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A study on the relationship between international trade and food security: Evidence from less developed countries (LDCs)

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Abstract: Hunger and poverty are main critical issues in less developed countries (LDCs) and can be attributed to the fact that almost 70% of the LDC populations are employed in the agricultural sector. Although the international trade can reduce food insecurity in LDCs, for example, facilitating the access to larger markets, the volatility in food prices since the late 2000s has negatively affected the food availability. This study examines the effects of trade on the food security and traces a U-shaped relationship between two variables, using 2000–2010 panel data for the LDCs. The results are robust across different methods and show that the food security decreases in the initial stages of the trade expansion but increases beyond a given threshold. The key finding of this study is the U-shaped relationship between trade and food security, which suggests that the policy makers should pay more attention to expanding investments in the agricultural productivity, particularly from the viewpoints of the self-sufficiency and self-reliance.

Key words: food security, international trade, less developed countries (LDCs), U-shaped relationship

According to the FAO (2006), the definition of food security has evolved over time and differs across several organizations. For example, the FAO (1983) defines food security as the continuous physical and economic access to basic food, while the World Bank (1986) distinguishes it between the chronic and transitory food insecurity; the former refers to a prolonged and structural poverty and low income, whereas the latter denotes periods of pressure such as those caused by natural disasters, an economic collapse, or conflicts. The World Food Summit (1996) defines food security as including food access, availability, utility, and stability, thus reinforcing its multidimensional nature (Table 1).

The USDA (2011) reported that the average number of food-insecure people was estimated to decline by about 9 million, from 861 million in 2010 to 852 million in 2011. Figure 1 illustrates the level of food insecurity in all developing countries for 2011 and shows that food insecurity was most severe in the Sub-Saharan Africa (SSA). And Figure 2 indicates the extent of food insecurity in lower income countries and highlights those with the food insecure population exceeding 40%. In addition, the USDA (2011) predicted improved food security in Asia and the Latin America and the Caribbean (LAC) region resulting from the increased food production and import capacity, whereas deteriorating conditions in the SSA owing to the rising export volumes and commodity prices.

Table 2 presents the trends of the per capita production variability[1] since 2000. Until the mid-2000, the per capita production variability for the world and developed countries has increased, whereas it marginally decreased in 2010. However, that of the less developed countries (LDCs)[2] has decreased

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[1]The per capita production variability is defined as the ratio of the net food production value (in constant 2004–2006 1000 international $) to the population number (as from the United Nation 2010 estimates) (FAO 2012). This captures the trend of the net food PIN (production index number) per capita over the period 1985 to 2010 and corresponds to the standard deviation of the deviation from the trend over a period of 5 years.

[2]According to the United Nations Department of Public Information (UNDPI 2011), issues facing LDCs can be argued as follows: (1) about 70% of the workforce is employed in the agricultural sector, (2) the agricultural sector in the LDCs contributes only 30% to the GDP, (3) farm exports constitute only 14% of the total LDC' exports, and (4) one third of the total population in the LDCs is chronically malnourished.

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Table 1. Twin track approach to protracted crises

Twin track approach	Availability	Access and utilization	Stability
Definition	Sufficient food quantities of appropriate quality, supplied through domestic production or imports	Access to adequate resources for acquiring appropriate foods for a nutritious diet. Utilization of food through diet, clean water, sanitation and health care	A population, household or individual must have access to adequate food at all times
Rural development/ productivity enhancement	– Enhancing food supply to the most vulnerable – Improving rural food production, especially by small-scale farmers – Investing in rural infrastructure – Investing in rural market – Revitalization of livestock sector – Resource rehabilitation and conservation – Enhancing income and other entitlements to food	– Re-establishing rural institutions – Enhancing access to assets – Ensuring access to land – Reviving rural financial systems – Strengthening the labor market – Mechanisms to ensure safe food – social rehabilitation programs	– Diversifying agriculture and employment – Monitoring food security and vulnerability – Dealing with the structural causes of food insecurity – Reintegrating refugees and displaced people – Reviving access to credit system and saving mechanisms
Direct and immediate access to food	– Food aid – Seed/input relief – restocking livestock capital – Enabling market revival	– Transfers: Food/cash based – Asset redistribution – social relief/rehabilitation programs – Nutrition intervention programs	– Re-establishing social safety nets – Monitoring immediate vulnerability and intervention impact – Peace-building efforts

Source: Pingali et al. (2005) and FAO (2006)

until the mid-2000, and then increased; this rise is particularly in Asia, the SSA, and the LAC. At the same time, food security and trade volume in the LDCs have increased, despite the ratio of trade volume being larger than that of the food security (Figure 3).

International trade can play a crucial role in reducing food insecurity in developing countries (especially the LDCs) by facilitating the access to larger markets and production specializations (FAO 2006). Johnson (1998) argued a direct relationship among food security, international food trade, and domes-

Table 2. Trends of per capita production variability (2000 = 100)

Years	Regions						
	World	Developed countries	LDCs	North Africa	SSA	Asia	LAC
2000	100	100	100	100	100	100	100
2001	52	41	92	76	72	110	72
2002	103	50	95	61	61	221	75
2003	163	67	62	63	57	393	78
2004	172	87	44	72	68	393	81
2005	126	110	77	73	77	286	62
2006	103	102	102	82	111	186	62
2007	107	111	125	89	133	205	63
2008	80	110	126	80	138	256	99
2009	98	103	126	81	137	315	115
2010	96	92	128	88	176	215	178

Source: FAO food security indicator (2012)

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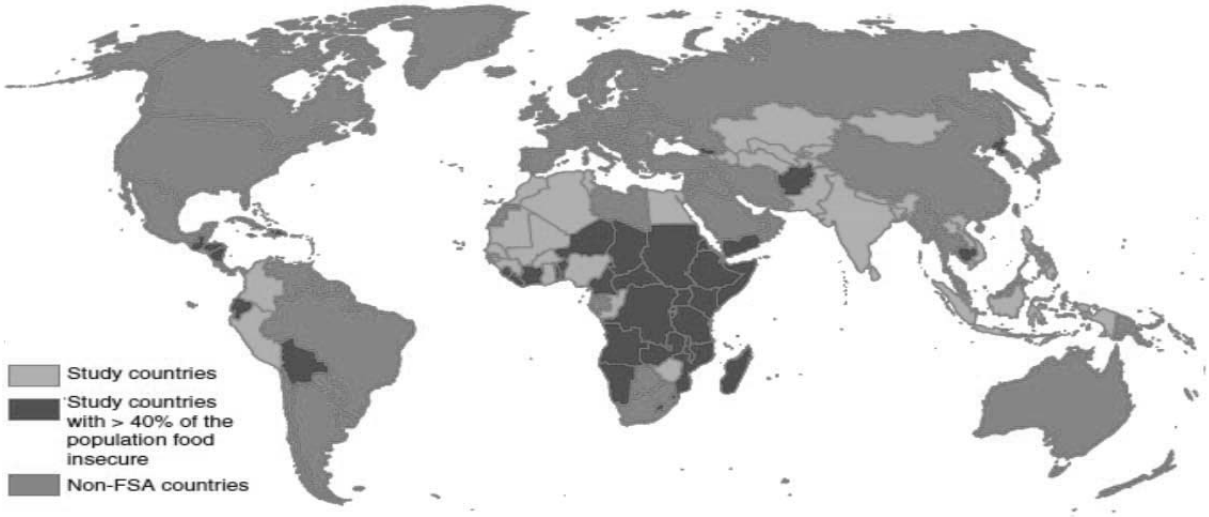

Figure 2. The degree of food insecurity in lower income countries (2011)

Note: This figure identifies the countries in which the consumption level is below the nutritional target of roughly 2,100 calories per person per day. The FSA stands for the Food Security Act.

Source: USDA, ERS (2011)

tic policies. However, various factors affecting the relationship make it difficult to determine whether the international trade has a positive or negative impact on food security (Diaz-Bonilla and Ron 2010).

This study aims to analyse the relationship between food security and trade in the LDCs. To accomplish the main object, the reminder of this study is organized as follows. Section 2 presents the empirical methods. Section 3 reports the empirical results and discusses the impact of the trade liberalization on food security. Section 4 concludes by summarizing the primary findings and their implications.

EMPIRICAL METHODS

The roles of international trade[3] have been probably the important policy objective and particularly con-

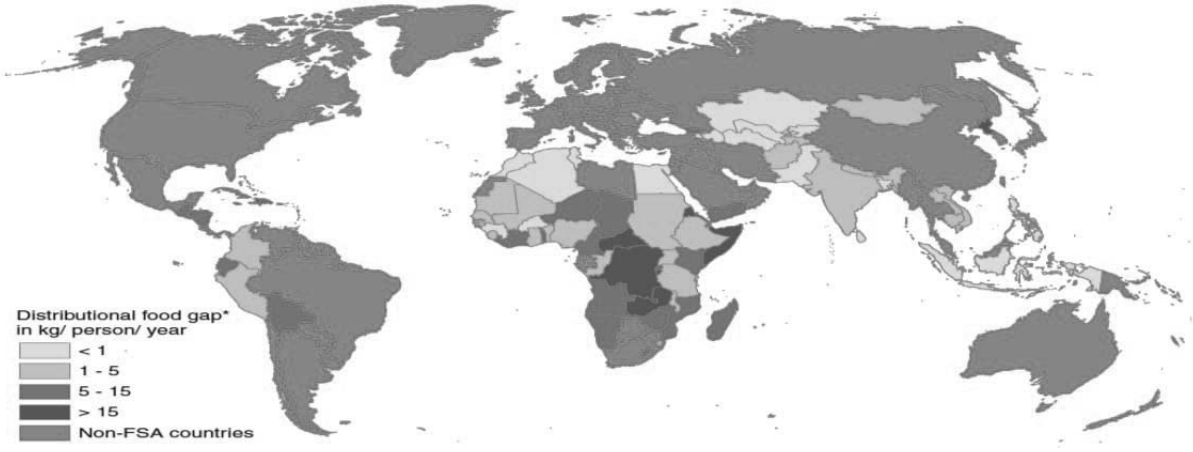

Figure 1. The level of food insecurity in all developing countries (2011)

Note: This figure depicts the distributional food gap in developing countries, which allows for the estimation of food needed to raise the consumption level of each income group to the nutritional target of roughly 2,100 calories per person per day. The FSA stands for the Food Security Act.

Source: USDA, ERS (2011)

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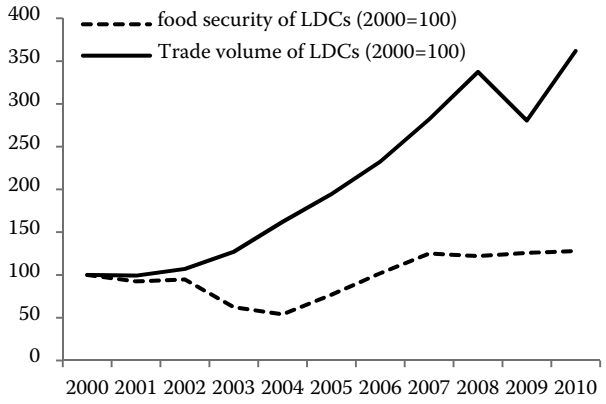

Figure 3. Comparison between food security and trade in the LDCs (2000–2010)

Note: Food security shows the per capita production variability and the trade volume denotes the sum of export and import volume.

Source: World Bank (World Development Indicator, 2012) and author's calculation

sidered the engine for growth in the LDCs (Johnston and Mellor 1961; Dawson 2005). Furthermore, the liberalization of international trade can increase food availability and decrease poverty in the world by supplying to meet demand, based on comparative advantages (Li 2009; Heo and Doanh 2009). In contrast, the pessimists of the trade liberalization argue that trade leads to the increase of poverty and inequality due to the proliferation of the low-wage income and higher food prices (e.g., since 2008, afflation), and therefore it negatively affects food autonomy at both the local and national levels (International Forum on Globalization 2001; Uzquiza 2009).

As for the previous debates, this study attempts to investigate the relationship between international trade and food security (availability)[4] in the LDCs. To examine the contribution of trade on food security, the empirical framework adopts the environmental Kuznets curve (EKC), which hypothesizes the U-shaped or the inverted U-shaped relationship between the two variables. Especially, the EKC provides the understanding of environmental consequences of international trade and the role of economic growth on trade (Kuznets 1955). In addition, the notion of the U-shaped relationship between trade and food security is roughly described as the work of Agénor (2004). Agénor (2004) shows the relationship between globalization and poverty in developing countries and finds that at the low level of globalization, trade appears to hurt the poor; but beyond a certain threshold, it seems to reduce poverty because it can be the renewed impetus for reform. Although this study considers food security rather than poverty, the baseline of this study follows the insights of Agénor.

Following the concepts[5] of the EKU and Agénor, this study aims to test whether the relationship between the international trade and food security has the U-shaped curve within the LDCs. To do so, it is hypothesized that the early stages of the trade liberalization decrease the level of food security owing to the imported products, but beyond some stage the trade liberalization leads to the food security improvement. Therefore, this study conducts an empirical analysis using the panel data on the LDCs for 2000–2010 and finds a U-shaped relationship between the international trade and food security.

First, this study specifies and estimates the relationship between international trade and food security using the EKC and Agénor's (2004) models which include *TRADE* (also $TRADE^2$ *and* $TRADE^3$) as the independent variables and *FS* as the dependent variable for the panel data. To verify this relationship, the ordinary least squares (OLS) procedure was conducted on the pooled data:

$$FS_{it} = \alpha_0 + \alpha_1 \times (TRADE_{it}) + \alpha_2 \times (TRADE_{it}^2) + \varepsilon_{it} \quad (1)$$

$$FS_{it} = \alpha_0 + \alpha_1 \times (TRADE_{it}) + \alpha_2 \times (TRADE_{it}^2) + \alpha_3 \times (TRADE_{it}^3) + \varepsilon_{it} \quad (2)$$

where FS_{it} is the level of food security for country i in period t, which is estimated by the log of the average value of food production[6] (\$ per capita). $TRADE_{it}$ is the trade value for country i in period

[3]Furthermore, see Appendix

[4]Food availability is a component of food security and has a positive relationship with the decreasing malnutrition (Smith and Haddad 2000).

[5]In addition to the EKC, this study relates to the previous researches with respect to methodologies; e.g., Tam (2011), which finds the U-shaped relation between the feminization of the labor force and the real GDP, Hansen (2012), which traces the U-shaped path between wealth and health, and Heid et al. (2012), which shows a positive relationship between income and democracy.

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t, which is specified by the log of the export and import values for goods and services (current US $). The panel data for 2000–2010 is adopted from FAO food security indicators (2012) and the World Bank (World Development Indicators 2012). The total number of LDCs was 139 (based on the World Bank), of which 111 countries were selected on the basis of the data availability.

In equation (1), the signs of the coefficients are crucial to elucidate the relationship between *TRADE* and *FS*, and test for the U-shaped (or inverted U-shaped) path. If $\alpha_1 = \alpha_2 = 0$, then there is no relationship between *TRADE* and *FS*. However, if $\alpha_1 < 0$ and $\alpha_2 > 0$ (or $\alpha_1 > 0$ and $\alpha_2 < 0$), then the two variables demonstrate as the U-shaped (or inverted U-shaped) relationship. Furthermore, in equation (2), we can easily test for the presence of an N-shaped[7] relationship by including the cubic functional form ($\alpha_3 > 0$).

However, although we can pool the data set over time, the OLS procedure of the panel data neither allows for country specific effects nor deals with the problem of an unobserved heterogeneity. Therefore, the equation for the fixed effect (FE) model is as follows:

$$FS_{it} = \beta_1 \times (TRADE_{it}) + \beta_2 \times (TRADE_{it}^2) + T_i + C_t + \mu_{it} \quad (3)$$

$$FS_{it} = \beta_1 \times (TRADE_{it}) + \beta_2 \times (TRADE_{it}^2) + \beta_3 \times (TRADE_{it}^3) + T_i + C_t + \mu_{it} \quad (4)$$

where *T* and *C* are time and country specific effects, and μ is the error term. The FE model is useful to investigate the relationship between the predictor and outcome variables within an entity (e.g., country and person), and checks for individual influences on the predictor and outcome variables (Clarke et al. 2010).

In addition, to test for the dynamic effects and the endogeneity problem, this study adopts the dynamic panel data (DPD)[8] generalized method of moments (GMM) estimation by Arellano and Bond (1991), whose estimation equation form is as follows:

$$FS_{it} = \delta FS_{it-1} + \gamma_1 \times (TRADE_{it}) + \gamma_2 \times (TRADE_{it}^2) + T_i + C_t + \mu_{it} \quad (5)$$

$$FS_{it} = \delta FS_{it-1} + \gamma_1 \times (TRADE_{it}) + \gamma_2 \times (TRADE_{it}^2) + a + \gamma_3 \times (TRADE_{it}^3) + T_i + C_t + \mu_{it} \quad (6)$$

Finally, using the above equations, this study explores the U-shaped (or inverted N-shaped) relationship between *TRADE* and *FS* using three functional forms (linear, quadratic, and cubic). However, in investing the relationship between two variables, An and Jeon (2006) argue that we generally depend on specific functional forms. They suggest that the best way to resolve the specific forms is to utilize a non-parametric kernel regression[9]. Thus, this study also provides the results of a non-parametric kernel to demonstrate the relationship between *TRADE* and *FS*.

EMPIRICAL RESULTS

Table 3 reports the estimation results from the panel data. Columns (1)–(3) indicate the OLS estimation results. α_1 in column (1) and α_2 in columns (2) and (3) are positive with statistically significant. α_3 in column (3) is negative with statistically significant. Although the OLS estimation results indicate a U-shaped and inverted N-shaped relationships between *TRADE* and *FS*, these results are inconclusive due to the unobserved heterogeneity.

Columns (4)–(6) are the results of the FE model. Column (5) shows that β_1 is negative and β_2 is positive, and both are statistically significant. In column (6), β_1 and β_3 are negative and β_2 is positive, and all are statistically significant. Therefore, the within-group estimation shows the U-shaped and inverted N-shaped relationships between *TRADE* and *FS*.

[6]According to the FAO food security indicators (2012), the average value of food production is defines as the total value of annual production (US $) divided by the total population. It provides a cross country comparative measure of the relative economic size of the food production sector in a given country.

[7]The specifications of cubic model are provided in Torras and Boyce (1998).

[8]The Arellano-Bond dynamic panel GMM estimation is preferred when (i) independent variables are assumed to be endogenous, (ii) fixed effects (e.g., country characteristics) may be correlated with the independent variables, (iii) the presence of the lagged dependent variable leads to an autocorrelation, and (iv) the panel data set is based on a short period (within 10 years) and wide country dimensions (over 20 countries) (Holtz-Eakin et al. 1988; Arellano and Bond 1991).

[9]Also, see Nadaraya (1964) and Epanechnikov (2006).

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Table 3. Results of panel data estimations

Independent variables	Dependent variable = FS								
	OLS			Fixed effects (within)			GMM (Arellano-Bond)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
constant	2.3026*** (13.29)	5.2590*** (3.21)	67.3822*** (4.71)	3.3512*** (28.27)	8.4940*** (11.09)	22.6479*** (4.57)			
FS(-1)							0.7887*** (9.01)	0.6045*** (7.40)	0.4899*** (26.97)
Trade	0.1294*** (17.15)	−0.1286 (−0.90)	−8.2518*** (−4.43)	0.0836*** (16.14)	−0.3654*** (−5.51)	−2.2102*** (−3.45)	0.0238*** (3.11)	−2.2261*** (−2.53)	−7.5595*** (−2.60)
$Trade^2$		0.0055* (1.82)	0.3575*** (4.42)		0.0094*** (6.79)	0.0893*** (3.24)		0.0499*** (2.64)	0.3294*** (2.57)
$Trade^3$			−0.0050*** (−4.37)			−0.0011*** (−2.89)			−0.0047** (−2.54)
# of countries	111	111	111	111	111	111	111	111	111
# of observations	1221	1221	1221	1221	1221	1221	999	999	999
R^2	0.1943	0.1965	0.2089	0.1902	0.2226	0.2284			
Sargan test (p-value)							0.252	0.103	0.250

t-values are in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively

The GMM procedure results are shown in columns (7)–(9). The coefficient signs of the GMM derive the same results as the FE estimation. Here as well, the results for columns (8) and (9) show the U-shaped and inverted N-shaped relationships between the two variables. In addition, the results of the Sargan test (over-identifying restrictions) are not rejected, which implies that the GMM procedure supports the consistency and validity of the DPD estimators.

Finally, Figure 4 illustrates the results of the non-parametric kernel regression and shows the U-shaped relationship, in which *TRADE* has a negative coefficient and $TRADE^2$ has a positive coefficient. In addition, the evidence of the inverted N-shape is weak beyond a certain trade value, which is roughly 20 and 28 (about $ 4.6E+08 and $ 1.3E+12).

In sum, this study finds evidence for the U-shaped relationship between food security and trade in the LDCs. The early stages of trade negatively impact on food which implies that the increased trade openness contributes to the redistribution of the world production on the basis of a comparative advantage.

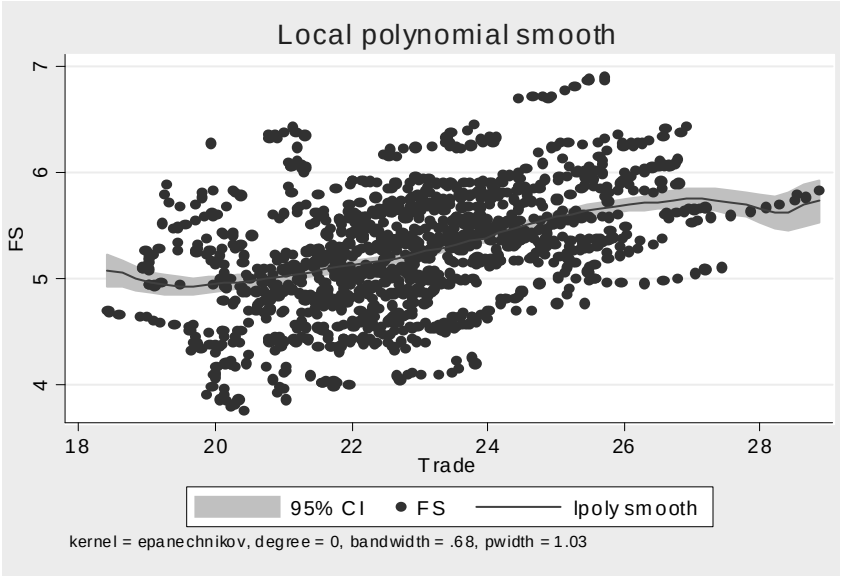

Figure 4. Results of the non-parametric Kernel estimation

Notes: This graph includes Kernel regression with 95% confidence bands, default Kernel (Epanechnikov) and default bandwidths.

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That is, certain industries in an importing country may shrink because of the increasing availability of cheaper imports, and its production structure may have a negative impact on food security. On the other hand, beyond a certain threshold of the trade expansion, food insecurity tends to improve. This indicates that cheaper import products can stimulate domestic consumption and investment. In other words, the participation in the world markets through the international trade can increase food security.

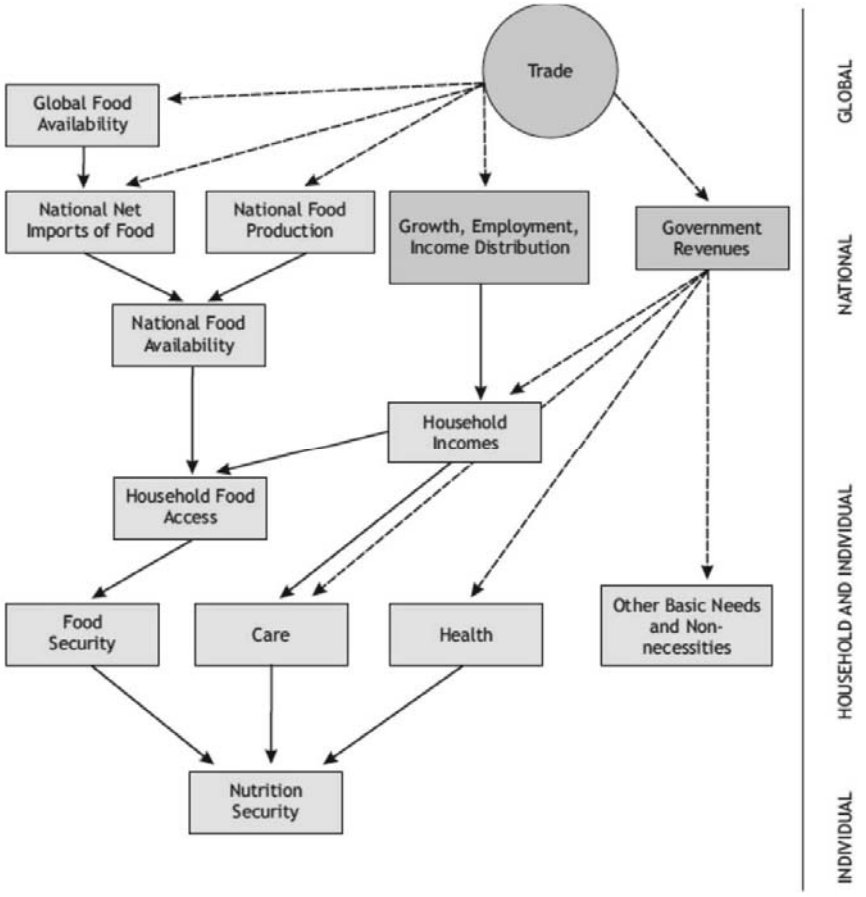
After the World Trade Organization (WTO) was established, much research has been conducted on the benefits of the trade liberalization. Some studies emphasized that trade could substantially contribute to improving food security and reducing the global food gap (Maasdorp 1999; Dorosh 2001). However, the view that the trade participation has favourable effects on food security cannot be universally applied, given that the trade restriction policies related to food vary acros s nations (Johnson 1998). Furthermore, Trueblood and Shapouri (2001) argued that trade in developing countries can affect food security through the global food prices. That is, the increased volatility of food prices, leading to higher expenditures on food imports, can be burdensome to low-income countries.

CONCLUSION

This study analysed the relationship between the international trade and food security in the LDCs for the period 2000–2010. It hypothesized the U-shaped relationship between the two variables by adopting EKC and Agénor's (2004) models. In addition, this study performed the OLS procedure for the pooled data and used the FE model to resolve the unobserved heterogeneity. Furthermore, it used the GMM to test for dynamic effects and endogeneity, and conducted a non-parametric kernel regression to resolve the specific functional form.

The main finding of this study is the U-shaped relationship between the international trade and food security in the LDCs. This indicates that in the initial stages of the international trade expansion in

Appendix



Conceptual framework for food security and trade

Source: Diaz-Bonilla and Ron (2010)

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the LDCs, food security worsens, but thereafter, it is shown to improve.

From a different perspective, the FAO (1996) suggests two additional strategies to achieve food security: self-sufficiency (growing within the country to satisfy food demands as much as possible) and self-reliance (importing when the price of food is lower than that of self-sufficiency). Even if these two strategies are questioned by the policy makers, an important measure that could resolve food insecurity is the expansion of investments in agricultural productivity in the LDCs. Increased agricultural productivity can reduce the volatility of food prices and contribute toward improving the farmer and consumer' welfare.

Nevertheless, this study focuses on food productions, which is one of the many aspects of food security, namely availability. Moreover, this study assumes food security in the context of food production. This assumption has its limitation and warrants a further research.

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