frey (1985) and Bengoa and Sanchez-Robles (2003). Lastly, as expected, lagged foreign capital stock has a significant and negative effect on net FDI inflows. Thus, a higher level of last period capital stock at the foreign plant reduces next period net FDI inflows.

6. Conclusions

This study assesses the effect of remittances and per capita GDP on net FDI inflows. To investigate this issue, this research uses a sample of 14 LAC countries over the period from 1983 to 2003. The most important finding of this research is a positive effect of remittances on net FDI inflows given a threshold of host country per capita GDP. The results also suggest a complementary effect of remittances and per capita GDP on net FDI inflows. Additionally, per capita GDP has a positive and significant effect on net

FDI inflows. This is consistent with the theory of market size and the research that finds positive relationships between FDI and market size for developing countries (e.g., Bengoa & Sanchez-Robles, 2003).

It is important to mention that the effect of remittances on net FDI may be affected by some uncertainties in measuring remittances. Our data on remittances measures the sum of workers' remittances, compensation of employees, and migrants' transfers as defined in the fifth edition of the IMF's Balance of Payments Manual. However, some countries report remittances data to the IMF as only workers' remittances or compensation of employees. In addition, the true size of remittance flows may be 50 percent higher or more than the actual flows (World Bank, 2006, p. 85). Thus, the measure of remittances underestimates the total value of remittances sent by migrants to their home countries. To the extent that this bias in remittances is constant across remittance receiving countries and over time, the qualitatively results are not affected.

With respect to future research, it would be interesting to analyze the relationship between remittances and sectoral FDI such as that of the services and manufacturing sectors that seek to serve host country markets. It would also be interesting to assess the effect of remittances on FDI while using data from household surveys in developing countries that collect data on migration and remittances.

Appendix 1

Variable Definitions and Data Sources

Variable name	Variable definition	Source
FDI inflows	Net FDI inflows as a share of host country GDP.	World Development Indicators CD-ROM, World Bank 2006.
Per capita GDP	Real per capita GDP.	Penn World Tables version 6.2, 2006.
Remittances	Natural log of workers' remittances, compensation of employees and migrants' transfers as a share of host country GDP.	World Development Indicators CD-ROM, World Bank 2006.
Remittances * per capita GDP	Interaction of the log of remittances/GDP and log of per capita GDP.	Own calculations.
Real exchange rate	Real exchange rate. U.S. Dollars per unit of foreign currency. It is defined as in Waldkirch (2003). It is computed by multiplying the nominal exchange rate by the ratio of the host CPI to the U.S. CPI.	Own calculations.
Lag imports	First lag of host country imports as share of GDP.	World Development Indicators CD-ROM, World Bank 2006.

Appendix 1 (Continued)

Variable name	Variable definition	Source
Inflation	Natural log of 1 plus the annual change of GDP deflator.	Own calculations.
U.S. wage/Host wage	The ratio of U.S. wages to host country wages.	Own calculations.
Lag foreign capital stock	First lag of the foreign capital stock in the host country.	Key Data from WIR (World Investment Report) Annex Tables, UNCTAD (United Nations Conference on Trade and Development), www.unctad.org/fdistatistics.
U.S. CPI	U.S. consumer price index.	International Financial Statistics CD-ROM, IMF 2007.
Host country CPI	Consumer price index for each LAC country.	International Financial Statistics CD-ROM, IMF 2007.
U.S. wage	Real U.S. wages. Average weekly hours times average hourly earnings times 48. The result is divided by the U.S. GDP deflator.	Own calculation.
Weekly hours	Average hours worked per week in a year.	U.S. Bureau of Labor Statistics.
Earnings/hour	Average earnings per hour in a year.	U.S. Bureau of Labor Statistics.
Host wage	Real host country wage. Compensation of employees divided by total employees. The result is divided by GDP deflator.	Own calculation.
Compensation of employees	Yearly wage bill of majority-owned nonbank foreign affiliates of Nonbank U.S. parents paid to their workers in the host country.	U.S. direct investment abroad, operations of U.S. parent companies and their foreign affiliates, data on majority owned nonbank foreign affiliates of nonbank parents, U.S. Bureau of Economic Analysis.
Total employees	Number of employees hired in a year by majority-owned nonbank foreign affiliates of nonbank U.S. parents in the host country.	U.S. direct investment abroad, operations of U.S. parent companies and their foreign affiliates, data on majority owned nonbank foreign affiliates of nonbank parents, Bureau of Economic Analysis.
GDP deflator	GDP deflator	International Financial Statistics CD-ROM, IMF 2007.
Nominal GDP	Total nominal GDP for each LAC country.	World Development Indicators CDROM, World Bank 2006.

Appendix 2

Summary Statistics, Annual Values for the Period 1983-2003

Variable	Obs.	mean	std. dev.	min	max
Net FDI/GDP	294	0.01869	0.04130	-0.44750	0.17421
Log per capita GDP	294	8.67268	0.46027	7.67961	9.81958
Log Remittances/GDP	285	-2.12045	0.20666	-2.30259	-1.31026
Log real exchange rate	294	-3.39563	2.87099	-10.12663	0.97013
Lag imports/GDP	294	0.34327	0.18967	0.05026	0.98070
Log inflation	294	0.25371	0.53250	-0.37864	4.00035
Log U.S. wage/host wage	249	-1.17566	3.93236	-22.715600	1.29531
Log lag foreign capital stock/GDP	286	-1.90728	0.87495	-5.20108	0.00513

Note: Lag means the first lag of the variable.

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EXCHANGE RATE VOLATILITY IMPACT ON SOYBEAN TRADE: EVIDENCE FROM A MULTI-COUNTRY ANALYSIS FRAMEWORK

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Abstract

This study examines the impact of exchange rate volatility on the soybean trade by focusing on three major soybean exporting countries (U. S., Brazil, and Argentina) and three major soybean importing countries (Japan, China, and Mexico). A Vector Autoregressive (VAR) model is used to estimate the relationship between soybean exports, conditional exchange rate volatility, and the FOB export prices of soybean and soybean oil, where conditional exchange rate volatility was estimated using an Exponential Generalized Conditional Heteroskedasticity (EGARCH) model. Results indicate that increased exchange rate volatility in China after 2005 Granger-caused a decrease in U. S. exports to China. Similarly, when Japanese currency was highly volatile, the U. S. soybean exports to China increased but exports decreased to Japan and Mexico. A trade diversion effect was also observed, while cross-country effects of exchange rate volatility and prices do not appear to have consistent impacts.

JEL Classification: F14, F31

Keywords: Exchange Rate Volatility, Soybean Trade, U. S. Soybean Exports

1. Introduction

Background

The volatility of exchange rates is a measure of the day-to-day movement in the price of a country's currency in terms of its trading partners' currencies. High exchange rate volatility creates a riskier financial environment for international transactions. Changes in exchange rates can also impact trade patterns. For example, a depreciating dollar with respect to the U.S. trading partners' currencies lower the U.S. exporters' costs and make

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their goods more competitive in the export market. Therefore, trade patterns are not only influenced by changes in the exporters' cost, but also additional risk is implied by movements in exchange rate volatility. Exchange rate volatility is particularly important for export/import oriented industries like the agricultural sector in the U.S.. Exchange rate volatility gained additional importance under present conditions with the increased opening of world markets and the reduction in trade barriers.

Globally, the U. S., Brazil, Argentina, and China are the top soybean producers, accounting for 90% of the global soybean output. Among them, the U.S. is the largest producer with an output of 79 million metric tons in 2008, followed by Brazil and Argentina (USDA-FAS, 2009). With the less than 3% annual growth rate of soybean production in the U. S., Brazil and Argentina are likely to surpass the U. S. within a few years. The export shares of the world soybean market for Brazil, the U.S., and Argentina were 39%, 45%, and 4%, respectively in 2009 (USDA-FAS, 2009). The U.S. export share of the soybean world market has been decreasing, especially during the last decade. In contrast, the Brazilian market share increased from 11% in 1995 to 39% in 2009, an increase of 28% in 14 years. China, the EU, Japan, and Mexico are the world's leading soybean importers. China's soybean imports skyrocketed in the last decade from 0.8 million metric tons in 1994 to 41 million metric tons in 2009, while soybean imports into the EU, Japan, and Mexico remained quite stable (USDA-FAS, 2009).

Soybean trade contributes a significant portion to the U.S. agricultural export revenue. However, increased competition from Brazil and Argentina has reduced the U.S. share of the global soybean export market. It is widely recognized that the exchange rate is playing a significant role in determining the terms of trade. In addition, given the worldwide gradual elimination of tariffs, the exchange rate and its volatility will remain the most important variable affecting the international trade of agricultural commodities. This research attempts to measure the significance and magnitude of the exchange rate volatility impact on multilateral soybean trade and its significance in the competition for key importing markets.

Literature Review

With the breakdown of the Bretton Woods System in the early 1970s, exchange rates were no longer fixed and international trade has since been increasingly vulnerable to the impacts of the exchange rate variation. There have been conflicting economic theories and empirical evidence for and against the impact of exchange rates on international trade. Some authors highlighted the negative effects of the exchange rate on trade while others argued it to be a positive effect (McKenzie, 1999). Schuh (1974, 1976) laid out the foundation work on research exploring the effects of exchange rates on agricultural trade. Anderson and Garcia (1986) found that exchange rate volatility has had a significant negative impact on U.S. soybean exports to three countries; Japan, France, and Spain. Pick (1990) found that exchange rate volatility was a significant risk factor causing fluctuation in U.S. bilateral agricultural trade. His findings suggest that exchange rate risk adversely affects U. S. agricultural exports. Similarly, Klein (1990) also argued for the negative effect of exchange rate volatility on U.S. agricultural exports. This finding is further supported by the work of Cho, Sheldon and McCorriston (2002). Langley et al. (2002) found that exchange rate volatility had a positive impact on Thailand's exports, but not on aggregate agricultural exports. They also examined the same issue on Canadian pork, U.S. and Brazilian soybeans and soy products and concluded that the exchange rate volatility impact of agricultural commodities differs with the nature of commodities and other economic factors. Further, Awokuse and Yuan (2006) examined the U.S. poultry export responses to exchange rate volatility. They also found a positive relationship between exchange rate risk and U. S. poultry exports. Various arguments have been used to explain the ambiguous results of exchange rate volatility impacts on trade. Some recent studies and literature reviews have found aggregation as one of the major reasons for the ambiguous results and suggest that the impact of exchange rate volatility on trade can be better understood by looking at sectoral and bilateral trade rather than at aggregate trade (Goodwin, 2001).

Estimating exchange rate volatility has also been a point of divergence in past research. Lagley and Hallahan (2000) used the ARCH model to assess exchange rate volatility by using monthly data from January 1990 to April 2000. Samwaru et al. (2001) analyzed Asian financial volatility and Korean agricultural trade during the Asian financial crisis. They used various methods to assess the real Dollar-Won exchange rate volatility such as ARIMA-type, GARCH-type and EGARCH-type specifications. ARIMA approximates the conditional mean dynamics of the real exchange rate while ARCH and GARCH approximate the conditional variance dynamics. Valdes and Hallahan (2001) estimated exchange rate volatility and its effect on the Brazilian soybean complex using the square of lagged errors and the ARIMA model to measure exchange rate volatility. Their empirical model specified exports as a function of world prices, domestic prices and exchange rate volatility while treating the three components of the soybean complex as separate commodities and did not consider the relationship among them. Langley et al. (2002) used the GARCH (1,1) specification to estimate the real dollar-baht exchange rate volatility to examine the impact of international financial volatility and agricultural trade. Bonroy, Gervais and Larue (2007) developed a theoretical trade model to account for production and marketing lags in the agricultural supply chain in order to analyze the effect of exchange rate volatility on the volume of trade. Their theoretical model suggested a non-linear export response to volatility. From the empirical results they suggested that impact of volatility on exports with linear models can be misleading. May (2010) used daily exchange rate data and monthly export and price data from Thailand to explain the relationship between international exchange rate volatility and commodity exports. Four measures of volatility were used and included trailing moving average standard deviation, ARIMA(5,4), ARIMA(2,1,3) and GARCH(1,1) to estimate the exchange rate volatility. Then, conditional volatility measures were used in OLS regressions to estimate the relationship between exports and exchange rate volatility. All four measures of real exchange rate volatility were found to have a significant negative impact on commodity exports. However, the lagged value of exchange rate volatility did not have a statistically significant relationship with agricultural production and exports.

Some past research work on this topic suggests that the exchange rate has played a crucial role in trade fluctuations. The analysis of exchange rates has been highly refined over time in order to assess the actual volatility of exchange rates. Most of the literature has focused on bilateral trade for the assessment of exchange rate volatility's impact. In contrast to the existing literature, the present research encompasses multilateral trade to analyze the impact of exchange rates on the volume of U.S. soybean trade. The effect of competitors in soybean export markets was also included along with exchange rate volatility.

Theoretical Framework

A partial equilibrium framework is used to analyze the impact of exchange rate volatility on U.S. soybean exports to China, Japan and Mexico. We use a partial equilibrium framework because the U.S. soybean exports in recent years have not been large enough to allow for a general equilibrium analysis, due to the presence of big competitors like Brazil and Argentina. This model uses the maximization of the expected utility of the exporting firm's profit under the presence of risk from exchange rate volatility. The model considers a firm in the U.S. exporting soybeans to major importing countries, who faces competition from firms in Brazil and Argentina. The firm faces export supply and import demand as below:

$$Q_m = \beta_0 + \beta_1 p_m + \beta_2 p_{sm} \tag{1}$$

$$Q_x = \gamma_0 + \gamma_1 p_x + \gamma_2 p_{sx} \tag{2}$$

where Q_m and Q_x are quantity demanded by the importer and quantity supplied by the exporter, p_m and p_x are the import price and export price while p_{sm} and $p_{sx}$are the import price and export price of the other exporting countries, respectively. It is assumed that domestic production technology is the same in the short run. It is also assumed that all the trade transactions are in U.S. dollars. We assume that the exporting firms do not hedge against exchange rate uncertainty in order to identify the impact from the exchange rate. Therefore, the exporting firm changes its behavior based on the exchange rate volatility of the importing country's currency with respect to the U.S. dollar. The time subscript t in π, p^*, Q^* and C is not included for convenience. The firm's profit under equilibrium price and exporting cost in time *t* is:

$$\pi_t = {p_t}^* \, {Q_t}^* - C_t - R_{t+1} \, {p_t}^* \, {Q_t}^* \tag{3}$$

$$\frac{d\pi_t}{dR_{t+1}} = -{p_t}^* \, {Q_t}^* < 0 \tag{4}$$

where C is the export cost of the firm, p^* is the equilibrium price of the commodity in the U. S. dollars, and R_{t+1} is the stochastic exchange rate (units of domestic currency in terms of importing country's currency). A reduction in the exchange rate of the exporting country's currency with respect to the importing country's currency leads to the increase in the firm's profit.

The risk averse firm maximizes the expected utility of profits over the quantity of exports (Q)

$$\mathbb{E}[u(\pi_t)] = \mathbb{E}[u(p_t^* Q_t^* - C_t - R_{t+1} p_t^* Q_t^*)] \quad (5)$$

For the risk averse firm, the utility function is increasing and concave; $u''(\pi_t) > 0$ and $u'(\pi_t) < 0$. The exporting firm, under exchange rate uncertainty, adjusts the quantity exported in order to maximize the expected utility of its profit. In the presence of competitors, the behavior of the exporting firm will be ambiguous. The assumptions concerning the type of market in the analysis (e.g., whether the trader is just an exporter or has the option to sell in the domestic market) also plays an important role in determining the results of the theoretical findings.

Methodology

Estimation Procedure

The empirical model includes a measure of exchange rate variability to reflect the riskiness of the trading environment. The volatility of the exchange rate is measured using the Exponential Generalized Autoregressive Heteroskedaticity model (EGARCH). The EGARCH specification is generally preferred to GARCH because of its advantages in fitting financial markets (i) allows for positive and negative correlation between current and future volatility and (ii) doesn't impose parameter restrictions that are often violated by estimated coefficients of the GARCH model (Koulakiotis et al, 2006). The EGARCH model was first proposed by Nelson (1991) and estimates the volatility $\ln(\sigma^2)$ as a linear function of z such that:

$$\ln(\sigma_t^2) = \omega + \sum_{i=1}^{q} \alpha_i g(z_{t-i}) + \sum_{j=1}^{p} \ln(\sigma_t^2) \quad (6)$$

$$\text{where,} \quad z_{t-1} = \frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}}$$

The stationarity of the exchange rate data series was empirically tested by using the Dickey Fuller test. The first-differenced data was found to be stationary. The volatility was then computed from the first-differenced data series.

The model for U.S. export demand to the major soybean exporting countries can be represented as:

$$X_{ijt} = f(ev_{it}, pr_{US\,jt}, pr_{BR\,jt}, pr_{AR\,jt}) \quad (7)$$

where, the dependent variable X represents the quantity of quarterly U. S. exports; ev is the exchange rate volatility; p_{US} is the export price in the U.S.; p_{BR} is export price in Brazil; p_{AR} is the export price in Argentina. Countries are denoted by i and include China, Japan and Mexico, while j denotes the commodities which include soybeans and soy oil, and time is denoted by t. The export price is the freight on board (FOB) price recorded at the port of exporting countries and expressed in U.S. dollars.

The model is estimated by using a VAR model, which was proven to be useful for describing the dynamic behavior of economic and financial time series. It often provides superior forecasts to those from univariate time series models and simultaneous equation models. The VAR model allows the endogeneity of explanatory variables such as price series in this model. The model can be expressed as:

$$X_{ijt} = \sum_{i=1}^{3} \beta_{ij} X_{ijt-1} + \sum_{i=1}^{3} \gamma_{ij} ev_{it} + \sum_{i=1}^{3} \pi_{kjt} pr_{kjt} + v_{ijt} \quad (8)$$

where, X_{ijt}= U. S. export to China, Japan and Mexico as a dependent variables,
ev_{it} = Exchange rate volatility of country i and time t,
pr_{kjt} = Price for exporting country k, product j and time t. The export price Brazil and Argentina were expressed in terms of ratio to the U. S. price, and

v_{ijt} = Normally distributed error term.

For the estimation, we use three countries and two products; soybean and soy oil which implies that altogether there are two systems each consisting of three equations to estimate. The dependent variables are subjected to unit root and co-integration test and estimation was carried out. The variables were transformed into logarithms and used for analysis because of ease in handling data with large magnitude and interpretation.

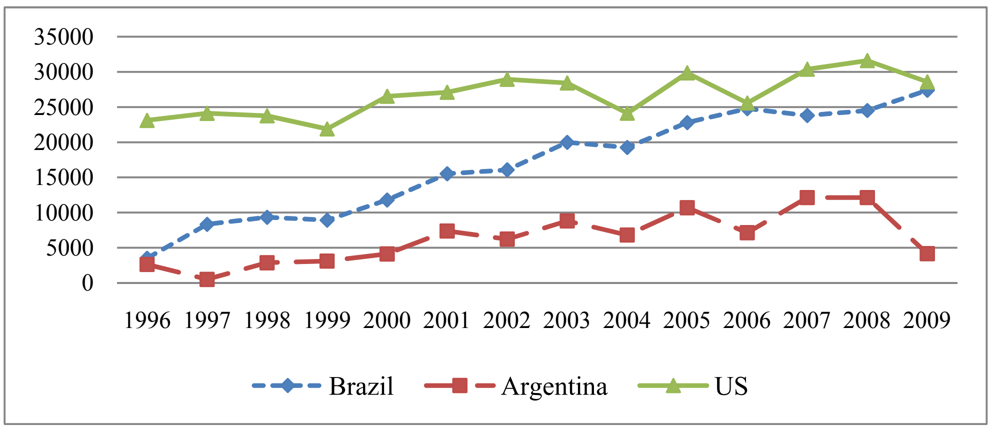
Data Collection

The estimation of U.S. soybean exports requires data on several variables that affect the export demand. For the purpose of the current research, a number of variables were identified. Based on these variables, the data were gathered from various sources. U.S. export data were downloaded from a USDA export data query (http://www.fas.usda.gov/esrquery/esrq.aspx) while price data and Brazilian and Argentina export data were collected from various publications from the Foreign Agriculture Service of the USDA. Weekly exchange rate data was gathered from the Federal Reserve data source from 1999 to 2008. Weekly U. S. exports of soybeans and soy oil were downloaded from the USDA export data query for 1999 to 2008. Weekly exports would seem to be very lumpy and seasonal. Weekly export data were aggregated into quarterly exports of soybean and soy oil. This level of aggregation would smooth out seasonality to some extent. We conducted a spectral analysis to confirm the existence of seasonality in the quarterly export data. Spectral analysis did not support the seasonality in the export data series. Similarly, Fisher's Kappa test and Bertletts's Kolmogorov-Smirnov test failed to reject the null hypothesis that the spectrum represents white noise.

Result and Discussion

Data description

The export data reveals that the U.S. has been by far the largest soybean exporting country compared to its competitors in the past. However, Brazilian exports have been continuously increasing at a higher rate (Fig. 1). As a result, Brazil soybean exports are expected to surpass the U.S. exports in terms of quantity within the next few years. As the export share of Brazil continues to increase, its importance in global soybean trade begins to outweigh the U.S. and increases the pressure on the U.S. soybean sector. Argentina has also been one of the largest producers of soybeans, exporting a significant quantity with an increasing export share. However, it does not show a significant growth rate like Brazil because of export restrictions placed by Argentina's government to protect its livestock sector. Due to the increasing shares of Brazil and Argentina's soybean exports, the U.S. share has been diminishing during the last decade.



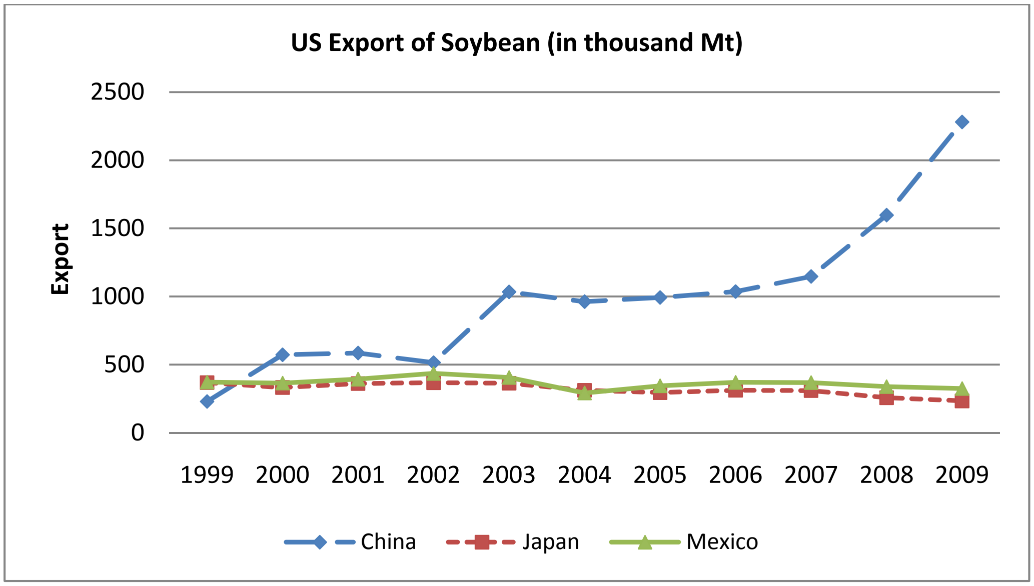
Source: Foreign Agricultural Service, USDA

Figure 1. Soybean Export by the U.S., Brazil and Argentina (in Thousand Mt).

China's soybean imports skyrocketed during the last decade from 0.8 million in 1994 to 37 million metric tons in 2008 while soybean imports by other countries like the EU, Japan and Mexico remained almost the same. Because of the astounding increase in soybean imports, China has become a major player in the world's soybean market. China is by far the largest importer of U.S. soybeans (Fig 2). Exports to Mexico and Japan have been quite stable with about 6% share in global soybean imports.

The export price movement for soybeans is almost similar in all three exporting countries because prices in these countries are co-integrated. The historical trend of prices is increasing. The rate of increase in export price was almost zero from 1999 to 2001 and increased afterwards until 2003. With a brief period of price decline after 2003, soybean exports rose very rapidly with a record high in 2007. The price trend of soybean oil also shows a similar trend as soybeans because of its nature of being a joint product.

Because of multicollinearity between price variables, the Brazilian and Argentine price were used as a ratio with the U.S. price for both soybeans and soy oil.



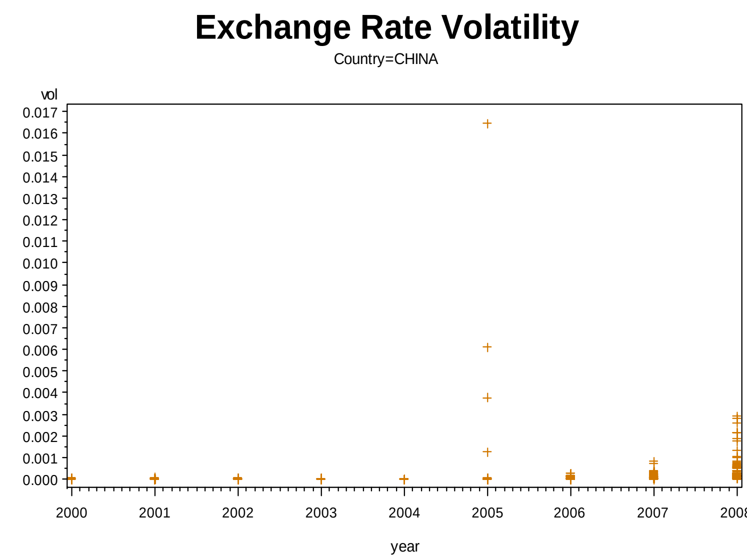
Source: Export Sales Query System, Foreign Agricultural Service, USDA

Figure 2. U. S. Export of Soybean (in Thousand Mt).

Model Estimation and Discussion

Weekly exchange rate data for the U.S.'s major soybean importers such as China, Japan, and Mexico with respect to U.S. dollars was used for exchange rate volatility estimation. The weekly interval time series also possesses characteristics similar to the other time series data. Time series data are frequently characterized by a unit root process, which makes it non-stationary leading to the error in inference. The Augmented Dickey-Fuller (ADF) test of unit root indicates that exchange rate data of all three countries were non-stationary and non-normally distributed. As a result, weekly exchange rate data are first differenced. The stationarity of the data are confirmed by the second ADF and are used to compute the volatility by using an EGARCH model.

The observed weekly exchange rate volatilities are shown by year in figure 3. China's exchange rate with the U.S. dollar shows very low volatility compared to Japan and Mexico exchange rates. However, the volatility remained almost the same in China from 2000 to 2004 and suddenly increased in 2005. The reason behind this sudden volatility increase may be due to the switching regime of the Chinese currency. The Chinese currency had been effectively pegged to the U.S. dollar at the rate of 8.28 RMB/dollar from 1997 until July 21, 2005. In 2005, Chinese authorities announced a switch to a new exchange rate regime. The exchange rate would henceforth be set with reference to a basket of other currencies, allowing movements within any given day. Since the Chinese currency was pegged to the U.S. dollar, there was a nearly constant volatility. After 2005, volatility no longer remained constant but rather increased. The Japanese exchange rate with respect to the U.S. dollar, however, was highly volatile. In 2008, its volatility reached a very high level which might be related to a spillover effect of the U.S. economic meltdown due to the housing crisis. In other years, the volatility has been up and down in a cyclical pattern. In 2002, 2005, 2007 and 2008 the Japanese currency showed high volatility while in 2001, 2003, and 2006 it presented low volatility (fig 3).



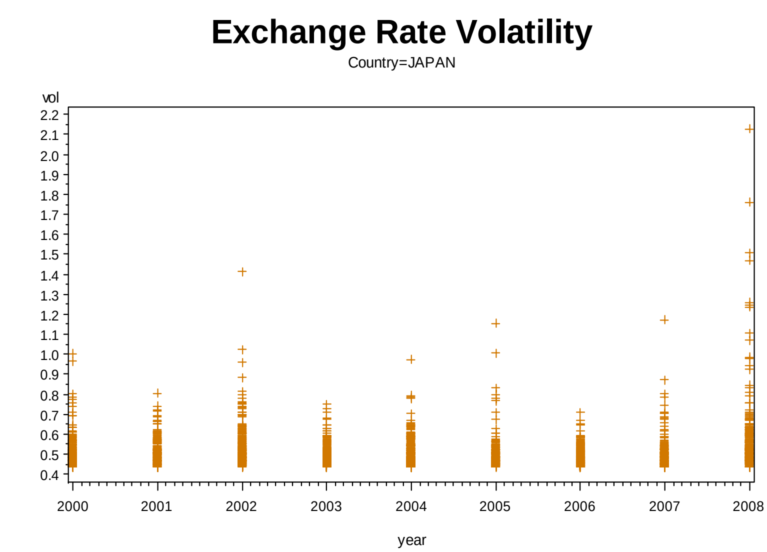


Figure 3 (Continued)

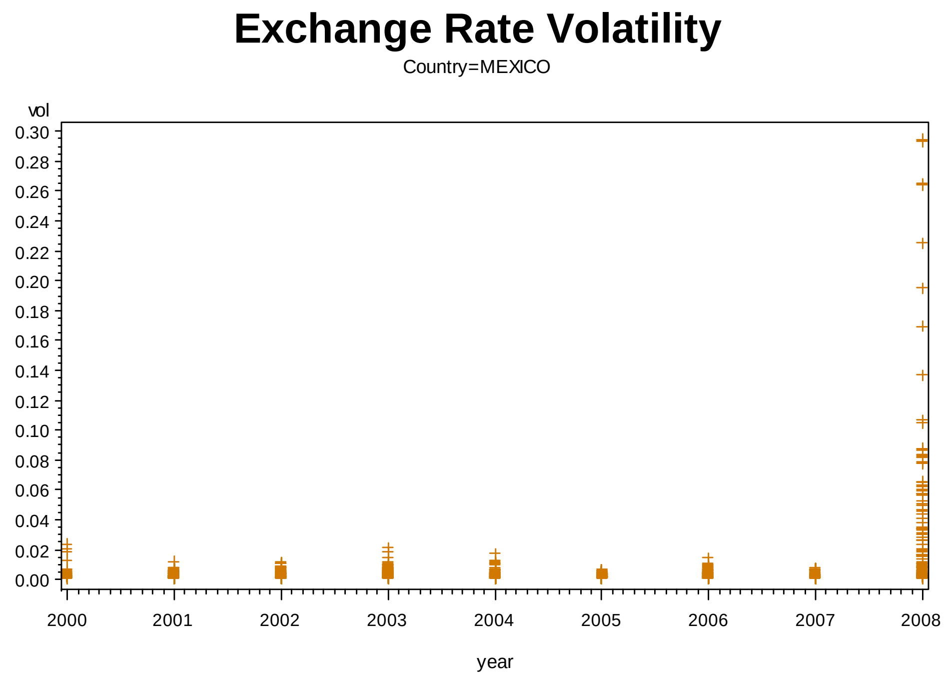


Figure 3. Exchange rate volatility.

In Mexico, the exchange rate volatility was much smaller compared with Japan but higher than China. Nearly every year the Mexican exchange rate was constantly less than 0.02. However, the volatility suddenly jumped to a very high level in 2008. The higher exchange rate volatility may be due to the weak dollar in 2008. As a major trading partner, the economic crisis in the U.S. has a direct impact on Mexico resulting in higher exchange rate volatility.

The exchange rate volatility and export prices are used as explanatory variables in the VAR model to estimate the impact of the exchange rate volatility and export price on the U.S. soybeans export quantity. The U.S. export quantities to China, Japan, and Mexico are the dependent variables in the model. Unit root tests were then computed based on the Dickey-Fuller unit root test. Following the unit root test, they were tested for co-integration by using Stock-Watson's common trend. The unit root test rejected the null hypothesis of existence of unit root (Table 1a). The dependent variables in the model are I(0) which means that the model can be estimated without difference. The co-integration test suggested that there is a single common trend (Table 1b). Test for the rank of 1 against rank of 2 showed that the 5% critical value for rank of 1 is more negative (-25.02) than critical value at 5% (-17.50). The export series has a co-integration of order 1. The VAR Error Correction Model (VAR-ECM) is appropriate when the dependent series are co-integrated by order 1.

Table 1a. Dickey-Fuller Unit Root Tests

Variable	Type	Rho	Pr < Rho	Tau	Pr < Tau
U.S. export to Mexico	Zero Mean	-0.03	0.6766	-0.17	0.6265
	Single Mean	-33.14	0.0019	-4.07	0.0012
	Trend	-33.63	0.0035	-4.10	0.0065
U.S. export to Japan	Zero Mean	-0.04	0.6735	-0.27	0.5876
	Single Mean	-34.08	0.0019	-4.17	0.0009
	Trend	-35.65	0.0022	-4.24	0.0040
U.S. export to China	Zero Mean	-0.10	0.6609	-0.16	0.6284
	Single Mean	-29.40	0.0019	-3.79	0.0033
	Trend	-30.54	0.0071	-3.88	0.0131

Table 1b. Testing for Stock-Watson's Common Trends Using Differencing Filter

H0: Rank=m	H1: Rank=s	Eigenvalue	Filter	5% Crit. Value
1	0	0.999986	-0.03	-8.00
2	0	0.999978	-0.04	-3.78
	1	0.986750	-25.02	-17.50

Parameter estimates of the explanatory variables for U.S. soybean exports to China, Japan, and Mexico are presented in Table 2. As expected, higher export prices at the U.S. port has a negative effect on U.S. exports. With higher prices in the U.S., the importing countries would either reduce imports from the U.S. or satisfy their domestic demand by importing from competing countries like Brazil and Argentina A one percent increase in the price of soybeans reduces 2.3, 0.07 and 0.05 percent the U.S. soybeans exports to China, Japan and Mexico respectively. Because China is the largest importer of U.S. soybeans, the impact of price increase was larger in China than in the other two countries. The price effect was the smallest in Mexico. The price effects of the competitors have mixed effects. According to our expectation, the export price of Brazilian soybeans has a positive impact on the U.S. soybeans exports to China and Mexico while it has a negative effect on exports to Japan. However, the related coefficient is not significant. Competitor’s price was expected to impact U.S. exports positively. This is true in the Brazilian case. However, the price of Argentina’s soybeans has negative effect on the U.S. exports to Mexico. This conflicting result might be related to the restriction of Argentina’s soybean exports. China and Japan switch their imports source based on the prices of competitive exporting countries because its soybean imports from the U.S. negatively reacts to U.S. prices and positively reacts to competitors’ prices.

Exchange rate volatility seems to have a strong impact on U.S. exports. Higher exchange rate volatility in China may explain the decrease in imports from the U.S. by China and Mexico and it has a positive effect on Mexican imports of U.S. soybeans. A one-percent increase in volatility of the exchange rate causes the decline in U.S. exports to China by 0.21, but increased exports to Mexico by 0.4 percent. The effects are statistically significant. The impact of volatility in the Japanese yen with respect to the U.S. dollar negatively affects its import of soybeans from the U. S. When the Japanese currency is more volatile, U.S. exports of soybeans rise in China and shrink both in Japan and Mexico. Because of the high risk associated with high Japanese exchange rate volatility, exports tend to shrink in Japan and be diverted to China. This causes increased exports to China but the effect on exports to Mexico was not significant. However, the impact of exchange rate volatility on the Mexican Peso led to a reduction in U.S. soybean exports but increased U.S. exports to Japan and China. Because of the higher volatility of the Peso to the U.S. Dollar rate, the U.S. exporter prefers to export to Japan and China rather than to Mexico. The effects on all three countries are statistically significant at 0.01 levels. The cross effects of exchange rate volatility were ambiguous which can be explained within the big picture of the countries' trade relationships. For example, Japan and the U.S. have been traditional trade partners and have unique positions in bilateral trade. Similarly, Mexico and the U.S. are neighbors, and so they also share special trade relationships. These factors also have effects on U.S. exports and exchange rate volatility. Thus, competitors' exports have also a significant effect on U.S. soybean exports. In most cases, the high volume of exports from either Brazil or Argentina, negatively affects U.S. soybean exports.

Table 2. Parameter estimates of explanatory variables for soybean (U. S. export: Dependent variable)

Variables (log of)	Definition	China		Japan		Mexico	
		Estimate	Std Error	Estimate	Std Error	Estimate	Std Error
US_Pr	US Export Price	-0.0236*	0.0038	-0.0071*	0.00105	0.0055*	0.0022
BR_Pr	Brazilian Export Price	0.2862*	0.0516	-0.0133	0.01392	0.0939*	0.0290
AR_pr	Argentina Export Price	0.4686*	0.0782	0.0217	0.02111	-0.1460*	0.0439
vol_ch	Exchange rate volatility of Chinese currency	-0.0021*	0.0008	-0.0004	0.00023	0.0044*	0.0005
vol_JP	Exchange rate volatility of Japanese currency	0.0055*	0.0021	-0.0042*	0.00079	-0.0002	0.0016
vol_mx	Exchange rate volatility of Mexican currency	0.0009	0.0007	0.0005*	0.0002	-0.0025*	0.0004
Lag of dependen t variable	US export to China	0.9710*	0.0043	0.0009	0.0012	-0.0074*	0.00245
	US export to Japan	0.0640*	0.0117	0.99677*	0.0032	0.0229*	0.00657
	US export to Mexico	-0.041*	0.0087	0.00247	0.0024	0.9834*	0.00492

* - Significant at 0.01 level of significance.

Though soybeans and soy oil are joint products, the soybean oil exports equation was estimated as a separate VAR model because of the dimensionality issue for estimation. The parameter estimates for soy oil presented in Table 3 reveal that the U.S. export price negative affects the quantity of soy oil exports to China and Japan. However, it had positive effects on export quantity to Mexico. Thus, the soybean oil export quantity has an ambiguous relationship with its own export price. Competitor prices also had mixed effects. The Brazilian export price had a positive impact on U.S. exports to China and Japan while it had a negative impact on exports to Mexico. However, Argentina's export price had a positive effect on U.S. exports of soybean oil. Exchange rate volatility also had an ambiguous effect on the U.S. export quantity of soybean oil. The volatility of Chinese currency's exchange rate with respect to the U.S. dollar shows a negative impact on U.S. exports to China, Japan and Mexico. The volatility of the Japanese exchange rate has a negative impact on soybean oil exports from the U.S. to Japan and Mexico and a positive impact on exports to China. The coefficients for China and Mexico are not significant. However, the exchange rate volatility of the Mexican Peso had a positive effect on U.S. exports for all countries including Mexico while coefficients for volatility of the Mexican Peso are not significant. In some cases the results agree with prior expectations whereas some results do not confirm the expectation about the effects of volatility. The ambiguity of this relationship might be resolved by adding other variables that could cause trade variation among the countries of our concern.

Table 3. Parameter estimates of explanatory variables of Soybean Oil (U. S. export: Dependent variable)

Variables (log of)	Definition	China		Japan		Mexico	
		Estimate	Std Error	Estimate	Std Error	Estimate	Std Error
US_Pr	US Export Price	0.0096	0.0216	-0.0130	0.0139	0.0033	0.0042
BR_Pr	Brazilian Export Price	-1.541*	0.4723	1.4517*	0.3048	-0.0196	0.0927
AR_pr	Argentina Export Price	1.4817*	0.4544	1.3994*	0.2932	0.0131	0.0892
vol_ch	Exchange rate volatility of Chinese currency	-0.0350*	0.0096	-0.0032	0.0062	0.004*	0.0018
vol_JP	Exchange rate volatility of Japanese currency	0.0250	0.0349	-0.0110*	0.0025	-0.0017	0.0068
vol_mx	Exchange rate volatility of Mexican currency	0.0104	0.0085	0.0041	0.0054	0.0005	0.0016
Lag of dependent variable	US export to China	0.9917*	0.0025	-0.0032*	0.0016	-0.0006	0.0005
	US export to Japan	-0.0104*	0.0044	0.9870*	0.0028	0.0006	0.0008
	US export to Mexico	-0.0257*	0.0124	-0.0157*	0.0080	0.9950*	0.0024

* - Significant at 0.01 level of significance

Conclusions

In this research, we have evaluated the relationship between exchange rate volatility and U.S. exports of soybeans to China, Japan, and Mexico. Conditional exchange rate volatilities were estimated using an EGARCH model to characterize exchange rate volatility in all three countries. We have evaluated the impact of exchange rate volatility, export prices at the U.S. port, competitor prices, and export quantities (from Brazil and

Argentina) on U.S. soybean exports. The analysis demonstrates the significant impact of China's exchange rate regime change in 2005. The effects of their own exchange rate volatility on U.S. exports were significant for all three importing countries. However, an ambiguous relationship was found within the cross-effects of exchange rate volatility. Similarly, the own-price effects also had a negative impact on exports but the cross-price effects were not similar across the importing countries. There are several variables that affect trade such as free trade agreements, tariff structures, subsidies, quotas, and macroeconomic policies. Further research including some of these variables in the model may explain the ambiguity in some relationships found in this study.

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A Study of Iran's Comparative Costs in Saffron

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Abstract

This study uses a Policy Analysis Matrix approach to evaluate Iran's position in the world market for saffron. Data from 2007 are used to compute different measures of comparative costs. The results, based on various indices, indicate that Iran has a comparative advantage in the production of saffron. The nominal rate of protection on saffron shows that there has been an indirect tax on saffron production during the period of study. The elasticity analyses show that a 10% increase in the world price of saffron and the exchange rate would improve the domestic resource cost index of saffron by 0.067%. The value of the competitiveness index based on export prices was estimated to be 0.33, which shows that Iranian saffron farmers can compete in the world markets.

JEL Codes: Q17, Q18

Keywords: Saffron, Comparative Costs, Comparative Advantage, Policy Analysis Matrix (PAM), Iran

Introduction

Iran is OPEC's second largest oil producing country, but it has been trying to increase non-oil exports in recent years. Among non-oil exports, agricultural products play a major role in the Iranian economy and about 45% of the Iran's non-oil exports belong to the agricultural sector. Iran has been trying to join the World Trade Organization (WTO) and is currently an observer member. Markets in Iran are highly distorted by a host of government policies and this will need to change with WTO membership. In order to be competitive in international markets, it is important to determine which sectors of the economy can withstand international competition so that domestic resources can be channeled to proper sectors while at the same time bring about

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the needed improvements and necessary changes to secure the required structural adjustments.

Among the agricultural products exported from Iran, saffron is a key product. Iran produces about 170 tons of saffron annually, which is close to 85% of total world saffron production. The total land allocated to saffron cultivation is about 41,325 hectares (www.iransaffron.org). The income generated from saffron exports has grown from $34 million in 1999 to $86.3 million in 2006. Despite the fact that Iran is the world's number one producer of saffron, this country is not recognized as the number one producer and exporter. The reason is that many third party countries, such as Spain, Greece, France and Italy, buy Iranian saffron in bulk, repackage it, and export it to other countries with higher added value and price.

Saffron comes from the saffron crocus plant. Among the peculiar characteristics of saffron crocus is that it does not require much water for cultivation. Once it is planted it can be picked (harvested) for many seasons without replanting. In fact the plant's flower, where the saffron emanates, can be picked up to seven consecutive seasons. Saffron itself can be stored for many years without losing its quality and the transportation of saffron is rather easy and does not require heavy machinery. Since saffron is used in producing certain medicines and preparing different exotic dishes around the world, it earns its producers hard currency. Moreover, since saffron does not require high-tech farming machinery for its production, it can easily provide employment in the agricultural sector. Khorasan Razavi and South Khorasan provinces in eastern Iran are the two provinces where over 95% of Iran's saffron is cultivated and produced.

There is no alternative to saffron production in these two regions of Iran. Yet, it is vitally important to these regions to investigate what will happen to the profitability of growing saffron crocuses once liberalization takes place with future WTO accession. This study estimates the comparative costs of Iranian saffron production and looks at the protective indices afforded to this product. Government protection is calculated to determine whether there are explicit/implicit subsidies or taxes levied on saffron. An elasticity analysis is also performed to determine the sensitivity of the above indices to exchange rate changes and the world price of saffron. The computations and estimations are based on production costs and an analysis of protective policies of the government towards this product. A Policy Analysis Matrix (PAM) approach is used to conduct this research. Since most saffron is produced in the two mentioned provinces, the research covers these two areas. The data used are mainly from the Iranian Ministry of Agriculture and the Iranian Department of Commerce.

Background

There are no studies investigating the comparative costs of saffron in Iran. Tayebi and Ghanbari (2008) have used three stage least squares regression over the period 1976-2004 to simultaneously estimate both export demand and supply functions for saffron. They investigated the effects of the main determinants of Iran's saffron exports and explored the impact of Iran's potential WTO accession on saffron exports. Their results show that WTO entry is quite significant in Iran's saffron export promotion.

Paseban (2007) has also studied the determinants of saffron exports in Iran. She used annual data for the 1972-2004 to estimate a double log export supply equation for saffron. She found that saffron exports are not very price sensitive with an export demand elasticity of only -0.25. On the other hand her results show that saffron exports are fairly sensitive to annual saffron yield.

Methodology and Results

Comparative costs play an important role in the field of international trade and several indices have emerged to quantify this concept. Some of these measures are Domestic Resource Costs (DRC), Revealed Comparative Advantage (RCA), Net Present Value (NPV), Profitability Index (PI), and Social Benefit Cost Ratio (SBC). These indices have been criticized at times when they are applied individually, but together they give a good picture of what will happen as the Iranian market is liberalized.

This study uses the PAM approach to study the competitiveness of saffron production in Iran. PAM provides a framework through which one can compute the comparative advantage index, the protection coefficients and the cost competitiveness index simultaneously. These measures can be used to assess the impact of globalization on economic players. The PAM matrix can also be utilized to analyze the economic policies of the government and offer ways to improve them.

Table 1 presents a PAM matrix from Monke and Pearson (1987) and later modified by Masters and Winter Nelson (1995). The first row shows the revenue of a firm (A), the cost of tradable inputs (B), the cost of the non-tradable inputs (C) and the domestic profitability (D). The second row consists of the same elements as the first row except that the computations performed use shadow prices both for the products and the inputs. The third row is obtained by subtracting the elements of the second row from the first row. This row is used to analyze government policies.

Table 1. Policy Analysis Matrix

		cost		
	Revenue	Tradable Resources	Non-Tradable Resources	Profit
Private Prices	A	B	C	D
Social Prices	E	F	G	H
Effects of Divergences	I	J	K	L

As it is evident from the elements of the matrix in Table 1, one must compute the shadow prices of three main groups: the tradable inputs, the non-tradable inputs, and the exchange rates. Shadow prices reflect the real social cost of the resources used in producing a product. This is important because in many developing countries resource prices are distorted by government interventions. If the social profit H >0, this implies that the industry in question has a comparative advantage; but a negative H implies a waste or misuse of resources.

The Impact of the Agricultural Policies of the Government

As was mentioned earlier the elements of the above matrix can be used to analyze the impact of agricultural policies on output. An I greater than zero means that the producer in question receives indirect subsidies and government policies protect him. However, if I < 0, the market price is less than the shadow price and an indirect tax is imposed on the producer. I = 0 implies a situation where the producer is not affected by government policies.

J is the difference between the social prices and the private prices of tradable resources. J > 0 implies that the producer pays more than the social price for the input (a tax). A J less than zero means the producer pays less than the social price for the input (a subsidy). If J = 0, there is neither a subsidy nor any indirect taxes.

K measures the difference in non-tradable input value in producing one unit of output at market prices and social prices. A positive K implies that the producer pays an indirect tax when purchasing inputs, whereas a negative K implies that the producer receives an indirect subsidy. K = 0 means the producer is not affected by government policies.

L shows the difference between the producer's profits at market prices and at shadow prices: L = D - H = I – (J + K). In this relation if D is positive, then despite the government intervention in the market, the producer has a positive profit. If D is negative, the producer is incurring a loss. If D = 0, the producer is at break-even. H shows the producer's profit when both inputs and output are valued at shadow prices: H = E – (F + G). An H > 0 implies a positive social profit and the existence of comparative advantage for the producer in a free trade situation. A negative H indicates that the producer can not compete in a free trade situation if social prices are considered (we assume that international prices reflect social prices) and would lose money. Based on the above arguments the indicator L, which shows the profit discrepancies based on market and shadow prices, could reflect the impact of the government policies on the production of different goods.

The Estimation of Indices for the Policy Analysis Matrix

The Comparative Advantage Indices

The following indices account for comparative costs:

1- The Domestic Resource Cost: DRC = G / (E-F). This relation shows the ratio of domestic costs to the domestic value added (excluding domestic inputs) based on shadow prices. The DRC is a measure of net foreign currency gained (or lost) from producing a particular product. It provides a comparison between the domestic costs to produce a given good with its value added at international prices (Bruno (1963, 1972)). If DRC < 1, the producer enjoys a comparative cost advantage; the opposite holds if DRC > 1.

2- Unit Cost (UCs): In a sense this is a real competitive cost index because all price distortions imposed on inputs as well as output are excluded in this case. UC_s = (F +G)/E. The producer has a comparative cost advantage in the production of the good if $UC_s < 1$; if $UC_s > 1$, the opposite would be true.
3- Net Social Profit (NSP): This index computes the profit using the shadow prices of inputs as well as output: NSP = E - (F + G). If NSP > 0, the production of the good is socially profitable; if NSP < 0, then the producer is creating a social loss.

The Cost Competitive Indices

These indices show whether the country's producers can compete in domestic as well as in international markets:
1- Unit Cost (Domestic) (UC_d): This index shows whether the producer can compete domestically, given the distortions in input and output prices. It is computed by: UC_d = (B+C) / A. The production of the good is domestically cost competitive if $UC_d < 1$; if $UC_d > 1$ it is not.
2- Unit Cost (Export) (UC_x): This index shows whether the producer can compete internationally given the possible distortions in input and output prices brought about by subsidies and taxes. It is computed by: UC_x = (B+C) / E. The producer of the good is internationally cost competitive if $UC_x < 1$; if $UC_x > 1$ the producer is not.

The Protection Coefficients

Protection coefficients show the extent of protection by the government for an industry:
1- The Nominal Protection Coefficient of Output (NPCO): This coefficient measures the ratio of the producer's revenue at market prices to its revenue at shadow prices. This ratio, NPCO = A/E, can be used to measure the effect of government policies on the price of output. If NPCO > 1 then the domestic price of the good is higher than its shadow price, so the producer receives a subsidy. The producer is paying an indirect tax if NPCO < 1.
2- The Nominal Protection Coefficient of Input (NPCI): This coefficient measures the ratio of the cost of tradable inputs at market prices to such costs at shadow prices: NPCI = B/F. When NPCI > 1 the producer is paying an indirect tax and is receiving a subsidy if the coefficient is less than one.
3- The Effective Protection Coefficient (EPC): This coefficient shows the ratio of the value added of the tradable inputs at market prices to the value added of the same inputs at shadow prices: EPC = (A-B) / (E-F). An EPC > 1 implies that government policies are distorting prices in favor of the good's production; an EPC < 1 shows the opposite.

Determining the Shadow (Social) Prices

Shadow prices for non-tradable inputs, tradable inputs and exchange rates need to be computed in order to complete Table 1. Shadow prices reflect the real social cost of the resources used in producing a product. This is important because in many developing countries resource prices are distorted by government interventions (Najafi and Mirzaee, 2003).

1. The Shadow Price of Tradable Inputs**:** An input is considered tradable if it can be exported or imported. To determine the shadow price of such inputs one uses their world price. The CIF[2] and FOB[3]prices are used for inputs imported and the inputs exported, respectively. Shadow prices for the following inputs are computed: chemical fertilizers, pesticides, saffron crocus and machinery.
2. The Shadow Price of Non-Tradable Inputs**:** Inputs such as labor, land, capital, water and animal fertilizer are considered non-tradable in the production of saffron. The calculations of these prices are available from the authors upon request.
3. The Shadow Price of Saffron**:** The FOB price of saffron was multiplied by the exchange rate's shadow price. Transportation and the handling costs are then subtracted to obtain saffron's shadow price.
4. The Shadow Price of Exchange Rate**:** Londero and Cervini (2003) used the following formula to estimate the shadow price for the exchange rate: $SPR = RER\dfrac{M + T^m + X - T^x}{M + X}$ where SPR is the shadow price of the exchange rate, RER is the real exchange rate, M is the value of imports in terms of CIF prices, X is the value of exports in FOB prices, T^m is taxes on imports and T^x is taxes on exports. Based on Dehghani (2003), we used the following relation to compute the real exchange rate: $RER = ER.\dfrac{WPI}{CPI}$ where WPI and CPI are, respectively, the wholesale price index abroad and the domestic consumer price index. Since most products enter Iran through third party countries which are major US trade partners, the wholesale price index of the US is used in the above relation. The real exchange rate is calculated at 8680 (Iranian) Rials per US dollar based on the equation and the shadow price of the exchange rate is 8876 Rials.

Setting up the Policy Analysis Matrix (PAM)

Table 2 shows an estimated policy analysis matrix for saffron. The revenue from one hectare of saffron based on shadow prices is 17,950,000 Rials more than the revenue for the same amount of saffron based on market prices. The revenue using the shadow prices is 1.6 times the revenue of saffron based on market prices. Therefore, we can claim that a 60% tax has been imposed on saffron production.

Since K is -24,700,000 Rials this implies that the market or private prices for non-tradable inputs are less than their shadow prices, so the producers receive an indirect subsidy for such inputs. Government actions have caused a 68% cost reduction for the producer. According to Table 2, J is -1,180,000 Rials; the market costs of tradable inputs

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[2] Cost, Insurance and Freight
[3] Free on Board

to the producer are lower than their shadow or social costs for these inputs. Thus saffron producers are receiving a 57 % subsidy on tradable inputs.

The producer's profit at market prices, D, is 13,560,000 Rials, so saffron production at current market conditions is profitable. Profit at shadow prices (H) is also positive (5,630,000 Rials), so saffron production is profitable at shadow prices too. Since L > 0 (13,560,000 – 5,630,000 = 7,930,000) we conclude that saffron production at market prices is more profitable than at shadow prices. Thus the subsidies on saffron more than compensate for the taxes. In the next section we compute and analyze the different comparative advantage indices discussed earlier.

Table 2. PAM for the output of one hectare saffron plantation 2008 (Rials)

		Cost		
	Revenue	**Tradable Resources**	**Non-Tradable Resources**	**profit**
Private Prices	29,500,000	1,340,000	14,600,000	13,560,000
Social Prices	47,450,000	2,520,000	39,300,000	5,630,000
Effects of Divergences	-17,950,000	-1,180,000	-24,700,000	7,930,000

Computing the Indices in a PAM Framework

Table 3 shows the values for the three Comparative Cost Indices associated with saffron production. The DRC is 0.87, so at social prices, increased domestic production of saffron costs 0.87 while generating 1.00 in income from the international market, which implies that Iran has a comparative cost advantage in saffron production. The UC_s is also less than one which implies that saffron production is profitable given current market prices. Therefore, with UC_s equal to 0.88, Iran would have an advantage in saffron under competitive conditions (the situation that Iran will move towards when it becomes a member of WTO and shadow prices prevail in the country). The fact that NSP is positive indicates that the production of saffron is socially profitable, generating 5.63 million Rials per hectare.

Table 3. The Comparative Advantage Indices for the Output of One Hectare Saffron Plantation 2008 (Rials).

Comparative Advantage Indices	Abbreviation	Value
Based on Domestic factors	DRC	0.87
Based on unit costs	UC_s	0.88
Net social profit	NSP	5,630,000

The Protection Coefficients

Table 4 shows coefficients of protection awarded to saffron producers. Since the NPCO is less than one, the market price of saffron is less than its shadow price. So the producer pays an indirect tax while producing saffron. The NPCI index is less than one which implies that inputs are being subsidized. The value of EPC is also less than one, which means that in aggregate, government policies have not favored the production process of saffron. Thus if input and output price distortions in the saffron market were eliminated, there would be increased incentives for saffron production.

Table 4. Protection Coefficient Indices for Saffron Production, 2008

Protection Coefficients	Abbreviation	Percentage
Nominal Protection Coefficient of Output	NPCO	0.62
Nominal Protection Coefficient of Input	NPCI	0.53
Effective Protection Coefficient	EPC	0.62

The Cost Competitiveness Indices

Cost competitiveness indices indicate whether saffron can compete in domestic and international markets. Table 5 shows that all the indices for saffron are less than one, so saffron producers can compete both domestically and internationally. This gives increased evidence that liberalizing policies will increase saffron production in Iran.

Table 5. The Cost Competitiveness Indices for the output of one hectare saffron plantation 2008 (Rials)

	Abbreviation	**Percentage**
Unit Cost (Domestic)	**UC_d**	0.54
Unit Cost (Export)	**UC_x**	0.33

Elasticity Analysis

Table 6 presents the elasticity of all variables with respect to the exchange rate and the price of saffron. This will indicate what will happen with costs and profitability of saffron production if government policies change. Since the relationships are nonlinear, we changed the exchange rate and saffron price in three 10% increments, respectively, to compute the elasticities. Therefore, the reported elasticity is the average from a 10% increase in price, a 20% increase in price, and a 30% increase in price.

The elasticity of DRC with respect to the exchange rate is -0.067, indicating that there is an inverse relation between the exchange rate and the domestic resource costs. A

10% depreciation in the Rial lowers this index by 0.67%, which improves the country's comparative costs. As this index moves toward unity the producer's comparative costs improve when government interventions in the saffron market stop. The elasticity of DRC index with respect to saffron price is -0.053. The negative sign indicates that an increase in the saffron price increases the producers' comparative advantage.

Table 6. Index Elasticities with respect to Exchange Rate and Saffron price

Index Name	Abbreviation	With respect to Exchange Rate	with respect to the Price of Saffron
Domestic resource costs	DRC	-0.067	-0.053
Comparative advantage based on unit costs	UCs	-0.071	-0.056
Net social profit	NSP	0.222	0.108
Nominal protection coefficient of output	NPCO	-0.045	-0.333
Nominal protection coefficient of input	NPCI	-0.04	0
Effective protective coefficient	EPC	-0.063	-0.031
Competitiveness based on Domestic Prices	UC_d	0	0
Competitiveness based on Export Prices	UC_x	-0.077	-0.047

The elasticity of NSP with respect to the exchange rate is 0.222 which implies that with a 10% increase in the exchange rate improves the profitability of saffron by 2.2%. The elasticity of NSP with respect to the saffron price is 0.108, which shows a positive relation between saffron price and its profitability. The elasticity of NPCO with respect to the exchange rate and saffron price is -0.045 and -0.333, respectively. These elasticities imply that as the exchange rate depreciates and the saffron price increase, less protection is afforded to saffron production. The elasticity of NPCI with respect to the exchange rate is -0.04 which indicates an inverse relation between this index and the exchange rate. If the exchange rate depreciates by 10%, the NPCI will fall by 4%, bringing private costs from tradeables closer to social costs. The NPCI is not affected by the saffron price because it only involves tradeable inputs.

The elasticity of the EPC index with respect to the exchange rate and saffron price is -0.063 and -0.031, respectively. A 10% increase in these variables lowers the protection afforded saffron production by 0.63% and 0.31%, respectively. The competitiveness index based on Domestic Prices (UC_d) is not affected by the exchange rate or saffron price. The elasticity of UC_x index with respect to the exchange rate and saffron price is negative.

Concluding Comments

This research analyzed the comparative costs and export potential of saffron, known as Iranian gold. The Iranian market is much distorted on the input and output side, so this analysis is important to sort out the net impacts of these policies. The results, based on the comparative cost indices, including DRC and UCs, indicate that Iran has a comparative cost advantage in the production of saffron. Moreover, the nominal rate of protection on saffron shows that there has been an indirect tax on saffron production during the period of study. In other words government agricultural policies as a whole have penalized saffron growers.

The elasticity analyses show that a 10% increase in the world price of saffron and Iranian Rial would improve the Domestic Resource Cost Index of saffron by 0.67%. The value of the competitiveness index, based on export prices, was estimated to be 0.333, which shows that Iranian saffron farmers can compete in the world markets. Based on these results the amount of land allocated to saffron production in Iran should be increased. However, the elasticities are not very large in absolute value, indicating that changes in the exchange rate and saffron price do not have a huge impact on the competitiveness indices. Nonetheless, Iran already has a substantial comparative cost advantage in saffron.

The geography and the climate conditions of Iran and market conditions call for increased saffron production. Joining the WTO should benefit saffron growers because Iran has a comfortable comparative advantage in saffron production. Also, since saffron is produced in provinces where people on the average earn less income than the rest of the population, the expansion of saffron production is recommended to reduce poverty, especially because saffron production does not require any sophisticated or advanced technology.

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THE GLOBAL ECONOMIC CRISES AND THEIR EFFECTS ON FOOD AND NUTRITION SECURITY IN SRI LANKA

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Abstract

Sri Lanka heavily depends on the world market to meet the demand for some of its main food items, i.e., wheat, sugar, milk powder, and pulses and hence it is expected that the recent global crises situations, which have resulted in increased food and petroleum prices, have caused significant adverse effects on household food and nutrition security in Sri Lanka. It is highly likely that such adverse effects are associated with distributional implications as the economy is characterized by disparities in accessibility to food among households of various income classes, as well as sectors and regions. The overall objective of this paper is to assess the likely effects of the recent global crises on household food and nutrition security in Sri Lanka. The specific objectives are to (i) compute the changes in food prices during the pre global crises vs. global crises periods, and (ii) simulate the likely changes in household food consumption patterns, expenditure on food, and nutrient intake levels due to changes in world prices. A conceptual model was developed to accommodate changes in food prices and petroleum prices (which has an indirect effect on food consumption by lowering the budget allocation on food) in the world market, the degree of transmissions of prices to the local economy, elasticities of demand for food with respect to prices and expenditure, the relative importance of the food items as a source of nutrients and expenditure. An econometric analysis was performed using world market prices prevailed during July 2007-December 2009 and a simulation analysis was performed using food consumption data and estimates of demand and price transmission elasticities. The results of analysis show that prices of rice, wheat, milk and petroleum oil increased by 75%, 37%, 32%, 40% respectively during the food crisis period and changed by 64%, -29%, -50% and -25% respectively during the times of financial crisis when a growth in prices was as in the pre crisis period was considered in comparisons. The findings of the simulation analysis show a fall in energy and protein intakes at rates of 7.07% and 5.19% during the food crisis and a rise in the same at the rates 2.93% and 3.69% during financial crisis respectively at the national level. Further analysis reveal that increase in other food prices influenced the changes in nutrient intake more than that of cereal prices, due to inelastic nature of cereal demand, despite the rise in prices and its importance in Sri Lankan diet. The findings also suggested that the

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households residing in urban areas would have been more adversely affected than those who live in rural and estate sectors as the urban population of the country rely more on imported food items. Furthermore, households belonging to lower-income deciles who are already under-nourished were also found to be more vulnerable.

JEL Codes: F10, I30, N50

Keywords: Global Food and Financial Crisis, Household Food and Nutrition Security, Sri Lanka

Introduction

The economy of Sri Lanka has been highly trade dependent with a trade dependency ratio of approximately 60%. Garments, remittances, tea, transport services, rubber based products and tourism are the major foreign exchange earners of the country and they contribute 26.4%, 22.2%, 9.7%, 7.6%, 4.1% and 2.6% respectively (Central Bank of Sri Lanka, 2008). While the country has been self sufficient in terms of staple food (rice) over the past two decades, it depends heavily on the world market for many other food items such as wheat, sugar, milk powder, and pulses. According to the Department of Census and Statistics, the self sufficiency ratios of the country were 7% for sugar, 11% for milk powder, 22% for pulses and nuts, 41% for dried and salted fish, 79% for cereals, 86% for vegetables, 93% for fruits and almost 100% for meat, eggs, fresh fish and oil & fat in 2007. Consequently, one could expect to have varying adverse effects of recent global food and financial crises (in terms of food and nutrition security) on households depending on socio-economic segments they belong to.

Few studies have been carried out with the objective of assessing the impacts of the global food crisis on the Sri Lankan economy. Samaratunga (2008) contends that the crisis in the Sri Lankan food market during the times of high food prices in the world market (*i.e* 2007-2009), particularly for rice, is not merely due to global rice crisis. The same author further argues that the key reason behind the crisis in Sri Lankan food market is inadequate investment in agricultural research. Weerasooriya *et al.* (2010) have pointed out that the world market prices have not been fully transmitted to the domestic economy, partly due to agricultural and food policy responses of the government. They further argue that the country's dependency on imported food is small as large masses of rural poor rely heavily on locally grown food for consumption. There is a dearth of studies on the impact of food crisis on the wellbeing of various socio-economic segments (by province, sector and by income class) of the country. However, significant distributional implications on different socio-economic groups are inevitable due to varying food consumption patterns and sources of income shown by different socio-economic groups of the population (Department of Census and Statistics, 2006/2007 and Central Bank of Sri Lanka, 2003/04).

The overall objective of this paper is to assess the likely effects of the recent global crises on household food and nutrition security in Sri Lanka. The specific objectives are to (i) compute the changes in food prices during the pre global crises vs. global crises periods, and (ii) simulate the likely changes in household food consumption patterns, expenditure on food, and nutrient intake levels due to changes in world prices.

The paper first attempts to provide background information on food situation and the key characteristics of different households belonging to various socio-economic segments, followed by the review of literature and the presentation of the conceptual model adopted in this study for analyzing the impacts of global food and financial crisis. The paper then presents the data and data sources required for analysis, analysis of findings and ends with the conclusions and suggestions for further research.

Food Security Status in Sri Lanka

Food Consumption, Production and Trade at the National Level

Though Sri Lanka has been traditionally considered as an agricultural country, the country depends on the world market for some of the key food items. Table 1 shows the food production, imports and availability in Sri Lanka in 2007 (Department of Census and Statistics).

Rice self- sufficiency ratios have been closer to 100 (97.47 percent in 2006) for the last decade and a sharp decline in rice imports is hence evident. However a lower self sufficiency ratio of cereal is evident as there is a substantial increase in the consumption of wheat (*i.e.* the other main cereal commodity in the Sri Lankan diet) which is solely imported.

Vegetable production in the country more or less fulfills the domestic demand. Fruit can be cited as a commodity which enjoys near self sufficiency as reflected by self sufficiency ratio of about 93 percent. Of fruit production, lime and mango have been the largest which is followed by papaw, banana and pineapples. Fruit production seems to have a much greater potential with the appropriate post- harvest technologies for further processing. Lack of improvement in transportation, storage and marketing seem to be the bottlenecks in distributing fresh fruits during the off season and to areas that do not have an adequate production.

Legumes play a considerable role in the Sri Lankan diet and the annual per capita consumption of pulses in the country is 8 kg (FAO, 2009). They provide much-needed plant protein to most of the low-income groups who are mainly not in a position to afford animal protein sources. Mungbean, cowpea, black gram, soybean, and pigeon pea, are the most common grain legumes, that are mainly grown under rain fed conditions. Most of the legumes provide about 50 percent of starch and 25 percent of protein, and rich with vital minerals and vitamins as well. *Maisoor dhal* (red lentils) and chickpea can be cited as the major imported pulses to the country. Attempts to cultivate red lentils in Sri Lanka have failed due to the poor adaptation of the crop to local conditions, but newly developed cultivars of chickpea show some promise.

Self sufficiency ratio for sugar in 2007 was found to be around 7 percent. The high cost of establishing new factories and the limited availability of suitable land for

Table 1. Availability food and nutrients in Sri Lanka by product categories; 2007

Product category			Supply at National Level (000 Metric tons)				Per Capita Availability		
			Production	Gross Imports	Available Supply	Self sufficiency ratio	Calories per day	Protein gms per day	Fat gms per day
Cereals			3,193.10	834.26	4,027.90	0.79	1258.64	27.71	2.13
Roots, Tubers & Other Starchy Food			346.48	85.93	432.41	0.80	56.85	0.50	0.07
Sugar			33.46	470.52	506.15	0.07	266.10	-	-
Pulses & Nuts			34.01	121.01	155.02	0.22	72.82	5.00	1.02
Vegetable (including Onions)			979.76	164.48	1,137.82	0.86	75.57	3.64	0.50
T. V. P.			3.50	0.06	3.57	0.98	1.81	0.24	0.01
Fruits			523.35	37.41	555.13	0.93	76.20	0.86	0.23
Meat			128.97	0.96	129.93	0.99	22.96	4.20	0.69
Eggs			51.91	-	51.91	1.00	12.08	0.93	0.93
Fish	(i)	Fresh	291.05	10.92	282.61	0.96	22.18	3.23	0.91
	(ii)	Dried & Salted	36.20	51.75	87.95	0.41	29.50	6.11	0.48
	(iii)	Tinned Fish	-	23.69	23.69	0.00	5.58	0.68	0.32
Milk	(i)	Fresh	170.61	-	170.61	1.00	12.25	0.54	0.81
	(ii)	Whole Dried	7.24	61.60	69.15	0.11	46.86	2.44	2.52
	(iii)	Condensed	5.00	0.42	5.42	0.92	2.41	0.06	0.06
	(iv)	Milk Food (Yogurt etc.)	2.89	0.05	2.94	0.98	0.24	0.01	-
Oil & Fats (including Coconut)			1,136.00	24.86	1,101.67	0.98	395.08	2.95	38.15
Total							**2357.11**	**59.11**	**48.85**

Source: Food Balance Sheet, 2007, Department of Census and Statistic sugarcane cultivation has been be given as the main obstacles to the expansion of the sugar production in Sri Lanka.

The major share of oil and fat requirement of the country is supplied by coconut oil. Palm oils, palm stearin, palm kernels, soya, sunflower and corn oil can be cited as the major imported substitutes for coconut oil. Although low tariff rates have been introduced on imported edible oil, 97 percent self sufficiency ratio for oil and fat (as of 2007) indicates that the country still heavily depends domestic products for fulfilling its oil and fat requirement.

Although a reasonable growth in the cow milk production is evident, Sri Lanka relies heavily on imported milk and milk products, especially milk powder, in order to meet its growing consumer demand. Approximately 10 percent of the powdered milk requirement was produced domestically in 2007.

Fish production, especially deep sea fishing, has registered a substantial growth from the 1990s. Although the local fish production has met only half of the country's requirements in 2000 the self sufficiency ratio of fish has risen to about 70 percent in 2007. Fish consumption at the aggregate level in Sri Lanka has increased mainly for fresh water fish (which can be cited as cheaper animal protein) and aquaculture- based fish products.

Red meat consumption is traditionally low in Sri Lanka and the cattle faming for meat consumption purpose is not practiced commercially either. The current red meat requirement is fulfilled through slaughtering of less productive culled animals. Although meat production in the country with respect to other animal species has not expanded, a substantial growth in the poultry sector is evident.

Patterns of Expenditure by Socio-economic Groups in Sri Lanka

A satisfactory status of food security at the national level does not imply a satisfactory status of food security at the household level as the household food security is primarily dependent upon the economic, social and physical accessibility of food by the households. In this context, socio-economic characteristics of the household such as income sources and expenditure patterns, food preferences and access to and the status of infrastructure play significant roles. The socio-economic statistics published by the government agencies in Sri Lanka classify households into various segments based on residential sector (urban, rural and estate), income levels (by income decile), and province of residence.

Urban households found to be spending 31.2 percent on food items and the respective shares as per 2006/2007 household expenditure and income survey (Department of Census and Statistics, 2006/07) were 38.7 percent for rural 55.8 percent for estate sectors respectively. A similar pattern was observed in upper quintiles compared to that of lower quintiles. A household belonging to fifth quintile spent 27.1 percent on food items, whereas a household in the first quintile spent 61.1 percent. The percentage food expenditure was found to be lowest in the Western province and highest in the Eastern province. These findings comply with the accepted norm that the percentage of income spent on food decreases with increase in income.

An average household spends 16.1% on cereals, 9.3% on condiments, 8.6% on fish, 8.7% on milk products, 8.4% on vegetables, and 4.2% on meat out of the total food expenditure with significant disparities observed across sectors. The estate sector records the highest expenditure level on cereals (29.8%) whereas it is 11.2% in the urban sector and 16.4% in the rural sector. The percentage spent on meat (6.1%) and fish (11.3%) is quite higher in the urban sector. Rural people spend more on dried fish whereas both fish and dried fish consumption by the estate sector is found to be small. The regional disparities are visible in terms of cereal consumption. Households in agricultural provinces such as Uva (22.2%) and Sabaragamuwa (20.5%) spend more on cereals and the households in the Western province spend the least (12.6%) on cereal consumption. A special pattern is observed in the Eastern province as the household expenditure deviates from national averages as they spend above the national average on meat and fish and below the national average on pulses, coconut, vegetables and dried fish.

Available national average figures show that wheat flour-based products and take away food preparations constitute a significant portion of the food consumption expenditures in the recent past.

It should however be noted that the dependency of household on imported items is proportionately higher by the urban households. Furthermore it is evident that the dependency of households on cereals is higher for both energy and protein intakes.

Table 1 above also depicts the per capita availability of calories, proteins and fats in Sri Lanka based on the availability of food at the national level in 2007 (Department of Census and Statistics). According to the Department of Census and Statistics (2006/07), the average per capita energy consumption for all the households was estimated at 2110 kilocalories per person per day for the 2006/07 survey period. The corresponding figure for the poor households was 1696 kilocalories and for non-poor it was 2194.

Past Studies on Global Crises

Headey and Fan (2008) analyzed causes of the food crisis and provided an appraisal of the likely macro and microeconomic impacts of the crisis on developing countries. Microeconomic impacts were investigated due to increased cost of living and changes in macroeconomic conditions. Growth in demand from China and India, financial market speculation, export restrictions, weather shocks, productivity slowdown, low interest rates, depreciation of the USD, rising oil prices, biofuel demand and decline of stocks have been identified as potential causes. Zezza et al. (2008) found that most vulnerable households across 13 developing countries are: urban or rural nonfarm, larger, less educated, more dependent on female labor, less well served by infrastructure, and, households with limited access to land and modern agricultural inputs within the rural farn sector.

According to ADB (2008) the underlying causes of the recent surge in global food prices, particularly relating to the prices of cereals, can be of two forms as cyclical and structural. The cyclical factors are short-term phenomena that will ease over the years but the structural factors are medium to long term. The cyclical factors included; the random adverse weather conditions (flooding, pest infestations, cold weather, etc.) that have reduced harvests in key producing countries, depreciation of the United States dollar against major currencies, precautionary demand for food stocks in many countries, and policy responses (export bans, price floors) of key rice-exporting countries to domestic inflation, including China, Pakistan, Viet Nam, and India. Structural factors include rising energy prices that have caused higher cost of agricultural inputs like fertilizer and fuel, increased demand for bio-fuels, land diversification for urban/industrial uses, low and stagnated food grain productivity, policy inadequacies and weak institutions, steadily increased demand for food grains in Asia (see Ahmed, 2008 and Mitchell, 2008 for further details).

The extent to which household food security is affected by international food prices depends critically on the degree to which international food price increases are passed on to domestic prices. A number of studies have reported that the price impacts have been most pronounced in import dependent countries. From 2007 to 2008, domestic rice prices have doubled in Bangladesh and Cambodia and have increased by 70% in Afghanistan, and by 40% in the Philippines, while domestic wheat prices have increased by 36–100% in Bangladesh, Mongolia, Pakistan, Kyrgyz Republic, and in Tajikistan (ADB, 2008). However, according to Dawe (2008), who analyzed data from seven Asian countries during the food price crisis, high international food prices have only been weakly transmitted to domestic prices.

Haq et al. (2008) estimated price and expenditure elasticities and used them in deriving quantities consumed food expenditure and poverty in Pakistan. The results showed that poverty would have been increased by 35% and the effects would be severe in urban areas.

Jensen and Miller (2008) examined the impacts of increases of world food prices on consumption and nutrition of poor households in two Chinese provinces using primary data gathered through a survey. The results showed that the overall nutritional impact of the world price increase was small on households as the domestic prices of staple foods remained low due to government intervention in grain markets and the households were able to move to cheaper foods. It was also found that households were able to buffer the calorie intakes of children and there is no any evidence of any differential treatment of boys and girls. Food expenditure was increased in one province and it was largely unchanged in the other.

Conceptual Model

A conceptual model (i.e. figure 1) was developed, based on the above reviewed literature, in order to identify the ways in which world market prices influence household food and nutrition security of a small open economy such as Sri Lanka (figure 1). World market prices are considered as exogenous shocks and the price transmission elasticities (which capture the effects of government policies, currency exchange rate and the structure of markets), determine the degree to which world prices are translated into prices of commodities in the domestic market.

Food prices and petroleum oil prices are considered as the two key primary transmission channels of global shocks. An increase in domestic food prices is assumed to cause a reduction in food consumption levels depending upon the price elasticities of demand. Furthermore, it is assumed that in the context of inelastic demand for petroleum, an increase in domestic petroleum prices could lead to a reduction in food expenditure and thereby reduce food consumption.

However, the conceptual model does not take into account the capital and financial flows, trade in services (such as tourism and migrant workers), increase in export prices, employment and wages as it was assumed that such changes are immaterial as only short run effects were investigated in the analysis.

Empirical Model

Two distinct periods can be identified during the recent global crises situation, i.e., food crisis period and global financial crisis (GFC) period. First, an analysis was performed to identify the magnitude of changes in food prices and second, a simulation analysis was performed to assess the degree to which such price changes influence food consumption levels and nutrient intake levels.

Analysis of Price Changes

The percentage changes in food prices during these two periods were compared with the pre-crisis levels under two scenarios; A and B. In Scenario A, counterfactual price levels were assumed to be same as pre-crisis average prices (i.e., before and after comparison) and in Scenario B, counterfactual price levels were assumed to follow the natural trend as in the pre-crisis average prices (i.e., with and without comparison).

The differences between the two scenarios are shown in Figure 2. Suppose that the actual prices increase at a slower rate during the pre-crisis period, increase at a rapid rate during the food crisis period, and decrease during the GFC period. The changes in such are depicted by the solid line in Figure 2. The average prices prevail during the three periods, pre-crisis, food crisis and GFC are labeled as P_1, P_2 and P_3 respectively. Under scenario A, the percentage change in prices during the food crisis and GFC periods are given by $(P_2-P_1)*100/P_1$ and $(P_3-P_1)*100/P_1$ respectively. Under scenario B, a natural growth in prices as in the pre-crisis period is assumed (depicted by the dashed line in Figure 1). The average prices that would prevail during the food crisis and GFC periods if crises have not occurred are marked as P_4 and P_5 respectively. Accordingly, under scenario B, the percentage change in prices during the food crisis and GFC periods are given by $(P_2-P_4)*100/P_4$ and $(P_3-P_5)*100/P_5$ respectively. The growth rates during the pre-crisis period were estimated using pre-crisis actual world market prices (nominal prices in US dollars), in log linear functional forms using Ordinary Least Squares, to obtain P_2 and P_4.

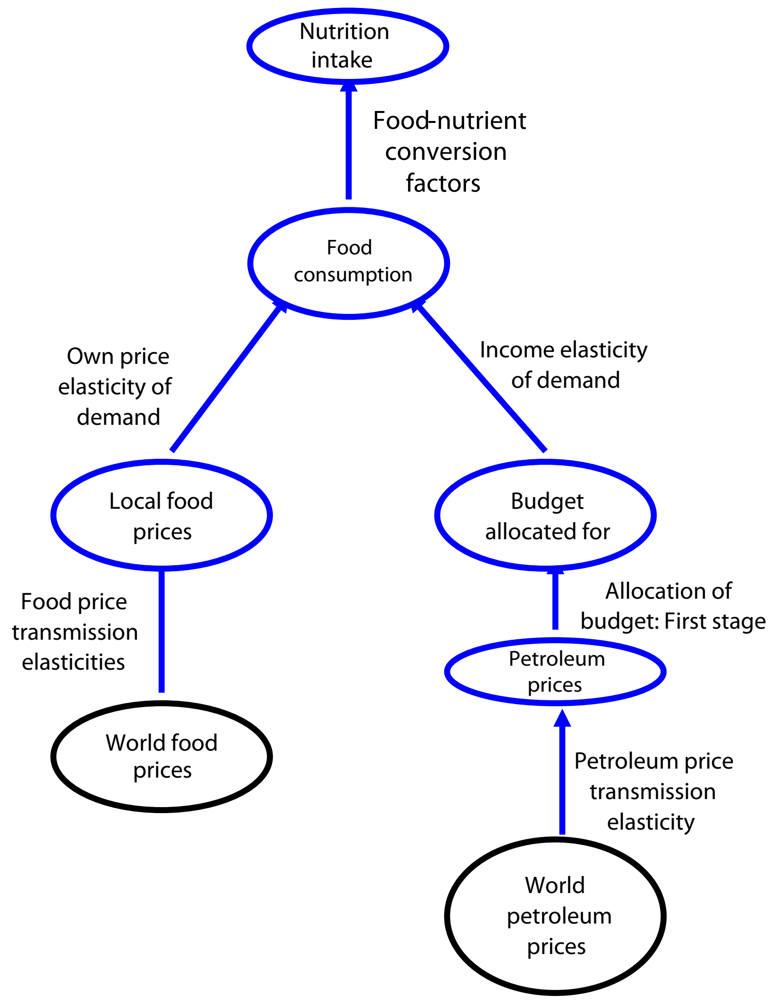

Figure 1. The conceptual model.

The extra expenditure incurred (saved) due to increases (decrease) in petroleum prices were computed using the changes in petroleum prices under scenario A and B during food crisis and GFC. They were expressed as a percentage of total food expenditure and were treated as the drop in the food budget[1].

[1] Suppose that consumer maximizes utility in two stages. In the first stage, the decision is made on the allocation of budget among different commodity categories, *i.e.,* food, fuel, clothing etc., based on the average prices of different commodity categories, total budget, and preferences. In the second stage, the decisions are made on the allocation of budget of a category among various items within the category based on the prices of different items within a category, budget allocated for the category and preferences. It is assumed in this study that demand for fuel is perfectly inelastic and the extra expenditure incurred due to high fuel prices will be taken from the budget allocated for food. Even though this assumption seems unrealistic it shows the maximum possible effect of higher fuel prices on food consumption. In the sensitivity analysis one of the alternative scenarios relaxes this seem to be unrealistic assumption and results were obtained assuming that the budget allocation for food is unaffected by the rise in fuel prices.

Analysis of Food Consumption and Nutrition lntake

A rise in food prices will cause a reduction in consumption of food and the magnitude of which is determined by the price elasticities of demand. Similarly a drop expenditure causes a reduction in consumption of food and the magnitude is determined by the income elasticity of demand.

Assuming that the cross price effects are negligible, the level of food consumption is given by:

$$\hat{D}_i = [\eta_i^p * \%\Delta P_i + \eta_i^m * \%\Delta M] + \overline{D}_i]$$

Where:

$\hat{D}_i$ = Level of consumption of the i^{th} food item after the crisis

$\overline{D}_i$ = Level of consumption of i^{th} product item before the crisis

η_i^p = Elasticity of demand of the i^{th} food item with respect to price

η_i^m = Elasticity of demand of the i^{th} food item with respect to income

$\%\Delta P$ = Percentage change in the price of i^{th} food item

$\%\Delta M$ = Percentage change in income

The change in local prices depends on price transmission elasticity and the percentage change in world market price:

$$\%\Delta P_i = \sigma_i * \%\Delta P_i^w$$

Where:

$\%\Delta P_i^w$ = Percentage change in world price of i^{th} food item

σ= Price transmission elasticity

The levels of nutrient intake are given by:

$$\hat{N}_j = \sum_{i=1}^{n} \alpha_{ij} \hat{D}_i$$

$$\bar{N}_j = \sum_{i=1}^{n} \alpha_{ij} \bar{D}_i$$

Where,

$\hat{N}_j$ = Intake of j^{th} nutrient after the crisis

$\bar{N}_j$ =Intake of j^{th} nutrient before the crisis

α_{ij} = Content of j^{th} nutrient in i^{th} food item

Accordingly, the overall impact on the household is determined by the magnitude of prices changes of food items in the world market, the degree of transmissions of such prices to the domestic economy, the magnitude of the changes in expenditure of households, elasticities of demand for food with respect to prices and income, the proportion of expenditure incurred on the food items that are subject to price changes and the nutrient contents of the respective food items. In this context, the higher the change in food prices and expenditure levels due to the global changes, the higher the absolute values of elasticities of demand with respect to price of food and income, and the higher the contribution of the food items to expenditure, energy intake and protein intake the higher the impacts of the global changes would be at the household levels.

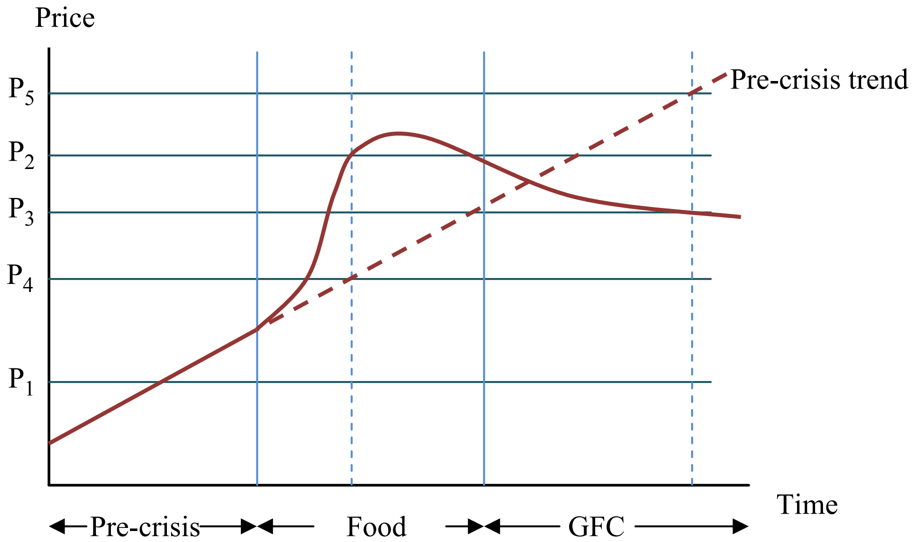

Figure 2. Average prices during pre-crisis, food crisis and GFC periods under alternative scenarios

The food consumption expenditure levels are given by:

$$\hat{EXP} = \sum_{i} \hat{D}_i * P_i (1 + \% \Delta P_i)$$

$$\bar{EXP} = \hat{\sum} \bar{D}_i * P_i$$

Description of Data and Data Sources

Food Consumption Levels and Nutrient Intake Levels: The levels of consumption of 236 food items and their respective expenditure levels were extracted from the Household Income and Expenditure (HEIS) survey conducted in 2006/07 by the Department of Census and Statistics of Sri Lanka and (the food items for which zero consumption quantities are recorded were excluded from the analysis). Food-nutrient conversion factors for calculating levels of energy and protein intake were obtained from standard food composition tables compiled by various Sri Lankan and international agencies[23]. Appendix Table 1 provides composition of major food items in different food categories. Edible portion in each food item was obtained from the standard food composition tables for the items available and guess estimates were made for the rest. In instances where quantities of food consumption was provided in units other than weight (such as bunches, numbers *etc.*) the relevant units were converted to grams by weighing a sample of the food item.

Expenditure on petroleum and related products: Expenditure on petroleum products (trains, bus, van, taxi, three wheelers, school transport, ships and airlines, other transport expenses, petrol and other fuel, lubricating oil, LP gas and Kerosine oil) were obtained from the HIES.

Elasticity estimates: The estimates on demand elasticities with respect to prices and income were obtained from Tudawe (2001) for different subgroups of households. Appendix Table 2 shows approximations made in assigning elasticity values for various food items and Table 2 and 3 shows average elasticity estimates for different food categories. The elasticities of demand with respect to own price and income used for the analysis indicate that they vary across food items. The elasticities of demand with respect to price and income are less than unitary for most food categories and for cereals they are relatively more inelastic (-0.55 and 0.42 respectively). An elastic response with respect to prices is recorded only for the meat products. An elastic response with respect to income is recorded for meat products, milk & milk products and fruits.

Price transmission elasticity: Similarly, price changes and price pass through coefficients were available only at an aggregated level and certain approximations were made in assigning such values for disaggregated data. The approximations made related to aggregation issues of price transmission are presented in Appendix Table 3.

Analysis of the findings

Results of the Price Analysis

For the analysis of prices, the period July 2005-June 2007 was considered as the pre-crisis period, July 2007-September 2008 was considered as the food crisis period, and October 2008-December 2009 was considered as the GFC period.

Compared to pre-crisis averages, the highest price changes during the food crisis period are recorded for palm oil (100.37%), soybean (93.11%), rice (92.26%) and wheat (82.17%). When it came to the GFC period, rice prices remained almost the same and reductions were recorded for palm oil (33.63%), soybean (35.10%) and wheat (19.98%). However, if the prices grew at the rates recorded in the pre-crisis period (*i.e.* scenario B as reported in Appendix Table 4), the changes in prices of palm oil, soybean, rice and wheat would have been 29.87%, 44.08%, 74.61% and 36.52% during food crisis period

[2] Medical research Institute of Sri Lanka (undated), Food composition table for use in East Asia (1972), Perera *et., al.* (1979), Standard Tables of Food Composition in Japan (2000), The official Danish Food Composition Database (2009) and USDA National Nutrient Database for Standard Reference (2010).

and -38.70%, -19.90%, 64.18% and -28.93% respectively during the GFC period. Table 4 shows the percentage changes in prices under alternative scenarios for selected food items using the growth rates shown in Appendix table 4.

Table 2. Elasticity Estimates of Demand for Food with respect to own price (uncompensated)

Food group	National	High income	Middle income	Low income	Urban	Rural
Rice	-0.6093	-0.3686	-0.6789	-0.7501	-0.6587	-0.5767
Cereals	-0.5090	-0.3881	-0.5595	-0.5512	-0.5763	-0.4855
Spices	-0.4156	-0.3885	-0.4602	-0.5106	-0.5287	-0.4722
Pulses	-0.5335	-0.4983	-0.5538	-0.6675	-0.5718	-0.5631
Vegetables	-0.6818	-0.4159	-0.7634	-0.7328	-0.7219	-0.6453
Meats	-0.8906	-0.8655	-0.9028	-0.9012	-0.9225	-0.9180
Fish	-0.8076	-0.7976	-0.8511	-0.8339	-0.8430	-0.8080
Milk products	-0.9538	-0.6848	-0.9868	-0.9763	-1.1049	-0.9189
Fats	-0.3871	-0.1765	-0.4548	-0.5316	-0.4715	-0.2500
Fruits	-0.8772	-0.8287	-0.9361	-1.1675	-0.9072	-0.8573
Others	-0.5216	-0.5033	-0.6151	-0.6533	-0.5357	-0.4838

Source: Tudawe (2001)

Table 3. Elasticity Estimates of Demand for Food with respect to expenditure

Food group	National	High income	Middle income	Low income	Urban	Rural
Rice	0.6284	0.2972	0.5912	0.7970	0.6757	0.6538
Cereals	0.3121	0.2118	0.2731	0.5896	0.3185	0.3654
Spices	0.8396	0.8415	0.9691	0.9862	0.8100	0.8758
Pulses	0.5534	0.3607	0.4814	0.7450	0.6065	0.5894
Vegetables	0.7865	0.7446	0.9818	0.9852	0.8535	0.7853
Meats	1.3242	0.9799	1.4126	1.5220	1.4076	1.3238
Fish	0.7813	0.7493	0.9578	1.3794	1.0520	0.7266
Milk products	1.3023	1.0250	1.2707	1.6595	1.3110	1.4341
Fats	0.3063	0.1334	0.2148	0.3695	0.6582	0.2220
Fruits	1.1688	1.0015	1.6065	1.4784	1.2112	0.9514
Others	0.7091	0.3973	0.8978	0.8971	0.8305	0.7198

Source: Tudawe (2001)

Table 4. Comparison of the rates of changes in world market prices of selected food items under alternative scenarios

Food item	Scenario A		Scenario B	
	Food Crisis	GFC	Food Crisis	GFC
Palm oil	100.37	33.63	29.87	-38.70
Rice	92.26	94.29	74.61	64.18
Soybean oil	93.11	35.10	44.08	-19.90
Sugar	-8.54	38.27	-8.88	29.65
Wheat	82.17	19.98	36.52	-28.93
Whole milk powder	84.65	-7.20	31.50	-50.23
Petroleum oil	58.81	-2.38	37.99	-25.39

Table 5. Expenditure on petroleum products and corresponding changes in expenditure due to changes in prices of petroleum products (Scenario B)

	Expenditure (Rs/month/household)			Change in expenditure		Percentage change in expenditure	
	Petroleum products	Food	Ratio of food exp	Food Crisis	GFC	Food Crisis	GFC
National	1,695.37	8,641.11	19.62	-644.07	408.92	-7.45	4.73
Urban	2,913.92	11,015.41	26.45	-1,107.00	702.84	-10.05	6.38
Rural	1,555.48	8,304.91	18.73	-590.93	375.18	-7.12	4.52
Estate	605.66	7,503.38	8.07	-230.09	146.09	-3.07	1.95
Low	336.88	4,352.24	7.74	-127.98	81.26	-2.94	1.87
Medium	1,131.54	8,504.24	13.31	-429.87	272.93	-5.05	3.21
High	4,747.79	13,343.99	35.58	-1,803.69	1,145.17	-13.52	8.58

As indicated earlier, the changes in the prices of petroleum products are assumed to cause a change in expenditure allocated to food in the initial analysis. An increase of petroleum prices have caused a drop in expenditure allocated for purchasing food by 11.54% and 0.14% during the food crisis period and GFC period respectively (note: on average a household spends Rs. 1695 per month on oil related products which is equivalent to an extra expenditure of Rs. 997 compared to pre-crisis situation) under scenario B. If the counterfactual values are compared considering the rate of growth during pre-crisis period, the changes are -7.45% and 4.63% during the food crisis period and GFC period respectively. The drop in expenditure levels are as high as 20.92% and 15.56% compared to pre-crisis period for high income groups and households in the urban sector during food crisis period. Table 5 shows the changes in food consumption expenditure due to changes in petroleum prices during food crisis period and GFC period under scenario B by household groups. It shows that for an average household, expenditure on petroleum oil related products is as high as 20% of total food expenditure.

It is visible that expenditure on petroleum oil related products by the urban households and high income households are higher both in relative terms and absolute terms.

Results of the Analysis of Food Consumption at the Household Level

Baseline equilibrium: Key Characteristics

As stated earlier, the detailed food consumption data reported by the Department of Census and Statistics was classified into 17 categories to cover the major food groups. An examination of the data, at a national level, reveals that cereals and food prepared outside (which consists of rice and wheat based products including bread) constitute 27% of total food expenditure providing 66% and 54% of the energy and protein requirement respectively. The livestock and fisheries products rank next constituting 18% of food expenditure which provide 3.23% and 16.68% of energy and protein requirement respectively. Vegetables & leaves and milk & milk products each constitute around 10% of the food expenditure but their contribution to energy and protein intake is smaller (except for milk and milk products which provide 5.67% of protein). Pulses and sugar contribute more to protein intake (11%) and energy intake (8%) respectively compared to the proportion of household expenditure incurred (around 4% each) on these food items. Table 6 shows the baseline values of expenditure, energy and protein intake by food category (see Appendix Table 5 for contributions by food category). This clearly indicates that the energy and protein intakes of households are greatly dependent upon changes in prices of cereals followed by livestock and fisheries products.

Results of the Simulations at the National Level

The results of the simulation analysis are presented mainly under scenario B whereas scenario A was used only to compare the results. Furthermore, a sensitivity analysis was performed at the national level to evaluate the significance of (i) cereal prices, (ii) non-cereal food prices, (iii) all food prices and (iv) petroleum oil prices one at a time.

In interpreting the changes, it should be noted that even though higher food prices certainly reduce food consumption levels, it does not necessarily indicate a reduction of food expenditure as it may either decrease or increase depending on the elasticity of demand and the magnitude of the price shock. The changes during the food crisis period are such that higher food prices were associated with lower expenditure levels. When a significant reduction in expenditure is coupled with a rise in price, a fall in food expenditure levels can be expected.

Table 6 also presents the key results of the analysis performed at the national level by applying all the shocks under scenario B. It should be reiterated that, due to the lack of household consumption/expenditure data for the crises years, the analysis was performed using the household expenditure and income data published for the year 2006/2007. Hence the findings are interpreted in terms of potential impacts of price changes of food items and expenditure levels, which are recorded during the crises years, on the levels of consumptions and expenditure of households recorded in the year 2006/2007, both under the scenarios A and B.

Table 6. Household monthly Food expenditure, Per capita Energy intake per day and Per capita Protein intake per day at the Baseline equilibrium and under scenario B during Food Crisis Period and GFC by food group at the national level

Food group	Baseline			Food crisis			GFC		
	Expenditure	Energy	Protein	Expenditure	Energy	Protein	Expenditure	Energy	Protein
Units	**Rs**	**Kcal**	**g**	**Rs**	**Kcal**	**g**	**Rs**	**Kcal**	**g**
Total	**8,138.49**	**2,106.00**	**56.95**	**7,685.28**	**1,957.08**	**54.00**	**8,109.87**	**2,167.70**	**59.05**
Cereals	1,388.87	1,137.87	24.07	2,286.75	1,123.39	23.70	2,117.89	1,138.91	24.14
Foods prepared outside	939.67	260.05	6.74	1,382.99	252.53	6.58	1,038.95	260.83	6.77
Pulses	303.72	86.67	6.25	402.38	81.04	5.83	252.64	89.36	6.45
Vegetables and leaves	679.23	31.48	1.98	665.34	30.54	1.93	688.05	32.08	2.01
Yams and other similar foods	180.32	24.69	0.32	180.28	24.40	0.31	186.96	24.86	0.32
Meat	365.66	15.32	1.93	346.04	14.53	1.84	378.12	15.83	1.98
Fish (fresh)	744.43	14.84	2.37	493.45	14.58	2.33	504.55	15.75	2.52
Dried fish	348.49	30.11	4.60	320.99	28.98	4.39	369.25	33.98	5.30
Eggs	85.12	7.77	0.60	83.19	7.64	0.59	86.35	7.86	0.60

Coconuts (nuts and powder)	472.81	13.22	0.24	603.79	12.08	0.23	271.17	14.68	0.25
Condiments	651.29	48.92	2.31	637.73	48.06	2.26	655.46	49.64	2.37
Milk and milk foods	691.19	68.26	3.23	601.14	53.82	2.93	429.75	76.28	3.45
Fats and oils	186.34	97.97	0.00	220.34	92.94	0.00	117.56	104.10	0.00
Sugar/ Jaggery and Treacle	324.06	169.72	0.04	295.07	169.66	0.04	414.83	168.59	0.04
Fruits (fresh and dried)	281.37	36.92	0.50	175.20	31.71	0.35	287.32	38.73	0.57
Confectioneries and other short eats	247.98	38.70	0.66	231.21	36.70	0.63	258.63	39.97	0.68
Beverages (non alcoholic)	247.94	23.47	1.12	-1,240.50	-65.51	0.05	52.39	56.27	1.58

The findings of the simulation exercise indicate that when food crisis shocks are applied, the results show a drop in energy intake from 2105 (which is above the recommended level of 2030 kcal per person per day) to 1957 kcal per person per day, a drop in protein intake from 56.95 to 54 g per person per day and a decrease in food expenditure from Rs. 8574.96 to Rs. 7685 per household per month. This means that the energy and protein intake of an average Sri Lankan household will decrease by 7.07% and 5.19% respectively and food consumption expenditure will decrease by 2.67%. These results imply that although the percentage drop of energy intake is small, the resulting energy intake level is below the recommended level. The drop in protein intake does not bring about serious concerns as the resulting level adequately meets the recommended level of protein for an average Sri Lankan adult (Department of Nutrition/Medical Research Institute, 1998).

The findings further indicate that that when GFC shocks are applied, the results show an increase in energy intake from 2105 to 2167 kcal per person per day, an increase in protein intake from 56.95 to 59.05 g per person per day and an increase in food expenditure from Rs. 8574.96 to Rs. 8109 per household per month. The energy and protein intake of an average Sri Lankan household will decrease by 2.93% and 3.69% respectively and food consumption expenditure will increase by 2.28%. It should be noted that though the changes of the GFC at the household level are positive in a static sense, the implications of lower prices would be seen elsewhere, *i.e.,* reduction in farm profit levels and wage rates etc. Such effects were not incorporated in the analysis as they were not evident in the real world data so as to develop respective policy shocks.

Results of the Sensitivity Analysis

A set of simulations was performed to evaluate the impacts of the food crisis and GFC assuming that the world market prices do not grow at the rate prevailed during pre-crisis period and rather they remained at the average pre-crisis price levels (i.e. scenario A). Table 7 presents the summary results of the simulation analysis performed at the national level. The resulting price and income shocks are higher during the food crisis period in absolute terms and small increases in price and positive income shocks are visible during the GFC period. When such shocks are applied, the results show that the energy and protein intake of an average Sri Lankan household drops by 15.92% and 11.61% respectively and food consumption expenditure drops by 19.66% during the food crisis period. The changes due to GFC are -8.40%, -7.32% and -3.90% respectively for food expenditure, energy intake and protein intake. A comparison between the results of scenario A and that of B suggest that the results of the studies that do not consider natural growth in prices highly over estimate the actual impacts.

Table 7 also shows the results of a sensitivity analysis performed to evaluate the outcomes that may occur due to cereal price changes (while holding other food prices and petroleum prices at their original levels) under scenario B. Due to the significant rise in cereal prices prevailed during food crisis times, significant reductions in energy and protein intake were expected.

Table 7. Sensitivity analysis at the national level changes in: Food consumption expenditure, Energy Intake and Protein Intake under alternative scenarios compared with the baseline

Policy Experiment	Food Crisis			GFC		
	Food expenditure	Energy Intake	Protein Intake	Food expenditure	Energy intake	Protein intake
Units	**Rs**	**Kcal**	**G**	**Rs**	**Kcal**	**g**
Baseline Equilibrium	**8,138.49**	**2,105.99**	**56.95**	**8,138.49**	**2,105.99**	**56.95**
All shocks under scenario B	7,685.28 (-2.81)	1,957.07 (-7.07)	54.00 (-5.19)	8,109.87 (2.40)	2,167.69 (2.93)	59.05 (3.69)
All shocks under scenario A	6,228.24 (-20.72)	1,770.68 (-15.92)	50.34 (-11.61)	7,193.80 (-8.85)	1,951.93 (-7.32)	54.73 (-3.90)
Cereal price shock under scenario B	9,267.79 (16.63)	2,086.18 (-0.94)	56.48 (-0.82)	8,737.31 (10.11)	2,106.42 (0.02)	57.02 (0.12)
Other price shock under scenario B	7,184.81 (-8.96)	2,040.56 (-3.11)	55.98 (-1.70)	6,805.55 (-13.62)	2,126.84 (0.99)	58.02 (1.88)
Food price shock under scenario B	8,538.46 (7.67)	2020.75 (-4.05)	55.51 (-2.52)	7,628.73 (-3.51)	2,127.26 (1.01)	58.09 (2.00)
Petroleum oil shock under scenario B	7,165.99 (-9.19)	2,042.32 (-3.02)	55.43 (-2.66)	8,389.14 (5.84)	2,146.42 (1.92)	57.91 (1.69)

Note: Percentage changes are shown in parentheses

However, the results indicate an increase in food expenditure by 15.79% together with drop in energy and protein intake by 0.94% and 0.82% respectively. This result indicate that, despite the significance of cereals in the Sri Lankan diet, the significant rise in cereal prices in the world market and the perfect price transmission, the cereal price shock only causes a reduction in nutrient intake by less than one percent (though the resulting expenditure change is larger). During the GFC, although a reduction in wheat and petroleum prices was evident, the rice market remained unchanged. The results of the analysis performed to evaluate the impacts of changes in cereal prices during the GFC show an increase in food expenditure by 9.60% and a slight increase in energy and protein intake by 0.02% and 0.12% respectively.

An alternative simulation was performed to evaluate the impacts due to price changes during the food crisis in relation to food other than cereals (by holding cereal prices and petroleum oil prices at their original levels). The results show an increase in food expenditure by 7.28% and reductions in the energy and protein intake by 3.11% and 1.70% respectively. The relatively higher changes in energy and protein intake, compared to what was resulted in the previous simulation, was due to the relatively elastic nature of non-cereal demand, which caused larger consumption shifts. A similar analysis was performed for the GFC period and the results show a decrease in food expenditure by 3.33% and increases in the energy and protein intake by 0.99% and 1.88% respectively.

The results indicate that food expenditure would be increased by 7.67% and energy and protein intake would be dropped by 4.05% and 2.52% respectively when only food price shocks were applied. The same analysis was performed for the GFC period and the results show a decrease in food expenditure by 3.51% and increases in the energy and protein intake by 1.01% and 2.00% respectively. These findings clearly demonstrate that the results on the nutrient intake are driven more by non-cereal food prices.

Results of the Simulations by Household Groups

The results of the analysis performed at the disaggregated level indicate that the impacts are more prominent among urban and low-income households during food crisis period (Table 8). The energy and protein intake of urban households go down by 9.15% and 6.83% (compared to 6.76% and 5.01% for rural households) and those of low-income households go down by 8.51% and 6.44% (compared to 5.48% and 4.38% for high-income households) respectively. Such reductions are associated with energy and protein levels which have gone below (*i.e.* with the application of shocks) the recommended dietary intake levels. A decrease in food consumption expenditure by 10.57% and 7.96% was also recorded for the urban and low-income households respectively. During the GFC, small increases in food consumption levels and energy and protein intake levels are observed among all household categories due to lowering of prices of petroleum and some key food commodities.

It is worthwhile recalling the key differences in the urban sector compared to those of rural and estate sectors so as to interpret above results. Among the sectors, the highest food expenditure level is recorded in the urban sector, followed by the rural and estate sectors. Urban households spend more on food prepared outside (the key items being bread), meat, fish, milk and milk products and fruits. The higher adverse impacts on the urban households could be attributed to the fact that cost of such products is imported with high price transmission elasticities.

A similar pattern can also be observed across income classes. The expenditure pattern of the households in the higher income deciles is very much similar to those in the urban areas. However, the results of the simulations show some similarity between those of urban sector and low income households, which is contrary for expectations as one could expect to observe similarities between urban and high income groups. While the reliance on imported food items must have been the main channel of transmission of price shocks to the households, the higher resultant adverse impacts on the low-income households should have been due to interaction of a number of factors.

Table 8. Food consumption expenditure, Energy Intake and Protein Intake at the Baseline equilibrium and Counterfactual Equilibria (Food crisis and GFC) by Household group

Household group		Food Crisis			GFC		
		Food expenditure	Energy intake	Protein intake	Food expenditure	Energy Intake	Protein intake
National	Baseline	**8,138.49**	**2,105.99**	**56.95**	**8,138.49**	**2,105.99**	**56.95**
	Simulated	7,685.28	1,957.07	54.00	8,109.87	2,167.69	59.05
		(-2.81)	(-7.07)	(-5.19)	(2.40)	(2.93)	(3.69)
Urban	Baseline	**10,228.66**	**1,970.89**	**54.90**	**10,228.66**	**1,970.89**	**54.90**
	Simulated	8,869.55	1,790.53	51.15	10,195.40	2,053.42	57.50
		(-10.57)	(-9.15)	(-6.83)	(2.39)	(4.19)	(4.73)
Rural	Baseline	**7,835.18**	**2,113.92**	**57.12**	**7,835.18**	**2,113.92**	**57.12**
	Simulated	7,651.42	1,970.98	54.26	7,864.87	2,172.72	59.19
		(0.46)	(-6.76)	(-5.01)	(3.18)	(2.78)	(3.62)
Estate	Baseline	**7,249.02**	**2,393.44**	**60.96**	**7,249.02**	**2,393.44**	**60.96**
	Simulated	8,201.75	2,300.43	59.19	7,252.96	2,424.79	62.31
		(15.25)	(-3.89)	(-2.91)	(2.17)	(1.31)	(2.22)
Low	Baseline	**4,760.44**	**1,859.95**	**47.70**	**4,760.44**	**1,859.95**	**47.70**
	Simulated	4,264.90	1,701.59	44.63	4712.36	1,909.64	49.79
		(-7.96)	(-8.51)	(-6.44)	(1.44)	(2.67)	(4.38)
Medium	Baseline	**8,484.82**	**2,159.34**	**58.47**	**8,484.82**	**2,159.34**	**58.47**
	Simulated	8,364.02	2,020.14	55.84	8,270.08	2,216.09	60.43
		(1.47)	(-6.45)	(-4.50)	(0.37)	(2.63)	(3.35)
High	Baseline	**12,342.76**	**2,278.96**	**64.32**	**12,342.76**	**2,278.96**	**64.32**
	Simulated	12,319.53	2,154.07	61.51	12,114.53	2,332.81	66.38
		(2.52)	(-5.48)	(-4.38)	(0.86)	(2.36)	(3.20)

Note: Percentage changes from the baseline equilibrium are shown in parentheses

It is worthwhile to note that when applied individually, *i.e.,* one at a time, the shocks in terms of changes in cereal prices, changes in other food prices, and changes in income levels also yield higher impacts on the urban (compared to rural) and low-income groups (compared to higher income groups). Of the three shocks applied, the highest impacts are seen in relation to the other food price shock with higher resultant impacts on low income groups and urban people (see Appendix Table 8). For an example, while the income change and cereal price changes would reduce energy intake levels up to 1821 kcal per day per person (-2.08%) and to 1835 kcal per day per person (-1.34%) respectively, the other food price shock would reduce energy intake up to 1765 kcal per day per person (-5.09%) in the case of the low-income group. When all three shocks are applied together, the reduction goes down up to 1702 kcal per day per person (-8.51%).

It is also interesting to note that when the absolute levels of energy and protein intakes are examined, they are the lowest in the urban sector (among the sectors) and in the low-income group (among the income classes) at the baseline equilibrium. The recorded energy and protein intake levels of 1860 kcal per person per day and 47.70 g per person per day by low income groups are below the recommended dietary intake. This suggests that the low-income households are nutritionally insecure even at the baseline equilibrium. When the absolute changes in energy and protein intake due to price and income shocks are examined, it is clear that such changes are relatively larger for urban and low-income households. Consequently, the percentage changes are quite larger for urban and low-income groups.

Conclusions

This study evaluated the likely changes that would occur in food consumption patterns of representative households of Sri Lanka as a result of the changes in world market prices during the periods of global economic crises. The analysis was performed taking into consideration all possible food items in the diet of an average household in Sri Lanka. Altogether 236 food items were taken into consideration, of which some are highly connected to the world market, some are moderately connected and the rest is not connected to the world market at all (as those food items are non-tradable either through regulation or due to market forces). The findings were presented based on 17 broader categories.

This study treated cereals, pulses, milk products, coconut and Maldives fish as food items/categories that are highly connected with the world market (with a price transmission elasticity of one) whereas potato, fish and condiments were treated as items/categories that are moderately connected (with a price transmission elasticity of 0.5), and the rest were treated as items that are not connected (with a price transmission elasticity of zero).

It was revealed from this study that prices of different food items in the world market have increased at varying rates during the crises periods. It was found that prices of rice, wheat, milk and petroleum oil increased by 75%, 37%, 32%, 40% respectively during the food crisis period (July 2007-September 2008) and changed by 64%, -29%, -50% and -

25% respectively during the times of financial crisis period (October 2008-December 2009) when the growth in prices was as in the pre crisis period (July 2005-June 2007).

Larger proportions of household expenditure are found to be incurred on cereals, fish, condiments, milk and milk food, and vegetables. It was revealed from the study that primary energy sources of the households are cereals, sugar, and fat & oils, whereas the key protein sources are found to be cereals, pulses, dried fish, and milk & milk food.

The simulation analysis carried out provided some interesting findings with respect to cereal consumption. As indicated earlier, cereal, which is a significant expenditure item (16.20% of the total food budget) of the household food budget, is also found to be the main source of protein (provides 42.26% of the total protein intake) and energy (provides 54.03% of the total energy intake) of an average household in Sri Lanka. While the prices of rice and wheat significantly increased during the food crisis times, the price of rice remained more or less constant and the price of wheat significantly dropped during the financial crisis period. Although, this indicates that households could have been severely affected due to high cereal prices prevailed during the food crisis period, the study revealed that neither energy intake nor protein intake of the average Sri Lankan Household have been affected, mainly owing to the inelastic demand of cereals. Rather, the results show that the energy and protein intake of the households are largely influenced by the changes in non-cereal food prices due to the elastic price response of non-cereal food items, despite their relatively smaller price changes in the world market and moderate connectivity to the world market.

All in all, the results of the simulation exercises showed that the impacts of global food and financial crises on nutrient intake levels of the households at the national level are small, although adverse impacts in terms of energy intake are evident. When food crisis shocks were applied, the results showed a fall in energy intake from 2105 to 1957 kcal per person per day, a fall in protein intake from 56.95 to 54 g per person per day and a fall in food expenditure from Rs. 8574.96 to Rs. 7685 per household per month. When GFC shocks were applied, the results showed a rise in energy intake from 2105 to 2167 kcal per person per day, a rise in protein intake from 56.95 to 59.05 g per person per day and a rise in food expenditure from Rs. 8574.96 to Rs. 8109 per household per month. The above changes are equivalent to a fall in energy and protein intakes at rates of 7.07% and 5.19% during the food crisis and a rise in the same at the rates 2.93% and 3.69% during financial crisis respectively at the national level.

The findings also suggested that the households residing in urban areas would have been more adversely affected than those who live in rural and estate sectors as the urban population of the country found to be relying more on imported food items that are highly connected to the world market. Furthermore, households belonging to lower-income deciles who are already under-nourished were also found to be more vulnerable.

Suggestions for Further Research

A few limitations of the study can be identified and further research is recommended with respect to them. Firstly, substitution among food items was not taken into account and adding up condition was not imposed in the analysis. Further research is recommended using theoretically consistent demand systems so as to impose above conditions.

Secondly, guess estimates for the price transmission elasticities were used in the analysis in absence of such estimates, so that government response was not explicitly modeled. The Sri Lankan government, during food crisis period, lowered restrictions on imports and adopted a fairly liberal food import policy, providing direct and indirect import subsidies to maintain domestic prices lower than world prices. However, as world food prices started to decline, i.e., with the onset of the GFC, there was a policy shift towards a more protectionist stance, shifting towards greater emphasis on food self sufficiency and encouragement of domestic production. Further research will be needed to provide the impacts of such responses in an explicit manner. In carrying out such analysis, it should be noted that government economic policies in the second half of 2008 were dominated not by considerations of the food crisis impact but by internal developments led by the end of the nearly three decade long civil war. The post-GFC expenditure and investment patterns indicate some renewal of policy emphasis on agriculture and food, but it is difficult to disentangle the domestic impact of the GFC from both government and private sector responses to the end of the civil war and elections in 2009.

Thirdly, it should be clearly noted that this study shows what the likely impacts on nutritional intake would be, given price changes. In effect, the simulations show which socio-economic groups would be vulnerable to rising prices, but not which populations are actually experiencing hardship as a result of rising food prices, because none of simulations incorporate actual price changes and food consumption at the household level. Studies using data gathered through primary surveys conducted just before and after the crises situations, i.e., HEIS of 2006/07 vs. 2009/10, are also recommended.

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Appendix table 1. Composition of food items by HIES category

HIES category	Food items covered
Cereals	Rice - (Kekulu), Rice - (Samba), Rice - (Nadu), Rice - (Basmathi), Rice flour Wheat flour, Kurakkan flour, Ulundu flour, Maize, Samaposha, Noodles, Papadam, Infants cereal foods (Nestum), Barley, Sago, Corn flakes, Other cereals
Foods prepared outside	Bread (Normal), Bread (Special), Roasted Bread, Buns/ Spunchi, Hoppers, String hoppers, Pittu, Roty, Thosai/ Itly, Rice (meat and vegetables), Rice (fish and vegetables), Rice (only vegetable), Curry (meat), Curry (fish), Curry (vegetables), Other prepared foods, Outside food by borders/servants
Pulses	Dhal, Green gram, Gram, Cowpea, Soya, Soya meat, Other pulses
Vegetables and leaves	Ash plantain, Brinjal, Bandakka, Bitter gourd, Long beans, Snake gourd, Ridge gourd, Sweet pumpkin, Beans, Carrot, Beetroot, Cabbage, Tomatoes, Leeks, Knol khol, Capsicum, Dambala, Radish, Drumstick, Cucumber, Kekiri, Ash pumpkin, Elabattu, Kohila yams, Lotus stems, Plantain flower, Ambarella, Cadju nuts (raw), Mushrooms, Polos, Other vegetables, Mukunuwenna, Gotukola, Kankun, Katurumurunga, Nivithi, Thampala, Sarana, Kohila leaves, Onion leaves, Cabbage leaves, Other leaves
Yams and other similar foods	Jak and jak seeds, Bread fruit, Potatoes, Sweet Potatoes, Mannioc, Kiriala, Innala,
	Other yams and similar foods
Meat	Chicken, Beef, Mutton, Pork, Sausages / Meat balls, Other meat
Fish (fresh)	Balaya, Seer, Mora, Paraw, Thalapath, Kelavalla, Other large fish, Sprats, Hurulla, Karalla/Katuwalla, Kumbalawa/ Angila, Salaya/ Sudaya, Other small fish, Lula, Teppili/ Tilapiya/ Korali, Other fresh water fish, Prawns, Crabs, Cuttlefish, Canned fish (Salmon)
Dried fish	Sprats (dry), Keerameen (dry), Salaya (dry), Hurulla (dry), Seer (dry), Katta (dry), Koduwa (dry), Anjila (dry), Balaya (dry), Mora/Keelan (dry), Paraw (dry), Anguluwa (dry), Prawns (dry), Cattle fish (dry), Fresh water dried fishes, Jadi, Other dried fishes
Eggs	Hen, Other Eggs

Appendix table 1. (Continued)

Coconuts (nuts and powder)	Coconut (Nuts), Coconut milk Powder
Condiments	Dried chilies, Chilly powder, Red onions, Bombay onions, Garlic, Maldives fish, Turmeric/ Turmeric powder, Curry powder (Sarakku), Green chilies, Limes, Cumin seeds, Panel seeds, Coriander, Mathe seeds, Mustard, Goraka, Tamarind, Cinnamon, Salt, Curry leaves, Ginger, Vinegar, Other condiments, Other packed/ tinned or bottled foods (group total), Sauce, Marmite/ Vegemite, Soup cubes, Lime pickle, Chutney, Canned fruits , Other packed/ tinned or bottled foods
	Pepper
Milk and milk foods	Cow milk, Goat milk, strilized milk, Milk powder, Infant milk powder,
	Curd, Yoghurt/ Moru, Condensed milk,Butter, Margarine, Cheese, Milk pakets (liquid), Other milk and milk products
Fats and oils	Coconut oil, Vegetable oil, Gingerly oil, Ghee, Other oils and fats
Sugar/ Jaggery and Treacle	Sugar, Juggery, Treacle, Bee honey, Other sweeteners
Fruits (fresh and dried)	Banana, Pineapple, Papaw, Mangoes, Apple, Avocado, Wood apple, Oranges , King coconut/ Kurumba, Grapes, Other fruits
	Dates, Cadju nuts, Groundnuts, Plums, Other dried fruits
Confectioneries and other short eats	Jam, Ice-cream, Chocolates, Toffees, Biscuits, Jelly, Snacks packets, Cake, Kawum/ Kokis etc., Muskets/ Kaludodol etc., Talabola/ Rulan etc., Cutlets/ Patties/ Wadei/ Pastries etc., palmyrah products, Other confectioneries and short eats
Beverages (non alcoholic)	Tea dust/ leaves, Coffee powder/ seeds, Soft drinks, Fruit drinks/ Cordials, Saruwath, Milk Tea, Plain Tea, Milk Coffee, Coffee, Drink packets/ Ice packets, Gruel, Bottled water, Other non alcoholic beverages

Appendix table 2. Approximations made in assigning values for the demand elasticities with respect to prices and income

HIES category	Food items covered	Food group as per Tudawe (2001)	Price elasticity	Income elasticity
Cereals	Rice - (Kekulu), Rice - (Samba), Rice - (Nadu), Rice - (Basmathi), Rice flour	**Rice**		
	Wheat flour, Kurakkan flour, Ulundu flour, Maize, Samaposha, Noodles, Papadam, Infants cereal foods (Nestum), Barley, Sago, Corn flakes, Other cereals	**Cereals**	-0.54	0.40
Foods prepared outside	All	Cereals	-0.51	0.31
Pulses	All	Pulses	-0.53	0.55
Vegetables and leaves	All	Vegetables	-0.68	0.80
Yams and other similar foods	All	Others	-0.52	0.71
	All	Others	-0.89	1.32
Meat	All	Meat	-0.81	0.78
Fish (fresh)	All	Fish	-0.81	0.78
Dried fish	All	Fish	-0.52	0.71
Eggs	All	Others	-0.52	0.71
Coconuts (nuts and powder)	All	Others	-0.50	0.73
Condiments	All except pepper	Others	-0.95	1.30
	Pepper	Spices	-0.39	0.31
Milk and milk foods	All	Milk products	-0.52	0.71

Appendix table 2. (Continued)

Fats and oils	All	Fats	-0.88	1.17
Sugar/ Jaggery and Treacle	All	Others	-0.52	0.71
Fruits (fresh and dried)	All	Fruit	-0.52	0.71
Confectioneries and other short eats	All	Others		
Beverages (non alcoholic)	All	Others		

Appendix table 3. Approximations made in assigning values for the price transmission elasticities

HIES category	Food items covered	Price transmission elasticity
Cereals	All	1.00
Foods prepared outside	All	1.00
Pulses	All	1.00
Vegetables and leaves	All	0.00
Yams and other similar foods	All except for potato	0.00
	Potato	0.50
Meat	All	0.00
Fish (fresh)	All	0.50
Dried fish	All	0.50
Eggs	All	0.00
Coconuts (nuts and powder)	All	1.00
Condiments	All except for Maldive fish	0.50
	Maldive fish	1.00

Milk and milk foods	Butter, Cheese, Infant milk powder, Milk powder, Condensed milk, Margarine	1.00
	Cows milk, goat milk, sterilized milk, curd, yorghurt, moru, milk packets, other milk and milk products	0.00
Fats and oils	All	1.00
Sugar/ Jaggery and Treacle	All	1.00
Fruits (fresh and dried)	Banana, pinnapple, papaw, mangoes, avocado, wood apple, other fruits	0.00
	Apple, oranges, king-coconut, grapes, dates, cashew-nuts, peanuts, plums and other dried fruits	1.00
Confectioneries and other short eats	All	0.00
Beverages (non alcoholic)	All	1.00

Appendix table 4. Log Linear Rate of Growth in Food Prices during Pre-crisis, Food Crisis and GFC Periods

Food item	**Pre-Crisis**	**Food Crisis**	**GFC**
Banana	0.46	1.84	-0.54
Beef	-0.03	-1.27	0.00
Chicken	0.04	0.78	-0.38
Corn	2.32	4.47	-0.30
Peanut	1.26	2.36	-0.95
Fish	0.66	1.44	1.96
Oranges	-0.10	0.92	2.09
Palm oil	2.23	1.24	3.14
Pork	-0.08	1.72	0.09
Rice	0.46	8.54	-0.11

Appendix table 4. (Continued)

Coffee	2.08	1.83	-1.25
Shrimp	0.45	-3.45	-2.68
Soybean oil	1.48	3.48	1.01
Sugar	0.39	2.69	6.45
Tea	-0.10	3.13	2.82
Wheat	1.51	1.18	-1.11
Butter	0.08	0.49	-2.43
Dairy milk	1.54	3.08	-0.21
Chedar cheese	0.47	-0.01	-2.42
Whole milk powder	1.83	-0.88	-1.82
Coconut oil	1.99	2.93	-0.21
Beverage price index	0.67	2.45	2.08
Commodity price index	1.11	3.20	1.86
Crude oil	0.83	3.94	3.44
Energy price index	0.82	4.18	2.16
Food & beverage price index	0.77	2.31	0.96
Food price index	0.79	2.30	0.82
Non fuel price index	1.56	1.24	1.43
Petroleum price index	0.83	3.94	3.41

Appendix table 5. Contribution to food expenditure and composition of energy and protein at the baseline equilibrium at national level

	% Expenditure	% Energy	% Protein
Cereals	16.20	54.03	42.26
Foods prepared outside	10.96	12.35	11.84
Pulses	3.54	4.12	10.97
Vegetables and leaves	8.48	1.49	3.48
Yams and other similar foods	2.44	1.17	0.56
Meat	4.26	0.73	3.38
Fish (fresh)	8.68	0.70	4.17
Dried fish	4.06	1.43	8.07
Eggs	0.99	0.37	1.05
Coconuts (nuts and powder)	5.51	0.63	0.42
Condiments	9.97	2.32	4.05
Milk and milk foods	8.79	3.24	5.67
Fats and oils	2.17	4.65	0.00
Sugar/ Jaggery and Treacle	3.79	8.06	0.08
Fruits (fresh and dried)	3.43	1.75	0.88
Confectioneries and other short eats	3.56	1.84	1.16
Beverages (non alcoholic)	3.16	1.11	1.97
	100.00	100.00	100.00

Appendix table 6. Average prices and percentage change in world market prices during pre crisis, food crisis and GFC periods

	Scenario A					Scenario B			
	Average Price			Percentage change		Mean		Percentage change	
Period	Pre-crisis	Food crisis	GFC	Food crisis	GFC	Food crisis	GFC	Food crisis	GFC
Banana	632.29	775.20	844.59	22.60	33.58	693.94	745.74	11.71	13.26
Beef	117.05	121.22	119.47	3.56	2.07	116.60	116.03	3.96	2.97
Chicken	72.23	82.15	85.75	13.73	18.72	73.15	73.64	12.30	16.45
Corn	126.91	209.81	166.20	65.32	30.95	198.88	285.09	5.49	-41.70
Peanut	844.37	1,525.44	1,069.07	80.66	26.61	1,097.48	1,333.76	39.00	-19.85
Fish	4.71	4.91	4.75	4.24	0.98	5.25	5.81	-6.45	-18.19
Oranges	811.16	1,141.06	907.63	40.67	11.89	817.83	804.77	39.52	12.78
Palm oil	459.78	921.28	614.42	100.37	33.63	709.37	1,002.34	29.87	-38.70
Pork	64.85	64.67	56.67	-0.27	-12.60	64.33	63.51	0.53	-10.77
Rice	302.65	581.88	588.03	92.26	94.29	333.24	358.15	74.61	64.18
Coffee	69.89	104.38	79.14	49.36	13.25	104.65	144.48	-0.25	-45.22
Shrimp	10.31	10.00	8.49	-3.01	-17.67	11.38	12.20	-12.10	-30.42
Soybean oil	578.29	1,116.73	781.30	93.11	35.10	775.09	975.46	44.08	-19.90
Sugar	12.70	11.62	17.56	-8.54	38.27	12.75	13.55	-8.88	29.65
Tea	2,248.26	2,517.16	3,025.81	11.96	34.58	2,182.40	2,148.07	15.34	40.86
Wheat	185.80	338.48	222.92	82.17	19.98	247.93	313.64	36.52	-28.93
Potato	236.28	260.48	291.92	10.24	23.55	254.30	269.79	2.43	8.20
Butter	1,963.25	3,836.40	2,134.17	95.41	8.71	1978.83	2002.16	93.87	6.59
Dairy milk	639.33	1,208.67	734.73	89.05	14.92	857.05	1088.51	41.03	-32.50
Chedar cheese	2,847.75	4,977.60	2,856.33	74.79	0.30	3111.02	3346.25	60.00	-14.64
Whole milk powder	2,469.54	4,560.07	2,291.85	84.65	-7.20	3467.79	4604.62	31.50	-50.23
Coconut oil	653.50	1,229.07	734.73	88.07	12.43	952.98	1297.13	28.97	-43.36
Beverage rice index	108.02	146.13	151.38	35.29	40.14	124.36	137.95	17.50	9.73

Commodity price index	117.93	172.53	119.99	46.30	1.74	144.77	171.86	19.17	-30.18
Crude oil	62.12	98.65	60.64	58.81	-2.38	71.49	81.28	37.99	-25.39
Energy price index	115.76	183.24	118.29	58.29	2.18	133.30	151.44	37.46	-21.89
Food & beverage price index	109.86	154.14	134.39	40.31	22.33	128.26	144.63	20.17	-7.08
Food price index	110.06	155.01	132.55	40.84	20.44	128.69	145.39	20.45	-8.83
Non fuel price index	121.63	154.21	122.89	26.78	1.03	164.81	209.81	-6.43	-41.43
Petroleum price index	116.42	184.89	115.59	58.81	-0.72	133.99	152.33	37.99	-24.12

Appendix table 7. Approximations made in assigning world market price shocks

HEIS Food Category	Food items covered	Relevant world market price
Cereals	All rice categories	Rice
	All wheat categories	Wheat
	Corn	Corn
Foods prepared outside	All rice categories	Rice
	All wheat categories	Wheat
Pulses	All	Soybean
Fish (fresh)	All	Fish
Dried fish	All	Fish
Coconuts (nuts and powder)	All	Coconut oil
Milk and milk foods	Butter	Butter
	Cheese	Cheese
	Infant milk powder, Milk powder	Whole milk powder
	Condensed milk	Fluid milk
	Margarine	Palm oil
Fats and oils	Coconut oil	Coconut oil
	King coconut	Coconut oil
	Rest of fats and oils	Palm oil
Sugar/ Jaggery and Treacle	All	Sugar
Fruits (fresh and dried)	Apple, oranges, king-coconut, grapes, dates, cashew-nuts, peanuts, plums and other dried fruits	Orange
Beverages (non alcoholic)	Tea dust/leaves, milk tea, plain tea	Tea
	Coffee, milk coffee	Coffee
	Rest of the beverages	Beverage

Appendix table 8. Sensitivity analysis under alternative policy experiments by household groups

HH Group	Price Shock	Income shock	Energy intake	% change in Energy
Rural				**2,113.92**
	All	-7.12	**1,970.98**	**-6.76**
	Cereal	No	2,094.81	-0.90
	Other Food	No	2,052.37	-2.91
	No	-7.12	2,051.64	-2.95
Urban				**1,970.89**
	All	-10.05	**1,790.53**	**-9.15**
	Cereal	No	1,950.19	-1.05
	Other Food	No	1,905.48	-3.32
	No	-10.05	1,876.64	-4.78
Estate				**2,393.44**
	All	-3.07	**2,300.43**	**-3.89**
	Cereal	No	2,382.88	-0.44
	Other Food	No	2,335.71	-2.41
	No	-3.07	2,368.73	-1.03
Low				**1,859.95**
	All	-2.94	**1,701.59**	**-8.51**
	Cereal	No	1,835.00	-1.34
	Other Food	No	1,765.21	-5.09
	No	-2.94	1,821.28	-2.08
Medium				**2,159.34**
	All	-5.05	**2,020.14**	**-6.45**
	Cereal	No	2,142.12	-0.80
	Other Food	No	2,087.86	-3.31
	No	-5.05	2,108.82	-2.34
High				**2,278.96**
	All	-13.52	**2,154.07**	**-5.48**
	Cereal	No	2,266.52	-0.55
	Other Food	No	2,227.78	-2.25
	No	-13.52	2,217.69	-2.69