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INTERNATIONAL TRADE AND FOOD SECURITY: CAN PUBLIC STOCKHOLDING BE DISMISSED?

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Abstract

The food crisis of 2007-2008 led to a renewed interest in public stockholdings for food security purposes. Stock acquisition for food security is constrained by WTO rules. Developing countries petitioned the WTO to remove the constraint. The negotiations over stockholding subsidies have been acrimonious and confrontational. A peace clause is in effect while a permanent solution is sought. Opponents to expanding stockholdings argue that market induced trade can maintain food security. This research finds, for major cereal crops, that a market response should not be relied upon. Developing countries require policy options to maintain food security – one of which is stockholdings.
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JEL Codes: F13, Q17, Q18

1. Introduction

In the wake of the spike in international food prices in 2007-2008 public stockholdings of food has become a contentious issue in trade policy. The central point of contention is the constraint existing World Trade Organization (WTO) commitments place on the ability of developing countries to subsidise the acquisition of stocks of food using administered prices. Developing countries contend that the WTO limits on acquisition of stockholdings reduces the policy space available to provide food security for their citizens.[1] Some agricultural exporting countries, on the other hand, argue that lifting the limits on the subsidized acquisition of stockholdings using administered prices is not necessary for food security and would simply lead to trade distortions detrimental to their interests. These contending positions have led to acrimonious negotiations at the WTO, including the near failure of the 2013 Bali Package (Kerr, 2014). As a temporary compromise, the negotiators at the WTO have agreed that no dispute will be brought against a member country's expenditures to acquire stockholdings while efforts are made to find a *permanent solution* (Kerr, 2015).

While the contending positions are put forcefully in the negotiations, there is a dearth of research upon which to base a *permanent solution* including, among others; whether the current WTO commitments actually represent a constraint on the ability of countries to maintain or enhance food security for its citizens, the degree to which increased subsidies for stockholding would distort trade and whether international trade can be relied upon to alleviate threats to food security in the absence of stockholdings. This paper addresses the latter question. Implicit in the argument of those countries resisting the lifting of the subsidy limit for acquiring stockholdings at administered prices is the proposition that a sufficient degree of food security can be obtained through reliance on food imports. If this proposition is correct, then increasing subsidies to acquire public stockholdings is not required. If it is not, then further evaluation of the role of stockholdings in providing food security is warranted. Hence, answering this question is central to finding a *permanent solution* to the issue of subsidies for the acquisition of stockholding for food security purposes at the WTO.

2. Food Security, Stockholding and WTO Commitments

Food security is a challenge in many developing countries. The Food and Agriculture Organization (FAO) of the United Nations suggest that 800 million people are at risk due to poor food security (FAO, 2014).Approximately 98 percent live in developing countries.

Public stockholding refers to state acquisition, storage and subsequent release of food stocks. Public stockholding programs are typically comprised of cereals (especially rice, corn and wheat) as they can be stored for extended periods and because of their importance in the diets of the poor. In developing countries, public food stocks are held to satisfy a number of objectives including for food security purposes because they can be a source of emergency food aid, stabilise food prices and provide a market for resource poor farmers (World Bank, 2012; Gilbert, 2011; Wiggins & Keats, 2009).

Public stockholding programs were, however, constrained as a result of the Uruguay Round of multilateral trade negotiations as part of the reform of disciplines on agricultural subsidies. This is because, arguably, their operations can distort trade. In particular, stocks can be acquired at government administered prices that are higher than prevailing market prices. High administered prices serve as a subsidy to farmers and induce a supply response beyond levels conveyed by markets. For large importing countries, subsidy-induced domestic production can reduce demand for imports and depress international prices. Further, cereals acquired under administered prices and stored can be sold in international markets at subsidized prices, which also have the potential to cause trade losses for competing countries.

With this in mind, the WTO member states agreed during the Uruguay Round to the following restrictions on public stockholding activities. Under the WTO Agreement on Agriculture (AoA), for public stockholding to operate in member states: (1) the stock levels must be predetermined and acquired only for the purposes of enhancing food security; and (2) the sale and acquisition of public stocks shall be made at prices not noticeably different from the prevailing market price. More importantly, government subsidies for stockholdings acquired through administered prices shall not exceed 5 percent and 10 percent of the total value of domestic production in developed and developing countries respectively – limits known as *de minimis*.[2] Violations can lead to a countervailing duty action under the Agreement on Subsidies and Countervailing Measures (ASCM).

The interest in revisiting the agreed WTO limits arose in the wake of the food crisis of 2007-2008. The formal request for regulatory reforms emerged at the WTO's 9th Ministerial Meeting in Bali in 2014 (ICTSD, 2014). A proposal by a group of developing countries – the G-33 – led by India, argued that the 10 percent allowable subsidy for acquiring stockholdings at administered prices is restricting the policy space needed to acquire adequate food stocks to mitigate supply shocks. Hence, the G-33 advocates the removal of the restrictions.

The G-33 proposal, however, proved contentious for some WTO members (Kerr, 2014). They argued that the current WTO commitments provide sufficient policy options to enable developing countries to address their food security problems without expanding the use of administered prices to acquire stockholdings. The subtext is that international trade flows are sufficient to overcome the effects of shocks that threaten food security. This is an empirical question that has not been adequately addressed. India threatened to block a major WTO deal on *Trade Facilitation* – an agreement aimed at harmonizing customs practices across member countries –unless reforms on the acquisition of public stockholding at administered prices were tabled for consideration. As an interim solution, it was agreed by WTO Members that countries would refrain from challenging stockholding programs of other member countries until a solution can be agreed – often referred to unofficially as a *peace clause* (Kerr, 2015).

Investigating whether international trade flows are sufficient to overcome shocks that threaten food security is the focus of this paper. This empirical question is investigated using data on cereal consumption in net food importing developing countries. Cereals are chosen for this investigation for a number of reasons. They constitute a large proportion of household food consumption in developing countries – over 60 percent of daily calories (Awika, 2011). The importance of cereals raises concerns about the impact of a future consumption shock. A consumption shock refers to a sudden increase in demand or decrease in quantity available for consumption leading to a major market disruption, which can be either a food shortage at prevailing prices, a spike in food prices or a combination of the two. Price spikes lead to deterioration in food security for the poor as they do not have adequate income to acquire sufficient food for an active and healthy life at higher prices (Kerr, 2011). Consumption shocks often arise from crop failures due to weather and/or disease infestations. However, consumption shocks in food importing countries also arise due to restrictions on exports by the food exporting countries. These restrictions include the use of export taxes and embargos to limit importers' access to food (Cardwell & Kerr, 2014).

While these shocks can have a considerable impact on a country's food security, this impact can be reduced for countries that are well integrated into the international trade system. Integrated markets can respond quickly to restore consumption in the event of a shock. Where market responses are slow, a shock to domestic consumption can lead to an acute food shortage. Hence, a country strongly integrated into the global trade system has the opportunity to access imports to respond to consumption shocks. A rapid response will reduce the duration of a shock's effects and enhance food security in importing countries while a slow response can deepen a food security crisis.

Developing countries' markets, however, may not respond adequately to assure food security despite the considerable liberalisation many of them have engaged in. Developing countries still exhibit high transaction costs, limited trade openness and suffer from export restrictions imposed by foreign sources of supply that have the tendency to undermine the ability of trade to mitigate the effects of shocks. High transaction costs have the potential to delay swift responses to assure food security in times of shock. Transactions costs are often higher in developing countries because the institutions needed to support a rapid response from markets have not developed (Hobbs & Kerr, 1999). As a result, the reliance on trade to provide sufficient inflows of food in a timely manner may be problematic. Further, the conclusions from Zant (2010) indicate that high transaction costs can reduce economic incentives that could induce timely imports in developing countries.

This is particularly a concern given that many developing countries depend on imports for their domestic food security. For example, the share of imported cereals in domestic consumption (referred to as cereal import dependency) has risen considerably for corn and wheat over time. Corn import dependency has increased from 5 percent in 1961 to approximately 30 percent in 2011; while wheat dependency grew from 35 percent in the 1960s to over 50 percent in 2011. Thus, the speed at which consumption shocks can be mitigated for food import dependent countries, in effect, is important in determining whether or not stockholding programs are needed. A specific objective of this paper is, therefore, to estimate the speed of market response to consumption shocks in developing countries. A rapid market response indicates that distortions in consumption can be restored to their long-run equilibrium (i.e. the acceptable consumption level) by relying on the international market.

In this study, a response is said to be low when it does not restore up to 50 percent of the food needs following a distortion, and vice versa – a very conservative threshold. The investigation uses a panel of 58 net food importing developing countries (NFIDCs) from 1961 to 2011 on rice, corn and wheat. Statistical tests did not indicate any structural changes in the consumption patterns over the years that could lead to potential differences in responses. Hence, the estimates use the full sample from 1961 to 2011 for the estimations. The study focuses on rice, corn and wheat because of their high importance in the trade, consumption and stockholding programs of NFIDCs.

3. The Model and Data

The model of cereal consumption is conceptualised within the context of utility maximization. A NFIDC is modelled as a representative consumer seeking to maximize utility in the international market subject to an income constraint. Assuming wheat (C_w), rice (C_r) or corn (C_c) are the cereals consumed, a representative NFIDC's utility (U) can be defined over consumption as U (C_w, C_r, C_c). Further, it is assumed that international prices largely determine cereal consumption since these are net food importing countries. Letting P_w, P_r and P_c represent international prices of wheat, rice and corn respectively, an income constraint implies that the value of wheat, corn and rice purchased cannot exceed a country's income. A representative NFIDC's economic problem of maximizing utility subject to an income (INC) constraint is stated as:

$$Max\ U(C_w, C_r, C_c)\ \ s.t\ \ (P_w C_w + P_r C_r + P_C C_c \ \le\ INC) \tag{1}$$

From equation (1), consumption demand for wheat (C_w), rice (C_r) and corn (C_c) are implicitly derived as functions of income, own price and prices of related cereals as:

$$C_w = f(P_w, P_r, P_c, INC) \tag{2}$$
$$C_r = f(P_w, P_r, P_c, INC) \tag{3}$$
$$C_c = f(P_w, P_r, P_c, INC) \tag{4}$$

Cereal consumption demand augmented with trade openness (TO) and error term (ε) becomes:

$$C_w = f(P_w, P_r, P_c, TO, INC, \varepsilon) \tag{5}$$
$$C_r = f(P_w, P_r, P_c, TO, INC, \varepsilon) \tag{6}$$
$$C_c = f(P_w, P_r, P_c, TO, INC, \varepsilon) \tag{7}$$

In conclusion, cereal consumption demand is a function of own price, price of related cereals, trade openness and income. Based on this structure we make the following propositions:

(1) *Income (INC)*: An increase in income will raise a country's purchasing power and increase its cereals consumption. Hence, income has a positive effect on cereal consumption.

(2) *International price of cereal (own price):* An increase in the price of a cereal will lead to a decline in imports and consumption. Hence, own price has a negative effect on cereal consumption in NFIDCs.

(3) *International price of related cereals (price of substitute):* A rising international price of one cereal will increase the consumption of another because wheat, corn and rice are substitutable. Prices of substitutes have positive effect on consumption. Hence, the inclusion of prices of related cereals indicates that these commodities are substitutable.

(4) *Trade openness (TO):* Trade openness measures a country's degree of integration into world trade. Higher integration is an indication of low trade barriers which induces imports and enhances consumption. Moreover, trade openness also facilitates a swift consumption response to shocks. Hence, trade openness has a positive effect on cereal consumption in NFIDCs.

(5) *The error term (ε):* The error term captures all other unobservable factors capable of influencing consumption.

Estimating the consumption functions above measures the effects of own price, price of related cereals, trade openness and income on consumption in the long-run. The estimated coefficients are long-run parameters. This does not explain market responses to consumption shocks. To specify the model to capture consumption response to shocks, the data must have panel unit roots and a cointegration process. The methods used to test for panel unit roots in the data are explained in the Appendix. In this paper, the panel error correction approach is chosen as it allows estimation of the speed of consumption response.

Testing for long-run relationships between consumption, income, trade openness and international price of cereals is a test for cointegration. The condition for a cointegration requires that the variables are non-stationary in levels and integrated of order one. Kao (1999) developed a residual-based fixed effect cointegration test, assuming cross-sectional independence and a homogenous unit root process. Thus, Kao's test restricts the cointegration vector to be the same across panels. Pedroni (1999, 2004) expands on Kao's work and proposed a test assuming cross-sectional independence and heterogeneity in the cointegration vector. This paper uses the Westerlund Cointegration test (Westerlund, 2007; Persyn and Westerlund, 2008) as it allows for cross-sectional dependence and heterogeneity in cointegration.[3]

Where unit roots and cointegration conditions are met, cereal consumption demand can be stated as a function of past and present own prices (OP) , prices of related cereals (PR), income (INC), trade openness (TO); and previous consumption (C) as:

$$C_{it} = \sum_{j=1}^{p-1} \tau_{ij}\, C_{i,t-j} + \sum_{j=0}^{p} \beta_{ij}\, OP_{i,t-j} + \sum_{j=0}^{p} \theta_{ij}\, PR_{i,t-j} + \sum_{j=0}^{p} \partial_{ij}\, TO_{i,t-j} + \sum_{j=0}^{p} \delta_{ij}\, INC_{i,t-j} + \mu_i + t + \varepsilon_{it} \quad (8)$$

Where '*i*' identifies countries and *t* is time; μ_i is country fixed effects; ε_{it} is error term; and 'p' is maximum lag included in the model. Equation (8) can be specified to capture a consumption response using a panel error correction approach. Panel error correction has three components:

(1) The long run component: Long run corresponds to the stable equilibrium consumption level of a country. Long-run consumption is assumed to be consistent with food security.

(2) The short-run component: Short-run consumption denotes deviations from acceptable equilibrium consumption levels arising from shocks.

(3) The speed of adjustment or error correction term-measures the speed at which deviations from equilibrium consumption are restored. The *speed of adjustment* is operationalized in this paper as *market response to consumption shock*.

Thus, equation (8) is specified in an error correction form as:

$$\Delta C_{it} = \delta_i\left(C_{i,t-j} - \beta_i OP_{j,t-1} - \theta_i PR_{j,t-1} - \gamma_i INC_{i,t-1} - \partial_i TO_{i,t-1}\right) + \sum_{j=1}^{p-1} \emptyset_{ij} \Delta C_{i,t-j} + \sum_{j=0}^{p} \beta_{ij}\, \Delta OP_{i,t-j} + \sum_{j=0}^{p} \Delta\theta_{ij}\, PR_{i,t-j} + \sum_{j=0}^{p} \partial_{ij}\, \Delta TO_{i,t-j} + \sum_{j=0}^{p} \delta_{ij}\, \Delta INC_{i,t-j} + \mu_i + t + \varepsilon_{it} \quad (9)$$

Where, $\delta_i = -\left(1 - \sum_{j=1}^{p-1} \tau_{ij}\right)$, is the speed of adjustment term measuring market response to consumption shocks. Market response to consumption shocks measures the extent to which countries can rely on the market to restore consumption.

Similarly, the corresponding long run and short-run consumption relationships in the model are:

$\left(C_{i,t-1} - \beta_i OP_{j,t-1} - \theta_i PR_{j,t-1} - \gamma_i INC_{i,t-1} - \partial_i TO_{i,t-1}\right)$ and $(\sum_{j=0}^{P} \theta_i \, \Delta C_{i,t-j} + \sum_{j=0}^{P} \emptyset_i \, \Delta OP_{j,t-j} + \sum_{j=0}^{P} \vartheta_i \, \Delta PR_{i,t-j} + \sum_{j=0}^{P} \varphi_i \, INC_{i,t-j} + \sum_{j=0}^{P} \alpha_i \, TO_{i,t-j})$ respectively. The estimated coefficients of prices, income and trade openness in the long run and short-run components of the error correction model measures their (prices, income and trade openness) impact on cereal consumption in the long and short-runs respectively.

Pesaran et al. (1999) developed models for estimating non-stationary panel data with heterogeneous parameters. These include the Mean Group (MG) and Pooled Mean Group (PMG) estimators. The MG model assumes that the long-run consumption relationship, speed of adjustment (i.e. response to shocks), short-run dynamics (i.e. short-run consumption) and intercept terms are different across panels.

The PMG estimator, on the other hand, assumes that the long-run consumption patterns is the same across panels but short-run parameters, intercepts and response to shocks are allowed to vary. We have reasons to impose these assumptions. Given that NFIDCs are low income countries there is tendency to agree that they have the same consumption pattern in the long-run. However, we have no reason to believe that each country's response to shocks is equal, particularly, when income, trade openness and other transaction costs are likely to vary among countries. The PMG model, by restricting long-run parameters to be equal across countries, leads to efficient and consistent estimates if the restriction is valid (Blackburne III and Frank, 2007).

The PMG is, however, inconsistent if the restriction is false. The MG estimator produces consistent estimates but are inefficient when the restrictions are true. Hence, a Hausman Test is conducted to select the best model – see Nakuja (2016). The MG and PMG degenerate into a dynamic fixed effects model (DFE) when an assumption of parameter homogeneity is imposed across long-run, short-run and speed of adjustment with the exception of country fixed effects. The counterpart of DFE in stationary data is standard fixed/random models, which assumes that all parameters are homogenous with the exception of individual fixed effects. The characteristics of MG, PMG and DFE are presented in Table 1.

Table 1. Comparing MG, PMG and DFE Models

	Mean Group (MG)	**Pooled Mean Group (PMG)**	**Dynamic fixed effect (DFE)**
Long-run	Different for each country	Same for each country	Same for each country
Short-run	Different for each country	Different for each country	Same for each country
Speed of adjustment (response to shocks)	Different for each country	Different for each country	Same for each country
Country fixed effects	Different for each country	Different for each country	Different for each country
Best model selected using Hausman test			

Source: Author presentation summarised from literature.

The panel consist of data on 58 NFIDCs spanning the period from 1961 to 2011. The NFIDCs are countries listed under the WTO Marrakesh *Decision*, which were considered to be at food security risk following the Uruguay Round reforms; and/or the FAO's low-income food-deficit countries.[4]

The data sources include:

Cereal consumption (wheat, rice, corn): Consumption of each cereal is measured as the sum of domestic production, imports, and change in stock minus exports. Data on production, imports, exports and stock variations are available at FAOSTATS from 1960-2014.

International price of corn, wheat and rice: Cereal prices are available from the World Bank Commodity Statistics for 1960-2013. The World Bank collects data on cereal prices in international markets important to developing countries. It identifies the US as the leading corn market and accordingly collects data on free on board number 2 yellow corn prices at the Gulf port. The US corn export price is used as the international price of corn. For wheat, Canada and United States are identified as the most important wheat markets for developing countries. However, data for Canada were discontinued in 2013.

Table 2. Descriptive Statistics

Model	Variable	Mean	Between variation	Within Variation	Overall variation	Sample Size
Rice	Consumption	12.19	2.34	0.73	2.43	2540
	International price of rice	5.54	0.07	0.42	0.42	2540
	Trade openness	4.00	0.44	0.33	0.55	2540
	Income (GDP)	22.32	1.57	0.96	1.87	2540
Corn	Consumption	12.49	2.27	0.86	2.32	2543
	International price of corn	4.62	0.09	0.39	0.40	2543
	Trade openness	3.98	0.44	0.36	0.55	2543
	Income (GDP)	22.32	1.57	0.96	1.87	2543
Wheat	Consumption	12.22	2.10	0.43	2.22	2560
	International price of wheat	4.88	0.11	0.43	0.44	2560
	Trade openness	3.99	0.44	0.34	0.55	2560
	Income (GDP)	22.30	1.57	0.96	1.87	2560

Source: Author's computation

As a result, United States number 1 hard red winter wheat is used as the international wheat price. In the case of rice, Thailand and Vietnam are noted as the most important markets but data on Vietnam are not consistently available. Hence, the Thai market price is used as the international market price. All prices are measured in United States dollars per tonne.

Gross Domestic Product (GDP) and trade openness: GDP (in current US dollars) is used as a measure of income. Trade openness is measured as ratio of total trade to GDP expressed in percent. Trade openness and GDP data are available from the World Bank from 1960-2014.

4. Results and Discussion

The results are presented in two parts: (1) the descriptive statistics, panel unit roots and cointegration tests and; (2) the estimated panel error correction models.

4.1 Descriptive Statistics, Unit Roots and Cointegration Tests

The descriptive statistics pertaining to the data are summarized, by model, in Table 2. All variables are in logarithms. The panel consist of data on fifty-eight (58) NFIDCs extending from 1961 to 2011. Countries, however, differ in their choices of commodity consumption, thereby, resulting in different sample sizes for wheat, corn and rice.

Estimated Market Responses to Consumption Shocks

The estimated panel error correction models for rice, corn and wheat are presented and discussed sequentially by commodity in what follows. The correlation between: rice and corn is approximately +0.87; rice and wheat is +0.89; and rice and corn is approximately +0.96. The high correlation led to multicollinearity issues in the models.

Table 3. Rice Model Results

Dependent variable: Rice consumption				
	Variable	**MG**	**PMG**	**DFE**
Long run	International price of rice (-1)	-0.1192	-0.2626***	-0.1601
		(0.1020)	(0.0401)	(0.1335)
	Trade openness(-1)	0.2119	0.7684***	0.1116
		(0.1549)	(0.0611)	(0.1368)
	GDP(-1)	0.5213***	0.5808***	0.6009***
		(0.0887)	(0.0194)	(0.0584)
Short run	Δ International price of rice	0.0526**	0.0081	-0.0064
		(0.0221)	(0.0208)	(0.0218)
	Δ Trade openness	-0.1381*	-0.0688	0.07572**
		(0.0787)	(0.0533)	(0.0341)
	Δ GDP	-0.1824*	-0.0213	0.0188
		(0.0718)	(0.0396)	(0.0358)
Response	$-(1-\tau_{ij})$	**-0.4102*** **	**-0. 1718*** **	**-0.1203*** **
		(0.0481)	**(0.0445)**	**(0.1112)**
Overall model significance (Chi-square(7))		248.96***	2639.97***	302.81***
Hausman stat. (chi-square (3))		13.66**		0.03
Sample size		2540	2540	2540

Notes 1: ***, ** and * are 1 percent, 5 percept and 10 percent significance level.
Notes 2: Model performance: DFE>MG>PMG. Hence, DFE is the statistically selected model.
Notes 3: Values in parentheses are standard errors

As a result, only own prices were incorporated in the estimations. Table 3 shows the estimated error correction models of rice consumption in NFIDCs. The test for overall significance for MG, PMG and DFE are all significant at 1 percent. This implies that trade openness, income and price jointly explain rice consumption in LFIDCs. Hence, the models are valid. The results are discussed by impacts of international prices, trade openness and income; and estimated market responses.

The international price of rice, trade openness and income have the expected effects on long-term rice consumption under the MG, PMG and DFE models. International price negatively affect rice consumption in the long run, as expected. This implies that rising prices reduces purchasing power and, hence, negatively affect consumption. However, its impact is found to be significant (1 percent) only under the PMG model. The results show that a 1 percent increase in rice price leads to decrease in long-run consumption of rice by 0.26 percent in developing countries. In the short run international price does not have significant impact on rice consumption for all cases though it does have the expected negative effect under the DFE. This implies that a price increase generally leads to a more devastating impact on long-term consumption and food security than in the short-term. This is because the attempt to substitute one cereal for another as a result a price increase lead to rising prices for all cereals in the long-term. The increased substitution drives up prices of all cereals in the long-term leading to a greater impact on consumption. The results, thus, agree with the FAO's (2008) assertion that global food crises will increase food security risk for developing countries in the long-term.

Further, trade openness and income positively affect long-term rice consumption in developing countries, as expected. This implies that long-term cereal consumption can be enhanced in developing countries with improved trade openness. Trade openness impacts are, however, only significant (1 percent) under the PMG estimation. In the short-term, trade openness has a significant positive effect on rice consumption under the DFE estimation although its economic importance is relatively small compared to the long-run case. Under the PMG case, trade openness is not significant in the short-term and, also, does not have the expected sign under MG. These results suggest that the benefits to rice consumption and food security as a result of trade openness improvements are more noticeable in the long-term. Their impacts on food security may not necessarily be immediate. A possible explanation is that the benefits of trade openness arise from efficiency gains, which leads to resource use adjustments in the long run. Without resource adjustment (the case in the short-run), such benefits cannot be captured. Income has a significant positive effect on long-term rice consumption, as expected, under all models.

Market response to consumption shocks is low in NFIDCs. The estimated responses are multiplied by 100 and interpreted in percentages. Market response to shocks under the DFE model is estimated at approximately 12 percent (and significant at 1 percent). This means that when countries are assumed to have same consumption patterns in the short- and long-runs, the market corrects about 12 percent of distortions per year. This constitutes a slow response because more than 50 percent of the consumption shock – a very conservative threshold – cannot be restored by relying on international markets. The slow response suggest that trade does not restore consumption swiftly enough to assure food security in developing countries, and, hence, should not be relied upon. This is because consumption shocks are relatively large in many NFIDCs. Consumption shocks relative to means deviates about 30 percent on average across developing countries but the impacts are fairly large (more than 50%) for some individual countries including Haiti, Malawi, and Chad among others.

The second case of market response to a consumption shock is estimated under the PMG model, where countries are assumed to have the same consumption patterns in the long run. Under this assumption, the estimated consumption response to shock improves to approximately 18 percent, and is significant at 1 percent. Although, response to shocks improved compared to the DFE case, more than 80 percent of a consumption shock will still not be restored by relying solely on trade generated by market forces. The third case of market response to consumption shock is estimated under the MG model, where countries are assumed to have different consumption patterns and responses to shocks. Under this assumption, the estimated consumption response to a shock improves to approximately 40 percent (and significant at 1 percent). The MG model represents best case among the three models but the response is still slow because 50 percent of the shock is not corrected following a disruption.

Table 4. Corn Model Results

Dependent variable: Corn consumption				
	Variable	**MG**	**PMG**	**DFE**
Long-run	International price of corn (-1)	-0.2347	-0.0884	-0.3615*
		(0.2425)	(0.0575)	(0.2052)
	Trade openness (-1)	0.3725	0.0082	0.1678
		(1.1411)	(0.0553)	(0.1551)
	GDP (-1)	0.6736***	0.5612***	0.7016***
		(0.2033)	(0.0189)	(0.0800)
Short-run	Δ International price of corn	0.1401	0.0658	0.0436
		(0.0835)	(0.0437)	(0.0386)
	Δ Trade openness	-0.0230	-0.0790	0.0627
		(0.1040)	(0.1887)	(0.0454)
	Δ GDP	-0.0460	0.1078	0.0603
		(0.0572)	(0.0911)	(0.0470)
Response	$-(\mathbf{1}-\boldsymbol{\tau}_{ij})$	**-0.3125***	**-0.1564***	**- 0.1384***
		(0.0302)	**(0.0235)**	**(0.0100)**
Overall model significance (chi-square(7))		141.66*** 1919.68***		381.92***
Hausman stat. (chi-square(3))		0.33	6.26	
Sample size		2543	2543	2543

Notes 1: ***, ** and * are 1 percent, 5 percept and 10 percent significance level.
Notes 2: Model performance: DFE>PMG>MG. Hence, DFE is the statistically selected model.
Notes 3: values in parentheses are standard errors

The Hausman test for model selection between PMG and MG is significant at 1 percent. This implies that the MG model under which countries have different consumption patterns and responses to shocks is preferred to the PMG. However, the comparison between PMG and DFE is not significant which implies that the DFE is superior. Consequently, it is possible to generalise that the market mechanism (i.e. trade) corrects approximately 12 percent of rice consumption distortions in NFIDCs. However, the choice of model has no consequence on the main conclusion that market induced trade flows cannot be relied upon to maintain levels of food security in the case of rice.

Table 5. Wheat Model Results

Dependent variable: Wheat consumption				
	Variable	**MG**	**PMG**	**DFE**
Long-run	International price of wheat (-1)	-0.4283***	-0.2902***	-0.2831***
		(0.0761)	(0.0305)	(0.0989)
	Trade openness (-1)	0.4423***	0.2101***	0.2596***
		(0.1030)	(0.0349)	(0.0788)
	GDP(-1)	0.7094***	0.5688***	0.6119***
		(0.0608)	(0.0123)	(0.0431)
Short-run	Δ International price of wheat	0.0721**	-0.0213	-0.0449
		(0.0285)	(0.0251)	(0.0304)
	Δ Trade openness	-0.0197	0.0204	0.0335
		(0.0551)	(0.0551)	(0.0365)
	Δ GDP	-0.03457	0.0558	0.0496
		(0.0490)	(0.0470)	(0.0380)
Response	$-(1-\tau_{ij})$	**-0.4615*** **	**-0.2464*** **	**-0.2241*** **
		(0.0407)	**(0.0334)**	**(0.0119)**
Overall model significance (Chi-square(7))		155.39***	4835.02***	884.50***
Hausman stat.(Chi-square(3))		5.06		0.97
Sample size		2560	2560	2560

Notes 1:*, ** and * are 1 percent, 5 percept and 10 percent significance level.
Notes 2: Model performance: DFE>PMG>MG. Hence, DFE is the statistically selected model.
Notes 3: Note: values in parenthesis are standard errors.

The estimated error correction models for corn are presented in Table 4. The prices of wheat and rice were excluded due to multicollinearity issues. The chi-square test for overall model significance for MG, PMG and DFE models are each significant at 1 percent. This implies that international price of corn, trade openness and income jointly explain corn consumption in NFIDC countries. Thus, the estimated models are valid. The results pertaining to the impacts of international prices, trade openness and income can be interpreted in a similar fashion as the rice model. The estimated market responses in the corn case are the focus of what follows.

Consumption responses to shocks for corn are low in NFIDCs. For the case of DFE, where countries are assumed to have the same consumption patterns in the long and short-runs, the market restores about 14 percent of consumption distortions per year. As such, over 85 percent of food consumption distortion is not restored. Where countries are assumed to have the same consumption patterns (PMG) in the long run, the estimated response to a shock is approximately 16 percent, and, is significant at 1 percent.

Under the MG, where countries are assumed to have different consumption patterns and responses to shocks, the estimated response is approximately 32 percent (and is significant at 1 percent). The response to shocks is an improvement over PMG and DFE but it is still low because more than 50 percent of consumption cannot be restored by relying on market induced trade flows in the event of a shock. The DFE is the selected model based for the Hausman test. However, the choice of model has no consequence on the conclusions. Market response to a corn consumption shock ranges from minimum of 13 percent to maximum of 31 percent in NFIDCs. The DFE, MG and PMG all suggest NFIDCs cannot rely on market induced trade flows to maintain food security levels in the case of corn.

The error correction models for wheat are presented in the Table 5.The price of rice and corn were excluded due to multicollinearity problems. The estimated MG, PMG and DFE models are each significant at 1 percent. Thus, trade openness, income and international price of wheat jointly explain wheat consumption in developing countries, and the estimated models are valid. The results pertaining to the impacts of international prices, trade openness and income can be interpreted in a similar fashion as the rice model. The estimated market responses in the wheat case are the focus of what follows.

Wheat consumption responses are low in NFIDCs. The estimated response to shocks under the DFE is approximately 23 percent and significant at 1 percent. Consequently, over 75 percent of the distortions to cereal consumption may not be corrected in the event of a shock. Under the PMG where countries are assumed to have same long-run consumption patterns, the market corrects approximately 25 percent of consumption distortion annually. In the case of MG, where countries are assumed to have different consumption patterns and response to shocks, the market corrects approximately 47 percent of a consumption distortion annually.

The DFE is the selected model based on Hausman test. The choice of model, however, does not alter the general conclusion as responses are slow under each model. The DFE, MG and PMG all suggest that NFIDCs should not rely on market induced trade flows to maintain levels of food security.

5. Summary of Results and Discussion

This paper investigates the speed of market response to consumption shocks and its implication for food security in NFIDCs. Response to shocks measures the extent to which a disruption in consumption can be mitigated by relying on the market.

Table 6. Estimated Market Responses (percentages)

	Mean Group (MG)	**Pooled mean Group (PMG)**	**Dynamic Fixed Effect (DFE)**
Rice	41.02	17.18	12.03*
Corn	31.25	15.64	13.84*
Wheat	46.15	24.64	22.41*

Notes: Asterisk (*) statistically selected preferred model.

It is posited that where responses are low, then relying on the market to restore consumption is a risk to food security. The results also provide useful insights for the ongoing WTO policy debate regarding food security and public stockholding in developing countries. The results are summarized in Table 6.

The results suggest that distortions in cereal consumption cannot be restored swiftly enough to assure food security in times of shock. The estimated consumption response indicates that the market mitigates at most: 41 percent of a rice consumption distortion; 31 percent of a corn consumption distortion; and 47 percent of a wheat consumption distortion in times of shock. Conversely, the market fails to restore approximately 59 percent of rice consumption shocks; 69 percent of corn consumption shocks; and 53 percent of wheat consumption shocks in times of food crisis. Thus, over 50 percent of the distortions to consumption cannot be restored by relying on the market. In NFIDCs where cereals are an integral part of food consumption, a considerable short-fall in consumption availability can significantly increase prices and consign vulnerable populations to going hunger given the low responses.

6. Conclusions

In terms of the relevance of this research for WTO policy debates on public stockholding, the results suggest that food security can be negatively affected in NFIDCs if they rely solely on markets to maintain food security levels in the event of a shock. This is because market responses are too slow to assure food security. Trade cannot be relied upon to swiftly restore consumption or address food security in the event of a food crisis.

The debate over the lifting of subsidy limits on acquiring public stockholdings of food – likely cereals – at the WTO has been conducted against a background of sparse empirical evidence. Those WTO members resisting the G-33's proposal to remove the *de minimis* limits on subsidized acquisitions of stockholdings through administered prices have implicitly assumed that food security can be maintained in times of a food price shock through market induced international trade flows. While this research cannot be used to directly make the case for a role for public stockholdings, it does suggest that if food security is to be maintained in times of a food price shock governments in NFIDCs require policy flexibility – one of those policy options is acquiring stocks of food using administered prices. Thus, the empirical results of this research should assist in moving the negotiations aimed at finding a *permanent solution* to the acquisition of stockholdings question away from polarized positions to discussions of a range food security policies and, if appropriate, the subsidized acquisition of public stockholdings using administered prices.

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Appendix

Panel Unit Root Test

Data is said to have unit roots if it is non-stationary in levels but becomes stationary after first differencing. Testing for stationarity is essential in order to avoid estimating spurious relationships (Kao, 1999). Unlike time series where the unit root process is homogeneous, panel unit roots may be heterogeneous. Stationarity in panel data is also affected by contemporaneous correlation between panels known as cross-sectional dependence. The presence of cross-sectional dependence causes estimates to be inconsistent and, thus, affect hypothesis testing (Baltagi, 2008). Fisher-ADF and Fisher-PP tests (Maddala & Wu, 1999; Choi, 2001) were developed to accommodate heterogeneity in the unit root process. Although originally developed under the assumption of cross-sectional independence, recent advances in panel data estimation using STATA allows for the implementation of a Fisher test that accounts for cross-sectional dependence. Also, Fisher tests are applicable where the data is an unbalanced panel. The Fisher Test developed in this chapter draws extensively from Baltagi (2008, Chapter 12).

The Fisher test combines probability values of each cross-section's unit root test to determine overall panel statistics. For a variable C (where C represents all variables to be tested for panel unit roots), the specified model of unit root test under Fisher assumes the following linear relationship:

$$C_{it} = \beta_i + \rho_i C_{i,t-1} + \varepsilon_{ijt} \qquad \text{(A.1)}$$

Where β_i is panel specific constant terms, i = 1, 2, ….., N unique cross-sections; t=1, 2, ….., T time frame and ε_{ijt} is an error term while J is the number of lags included, determined from lag selection criterion. The symbol ρ_i is the heterogeneous unit root process that varies across panels. The hypotheses used to test for unit root process in panel data are stated as:

Ho: $|\rho_i| = 1$, all panels contain unit root

Ha: $|\rho_i|<1$, at least one panel is stationary

Four test statistics are used to test the hypothesis. These include:

(a) Inverse chi-square statistic (P): The P statistic approximates a chi-square distribution, $P = -2\sum_{i=1}^{n} lnP_i \rightarrow \chi^2(2N)$, with a degree of freedom equal to twice the sample size (N).

(b) Inverse normal statistic (Z): The Z statistic approximates a normal distribution, $z = \frac{1}{\sqrt{n}}\sum_{i=1}^{N} \Phi^{-1}(p_i)$, with 0 and 1 as its mean and variance respectively.

(c) The inverse logit statistic (L): The L statistic approximates a logistic distribution, $L = \sum_{i=1}^{N} \ln(\frac{p_i}{1-p_i})$, with 0 and $\pi^2/3$ as its mean and variance respectively.

(d) The modified inverse chi-square statistic (Pm) is a standard normal distribution, which assumes a mean of 0 and a variance of 1. Where, $P_m = \frac{1}{2\sqrt{N}}\sum_{i=1}^{N}(-2lnp_i - 2)$

In each case, p_i is the probability value of the *i*th panel unit root test. The null hypothesis is rejected if p-calculated exceeds p-critical values (Baltagi, 2008).

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[1] The acquisition of stocks *per se* is not constrained by WTO commitments, only the subsidized acquisition using administered prices. Thus, it is the policy space of developing countries that is constrained. Developing countries through their membership in the G-33 have, however, negotiated stridently at the WTO to have this limit removed (Kerr, 2014; Kerr, 2015).

[2] A number of countries have limits fixed in monetary amounts – *bound* Aggregate Measures of Support AMS).

[3]Westerlund developed four statistics (Gt, Ga, Pt or Pa) for testing cointegration. The group-mean statistics (Ga and Gt) assumes that a cointegration relationship is different across panels. Hence, the null hypothesis of no cointegration is tested against the alternative that cointegration exists in at least one panel. The Panel Statistics (Pa and Pt) assumes a homogenous cointegration relationship; and test the null hypothesis of no cointegration against the alternative of cointegration. Where Group test (Gt, Ga) and Panel Test (Pt and Pa) leads to opposing conclusion, preference will be given to Panel Test since it focuses on the whole panel. Westerlund statistics are normally distributed under the null.

[4]The list of countries considered NFIDC are: Afghanistan, Algeria, Bangladesh, Belize, Benin, Burkina Faso, Cambodia, Cameroon, Central African Republic, Chad, China, Cote d'Ivoire, Cuba, Dominican Republic, Egypt, El Salvador, Gabon, Gambia, Ghana, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, India, Indonesia, Jamaica, Kenya, Laos, Liberia, Madagascar, Malawi, Mali, Mauritius, Mongolia, Morocco, Mozambique, Namibia, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Panama, Peru, The Philippines, Senegal, Sierra Leone, Tanzania, Togo, Trinidad and Tobago, Tunisia, Uganda, Venezuela, Vietnam, Zambia and Zimbabwe.