

# Market and Welfare Effects of Food Security Policies on Small Holder Rice Farmers in Sierra Leone

Mohamed Ajuba Sheriff\* & K. Lakoh \*\*

\* *PhD Candidate, Department of Agricultural Economics Njala University*

\*\**Lecturer, Department of Agricultural Economics, Njala University*

[medajuba@yahoo.com](mailto:medajuba@yahoo.com) /+23276646442

**Key words:** Ad-hoc food security policies, partial equilibrium displacement models, consumer surplus, producer surplus.

## Abstract

This research analyses the market and welfare effects of three food security policies in Sierra Leone. These include 1) reinstating tariffs on rice imports, 2) promoting value-chain strengthening interventions that increase production of locally produced rice and 3) instituting a quota on rice imports. These policies were envisioned, if enacted, would promote the welfare of smallholder rice farmers in Sierra Leone. For this analysis, a log-linear comparative static displacement model was employed. 20%, 30% and 40% shocks were introduced into the equilibrium system to represent decreases in the quantity of rice imported as a result of reinstating tariffs on imported rice. Results revealed that reinstating the tariffs on rice imports decreases household welfare of local rice consumers by 8.3%, decreases household welfare of imported rice consumers by 14.74%, increases welfare of rice importers by 4.12% and barely increases welfare of local rice farmers by 1.1%. Also, an increase in market power increases prices of both imported and locally produced rice when a 20% rice tariff is reinstated. The results show that the optimal policy in the current post Ebola national recovery environment is one that increases local rice production through cultivation intensification across the rice value chain.

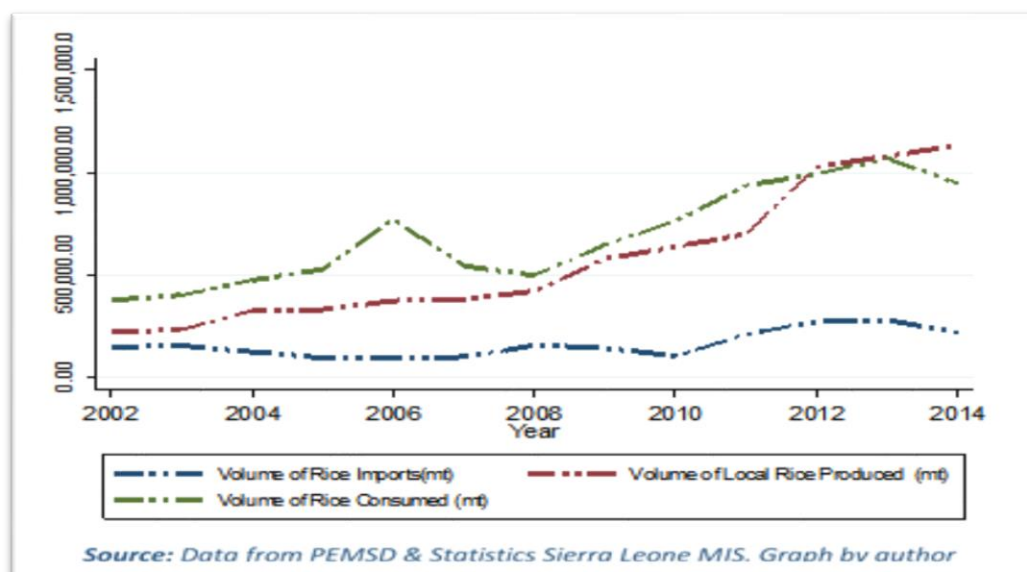
## 1. INTRODUCTION

Food insecurity continues to be a major problem in Sierra Leone. Despite reported increases in the production of the country's main staple crop (rice), national demand for locally produced rice remains to be very low (particularly in the populated urban areas of Sierra Leone), hence accounting for the negligible effect of the increased level of production on food security (Spencer, 2009). Local rice consumption, at the rural household level has been known to follow a seasonal pattern (high during the harvest months and low during the planting months). This premise may suggest that the prevailing level of food insecurity can be resolved mainly by stimulating local demand for locally produced rice. However, this isn't necessarily the case.

The majority of rice farmers in Sierra Leone cannot compete with imported rice in the domestic market as the high cost of production inhibits their ability to price below the market price of imported rice. This dampened demand of locally produced rice disincentivizes some smallholder farmers from increasing their production levels to simultaneously supply the market and meet their household consumption needs. Figure one compares annual volumes of rice imports, local production and local consumption. Encouragingly, production has been on the increase and slightly surpassing consumption in 2013. The striking revelation however is that some

amount of the inflows (imports and production) are not consumed locally. That is, rice supplies into the local market outweigh consumer demand.

**Figure 1. Rice Import, Production and Consumption: Compared 2002 to 2014**



These three related market patterns, to a great extent, seen to be counterintuitive, as they tend to contradict each other. i.e.: 1) Increased production of locally produced rice, 2) An irresponsive local rice demand to the increased production level and 3) Increased consumer demand for imported rice. These unexplained trends further raise questions around which markets absorb these surpluses and what factors may be driving all three trends.

There is an extensive literature showing that several factors influence policy decisions. Some of these include environmental, political, socio-economic, weather, production cycles, prices and trade patterns etc. Salami et al (AFDB 2011) confirms that in Africa, several food security policy frameworks have been influenced by price volatility and policies have been designed to stabilize prices. They further expressed that broadly policies against food security risk due to price volatility need to go beyond the food and commodity markets. Deviga Vengedasalam et al (2006) observed that Malaysia's rice sector is highly protected, with the protection justified largely by arguments for food security. Similarly in Sierra Leone, several rice policies have been enacted at different times to improve on the level of food insecurity. Kim Sunae (2016) highlights some of these policies, stating that the Ministry of Agriculture Forestry and Food Security in collaboration with FAO, WFP, IFAD and the World Bank adopted three major food security policies that focus on mitigation and response strategies. These include:

1. Mitigate price increases through reduction in tariffs on imported rice and to minimise the transmission of impacts of the price increase to consumers through discursion with importers.

2. The use of safety nets to mitigate the impact of rising prices on the poorest and most vulnerable, through targeted programs such as Food For Work (FFW), Cash For Work (CFW), school feeding and supplementary feeding for vulnerable groups- children under five years, pregnant and lactating women, and household affected by HIV AIDS.
3. Increasing national production by providing such incentives like additional seeds and fertilizer, encouraging investment by larger producers and improving handling and transport to ease access to food markets.

## **1.1 PROBLEM STATEMENT**

The just concluded national census in Sierra Leone reported a national population of about 7,075,641 (SSL, 2015) and characterised by about 70% to 75% rural rice producing farming households. Despite this high level of involvement in the sector and coupled with favourable agro-ecological endowments in the country, total production and productivity levels continue to be dismally low. This is as a result of several factors including, the use of low yielding varieties, and high cost of inputs, rudimentary farming technologies, poor agronomic practices, inappropriate food security policy choices and other socioeconomic factors.

Inappropriate choices of food security policies by Government and partners in the agriculture sector have been a serious problem inhibiting growth of the agricultural sector and negatively affecting the welfare of smallholder rice farmers for decades. The CFSVA (2015) report estimated that 49% (3,467,064) of Sierra Leoneans are food insecure, of which, majority are poor smallholder rice farmers living in rural areas of the country. The failure of such ad-hoc food security policies can be attributed partly to the lack of adequate capacity to conduct sound data-driven economic policy analysis to drive decisions or the role played by other political, social or rent-seeking interests in influencing these decisions. As is usually the case, to any bad ad-hoc policy, there are winners and losers. Nekhay O. et al (2012) showed that, even for a country like Ukraine that exports large shares of its grains produced, the introduction of ad-hoc export bans or very restrictive export quotas did not only favour domestic grain consumers but also had severe negative effects on the international grains market by contributing significantly to price increases and thus having adverse effects on global food security.

Similarly, in Sierra Leone, in addition to the internal constraints of food security policy decision making, the role played by donors and the international community in influencing food security policy has, for decades, affected decisions made by policy makers. This is mainly as a result of the over dependence on foreign donors to drive the national economy. The structural adjustment credit project (1993) of the World Bank are some of such policies. Despite the large sums of grants/loans received by these governments, the accompanying policies failed to make positive impacts on the lives of smallholder farmers.

Similar issues have been investigated by several researchers in different countries in Africa. Emmanuel et al (2012) looked at agricultural policies in Nigeria, showing how these policies have failed to improve welfare of smallholder farmers. The results showed that the current agricultural policy suffers enormously from a wide gap between intent and actual practices. Raltiza Dimova et al (2012) investigated the welfare implications of price

increases of key imported staple food -rice- and consider the consumption smoothing of locally produced food and cash crop varieties in Cote d'Ivoire. The result showed that, while middle-income households are found to be hardest hit by a price shock, the poorest appear to be immune to it. The study further stated that, when both cash and food crop production are considered, the negative impact becomes negligible. Furthermore, the result also shows interesting income reallocations from richer to poorer households, which can potentially be generalised across similar African countries.

Different from these highlighted studies, the use of ex ante empirical research to influence policy has not been a common place in West Africa, particularly, Sierra Leone. Yashiko (2007) have shown how such meticulous ex ante policy analysis has contributed to improving income levels of small scale local rice producers in Senegal. This has not been the case in Sierra Leone.

In this research, we provide a framework that can be used for current and future food security policy analysis in the country. In order to effect immediate influence on policy makers, we apply these methods to a current burning problem in the Ministry of Agriculture, Forestry and Food Security and the Bank of Sierra Leone: *How do we institute meaningful food security policies that would decrease rice importation (hence reduce its effects on foreign exchange reserves) without negatively affecting welfare of rice farmers in Sierra Leone?*

In this research, we use a partial Equilibrium Displacement Model (EDM) to carry out the analysis. While there exist other models for analysing food security policies, our choice is based on the flexibility and limited data requirements for the use of EDMs.

This research will contribute very little to the literature with regards to the methodology. However, the main contribution in this work is the application of these methods towards solving food security policy problems in Sierra Leone. In addition, this research will present a toolkit that can be referenced for future food security policy analysis and decision making.

## **1.2 Objectives:**

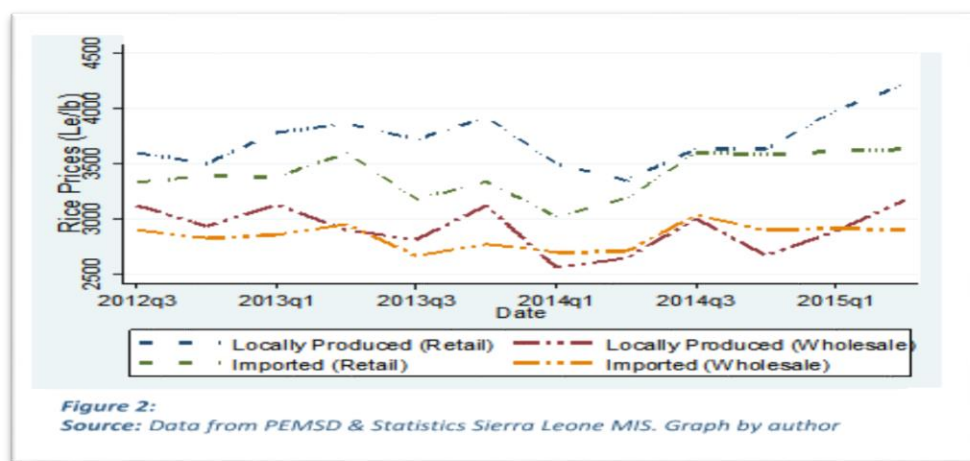
In trying to provide solutions to some of these problems, it is best that policy makers understand all the dynamics associated with the rice sector in the country. This would help them better understand the ramifications of the policy options/instruments available to fix these problems. This research is one step in that direction as we seek to better understand the sector. In this paper, we seek to analyse the welfare and market effects of three possible policies/instruments on the rice sector in Sierra Leone, showing the potential gains to producers and consumers. We hope to give policy makers policy options and their associated effects that would affect the rice sector in Sierra Leone. The three policy options considered are:

- i) The effect of reinstating tariffs on rice imports
- ii) The effect of instituting a quota on imports
- iii) The effect of providing subsidies that increase local rice production (supply) for farmers (A value-chain, multi-intervention approach).

For a better understanding of the problem, we initially looked at price trends across market types (periodic and daily markets), across product types (imported and locally produce rice) and market players (wholesale and retail). Looking at a quarterly series from 2012 to 2015, some very revealing trends can be observed (See Figure 2).

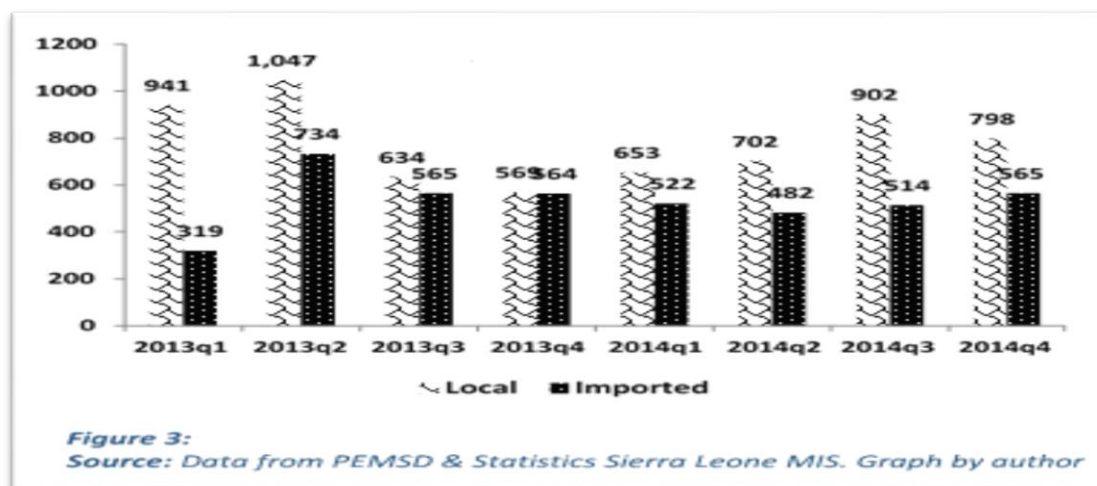
**Figure 2. Sierra Leone Quarterly Rice Prices 2012 to 2015**

**(Locally Produced vs Imported Rice Compared)**



The graph shows that 1) imported wholesale prices have been relatively stationary throughout the period (with more volatility seen in the wholesale prices of locally produced rice); 2) retail prices for locally produced rice are persistently higher than retail prices of locally produced rice. This is not the case for wholesale prices; 3) the gap between retail prices and wholesale prices are larger for locally produced rice than is the case for imported rice (See figure 3).

**Figure 3. Price Gaps between Wholesalers and Retailers**



These three results provide more contexts into our understanding of the problems with the rice sector. Observations 2 and 3 reveal that the share of the final price of both commodities is highest at the retail level. However, this share is far higher for locally produced rice than is the case for imported rice. This may suggest that retailers

fetch a higher margin on locally produced rice than on imported rice (assuming their costs per unit are not significantly different). This would not be true if there is limited demand for locally produced rice.

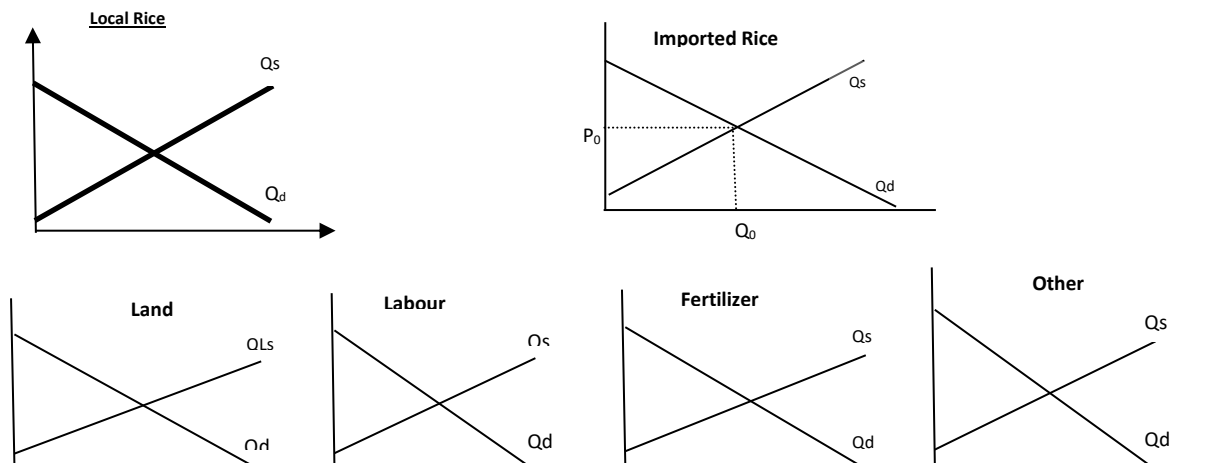
There may be some conflating factors at play. The seemingly obvious ones include: 1) trade flows (across borders) causing the unexplained high demand for locally produced rice and 2) the prevailing market structure giving market power to few retailers of locally produced rice.

This paper primarily seeks to provide answer to some of these trends and more specifically focuses on some policy options to address these problems. It is important to note that an important hypothesis that guides the interpretation of results obtained is that Sierra Leone is a net rice consuming country. We assume that total sales of rice to the market are less than total purchases of rice from the market.

## 2 Methods

To carry out this analysis, a partial equilibrium framework was used. Log-linear comparative statics in a multi-market environment was used to determine market effects while consumer surplus and producer surplus measures were used to estimate welfare. We follow closely frameworks used by Muth in the 60s and with modifications by Perrin, 1998 and others; S. Klaus, 1999 and more. Here, we show the effect of introducing shocks to a partial equilibrium system and how this system changes or responds to these shocks. For this analysis, we assume two up-stream markets (Imported Rice and Local Produced Rice) and four downstream input markets (Land, Labour, Fertilizer and Other). The inputs are used only in the production of locally produced rice and linked by a production function (represented as a cost function)  $C(Q_L, W_L, W_{Lb}, W_O, W_f) - Q$  being output of locally produced rice, and  $W_s$  representing input costs. See the equilibrium graphs (figure four):

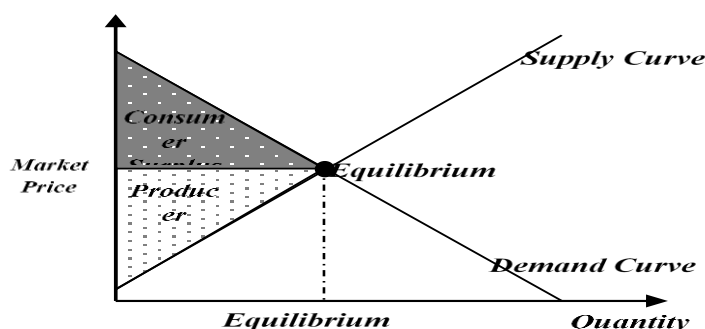
**Figure 4. Up-Stream and Down Stream Markets**



Using log-linear comparative static, 12 demand and supply equations were derived. These equations represent 12 endogenous and 12 exogenous variables. The objective is to use the exogenous variables to solve for the endogenous parameters. The exogenous variables are mainly elasticities and shares while the endogenous parameters are the market effects (changes in quantity demanded, supplied and prices). For details on equations and matrix of elasticities and shares, please see annex 1 of this paper. Welfare gains were estimated using

consumer surplus and producer surplus. Figure 5 below shows these measures of welfare in an equilibrium stage.

**Figure 5. Welfare measurement**



Shares and elasticities were obtained partly from the literature (Philippine Rice Research 2016) of other studies and from estimation from primary data using willingness-to-pay estimation techniques.

For the purposes of this version of the analysis, we present results for the upstream actors. That is, results on the market and welfare effects of the policy changes considered on the input market would be presented in the final paper.

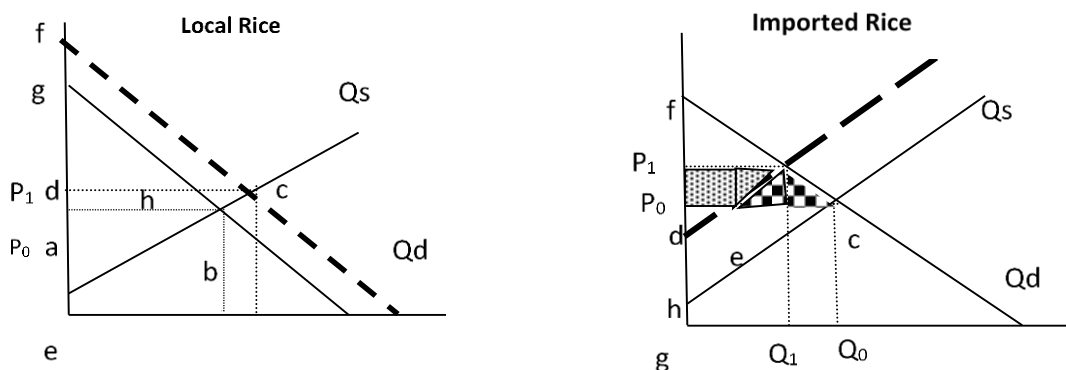
### 3 Analysis and Results:

#### 3.1 Policy Option 1: Reinstating Tariffs (*Multi-market – perfect market condition*)

We start by investigating the effect of reinstating tariffs on imported rice. Before 2010, Sierra Leone had a 10% tariff (NRA 2010) on all rice imports into the country. However, this had an unfavourable effect on market prices for imported and locally produced rice. With the change in government in 2007, the 10% tariff was removed. We assume a new equilibrium has been re-established with that price being  $P_0$  and quantity demanded and supplied being  $Q_0$ . We introduce shocks of 20%, 30% and 40% as decreases in the quantities imported. For the imported rice market, reinstating the tariffs would decrease supply of imported rice. This is the immediate shock to the system, see figure 6. Market and welfare effects are discussed below:

**Figure 6. The Effect of Reinstating Rice Importation Tariffs on Markets and Welfare**

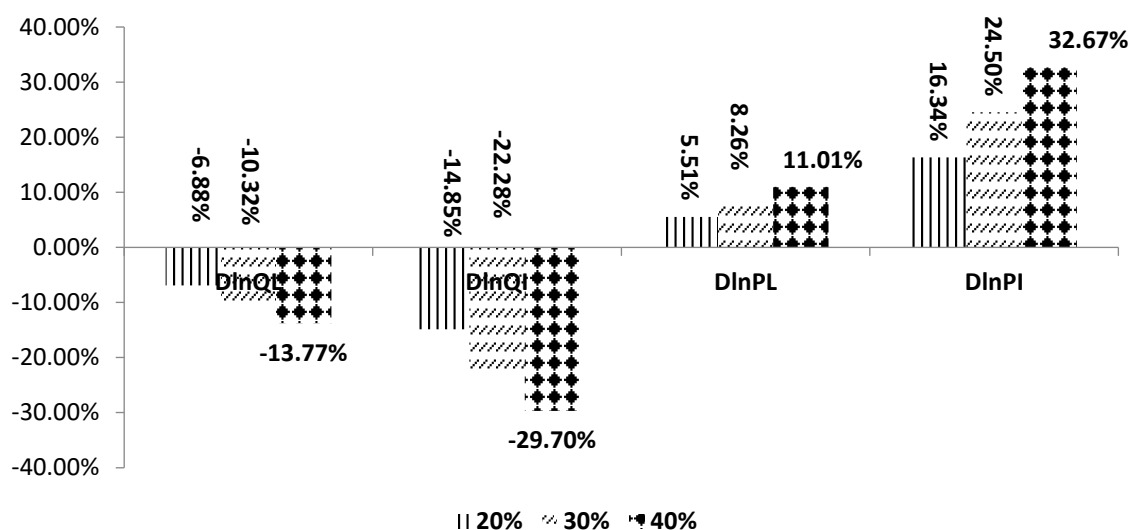
#### Multi-Market Comparative Static



## Market Effects

Figure 7 shows responses of equilibrium quantities and prices to these different shocks. As shown, the general trend is one that increases prices of both imported and locally produced rice and decreases in equilibrium quantities demanded and supplied for both products. Comparatively, these effects are greater for imported rice than is the case for locally produced rice.

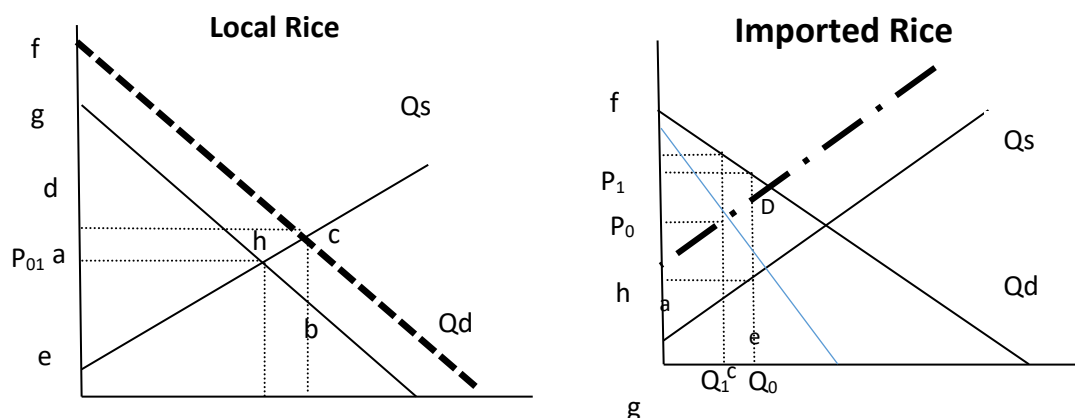
**Figure 7. Market effects for reinstating tariffs**



### 3.2 Policy Option 1: Reinstating Tariffs (*multi-market – oligopoly*)

Here we assume there exists a cartel of rice importers enjoying some market power. The greater the number of importers of rice, the lesser the market power and the closer we tend to perfect market conditions. We also assume that the few importers collude and agree on import volumes that are lesser than the equilibrium quantity. We also assume there is no incentive for a single importer to import more than the cartel agreed upon quantity.

**Figure 8. Multimarket model with oligopolistic rice importation market**





## Market Effects

Our premise in analysing this oligopolistic environment is that the higher the market power, the higher the price elasticity of demand and supply. We investigate what happens to the market when more importers exist in the market. The increase in market power increases prices of both imported and locally produced rice when a 20% rice importation tax is reinstated. That is, the more rice importers we have in Sierra Leone, the lower rice prices would be for both imported rice and locally produced rice. Regarding demand however, the more importers operating, the higher the demand for imported rice and the lesser the demand for locally produced rice.

**Table 1. Market Effect Matrix with increased oligopoly power**

	1.1	1.5	1.9
<i>DlnQL</i>	-6.41%	-8.58%	-10.01%
<i>DlnQI</i>	-15.21%	-13.58%	-12.51%
<i>DlnPL</i>	5.13%	6.87%	8.01%
<i>DlnPI</i>	15.21%	20.37%	23.77%

## Welfare Effects:

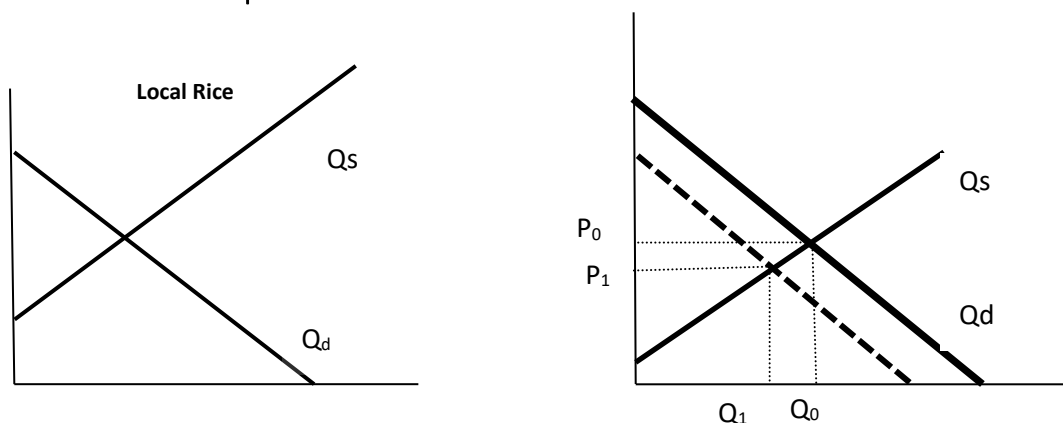
Reinstating the tariffs on imports decreases household welfare of local rice consumers by 8.3%, decreases household welfare of imported rice consumers by 14.74%, increases welfare of rice importers by 4.12% and barely increases welfare of local rice farmers by 1.1%.

With increased degree of oligopolistic power and reinstating tariffs, welfare of rice importers slightly decrease by 2.1%, however welfare of consumers decrease significantly, 15.2%. This is mainly because importers would increase rice prices beyond the equilibrium price to benefit from the super normal profit. Increasing more importers decrease this supernormal profit, decreased prices downwards towards the equilibrium price. The effects on the local market remain as discussed above.

### **3.3 Policy Option 2: Effects of an increase in local rice production levels**

With an increase in production levels as a result of the provision of input subsidies, consumer's welfare is enhanced while producer's welfare slightly enhanced. However in a single market framework, consumer's welfare remains unchanged while producer's welfare is significantly enhanced. Clearly this is a more feasible option than what was presented in the first analysis (Reinstating tariff). This is because as a result of the policy, consumers and producers do not lose anything. Rather it enhances producer welfare. However, a different policy analysis should be carried out on the specific type of subsidies that should be instituted. This is beyond the scope of this research.

## **Multi-Market Comparative Static**



## Market Effects

$D\ln QL$	$D\ln QI$	$D\ln PL$	$D\ln PI$
1	0	-1.12	0.80
0	1	1.11	-0.53
0.8	0	1	0
0	1.1	0	1

$D\ln QL$

$D\ln QI$

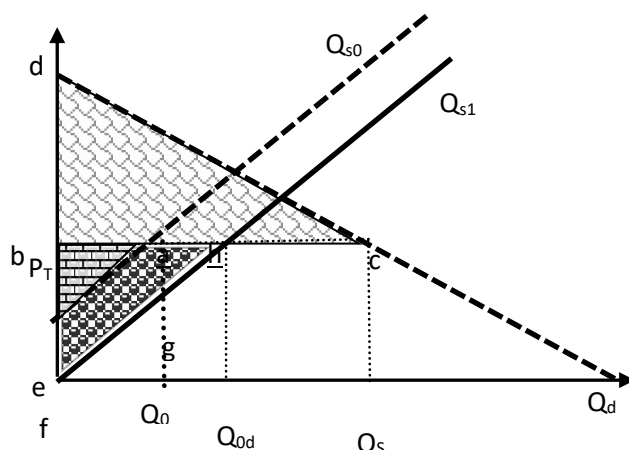
$D\ln PL$

$D\ln PI$

=

Shock	Results
0.2	14.25%
0	8.02%
0	-11.40%
0	-8.82%

Single Market:



Here we present results from the market effects when production levels increase by 20%. As shown above, equilibrium prices of both imported and locally produced rice decreases while equilibrium quantities increase for both products. Note that the 8.02% increase in demand and supply of imported rice is a response from the price decrease as a result of the shock.

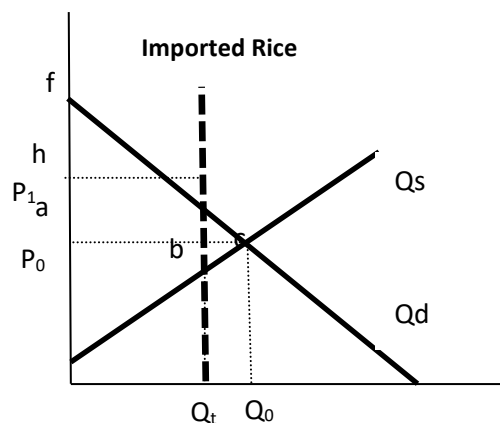
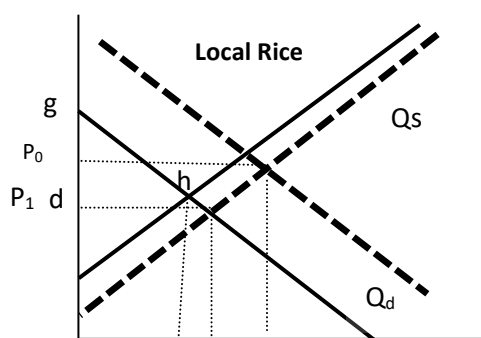
## Welfare Effects

Welfare estimates were obtained from the market effects presented above. As a result of the 20% increase in production, welfare of consumers and producers of locally produced rice was enhanced by 1.1% and 7.9% respectively. On the same token, welfare of consumers of imported rice increased by 8.3%, while importers' welfare diminished by 12.11%.

### 3.4 Policy Option 3: Effects of instituting a quota on imported rice

A quota leads to a win-win solution for both producers and consumers of locally produced rice. This is true only if there is enough local rice production to meet the gap created by the quota restriction. If this is not the case, the ramifications can be unfriendly for both consumers and producers. Given the current landscape coupled with the low level of production and productivity in last two year's production cycle (as a result of Ebola Virus Disease) it is best that a quota is not levied in the next three years to allow the sector to recover completely.

## Multi-Market Comparative Static



### Market Effects:

In this section we assume a 15% reduction in rice imports as a result of an instituted quota, as a result of this quota, prices of both products increased; with the increase in imported rice prices being higher. Equilibrium quantities of both products also decreased, with the decrease being higher for imported rice. Ie Equilibrium prices for imported rice increased by 14.14%, while prices of locally produced rice increased by 4.8%. Demand and supply of local rice decreased by 5.9% while demand and supply of imported rice decreased by 12.85%.

$\frac{D\ln QL}{D\ln QI}$	$\frac{D\ln QL}{D\ln PL}$	$\frac{D\ln QL}{D\ln PI}$	$\frac{D\ln QL}{D\ln QI}$
1	0	-1.12	0.80
0	1	1.11	-0.53
0.8	0	1	0
0	1.1	0	1

$\frac{D\ln QL}{D\ln QI}$

$\frac{D\ln QL}{D\ln PL}$

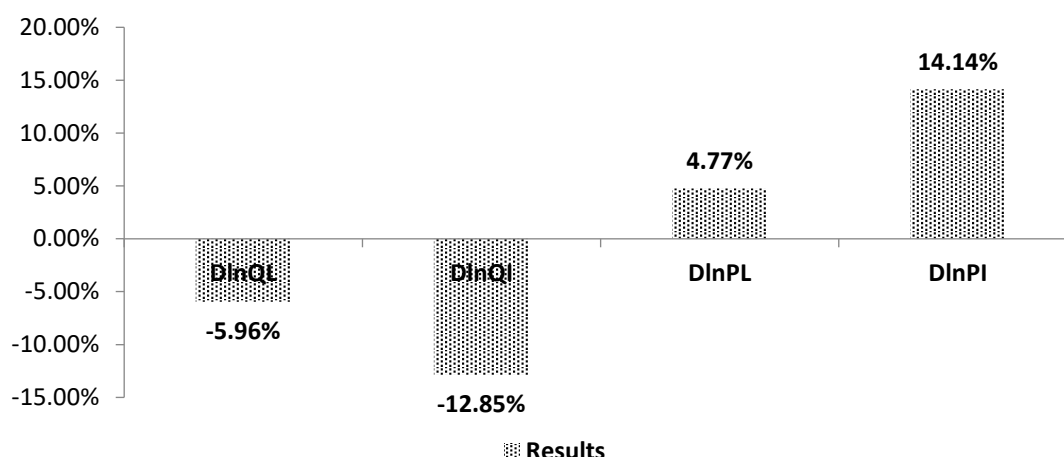
$\frac{D\ln QL}{D\ln PI}$

$\frac{D\ln QL}{D\ln QI}$

=

Shock	Results
0	-5.96%
-0.15	-12.85%
0	4.77%
0	14.14%

## Market Effects of a Quota



### Welfare Effects:

From the market effects reported above, welfare effects were estimated. Welfare of consumers of locally produced rice was dis-enhanced by 4.5%, welfare of producers was enhanced by 6.1%. For rice imports, welfare of rice importers was enhanced by 8.1% while welfare of consumers of imported rice was significantly dis-enhanced by 14.3%.

## 4 Conclusion and Recommendations:

This policy paper is an excerpt from a full-blown PhD thesis research analysing the effects of different food security policies in Sierra Leone on welfare and markets of smallholder farmers. Funds from IFAD made it possible for these earlier findings to be reached. Another version would be made public in the following months when the full analysis has been completed. However, the study concluded as follows:

1. Initial results reveal that the most gains are obtained when multiple food security policies at different times are used.
2. Welfare of consumers and producers of locally produced rice is enhanced significantly by the third policy option (increase in production of locally produced rice).
3. The gradual introduction of tariffs on imported rice, particularly after the effects of the Ebola Virus Disease (EVD) have been cancelled would be the best way to proceed.
4. That rice trade flows (across borders) is causing the unexplained high demand for locally produced rice and the prevailing market structure which gives market power to few retailers of locally produced rice.
5. Clearly, the above results suggest having separate studies focusing on these two factors for the whole country.

An in-depth research on the types of subsidies and strategies that can trigger local rice production and at the same time promote the welfare of smallholder rice farmers is recommended

## **Acknowledgement:**

This research work was partially funded by International Fund for Agricultural Development (IFAD) Sierra Leone. Many thanks to Njala University- Department of Agricultural Economics for their technical support.

## **References:**

Bank of Sierra Leone, 2015 –Monetary Policy statement

Deviga et al, 2006. Malaysian Rice Trade and Government Interventions- Agricultural and Resource Economics Group, Faculty of Agriculture, Food and Natural Resources, University of Sydney.

Spencer D, 1978. Rice Policy in Sierra Leone – West Africa Rice Development Association

Alieu E, 2005. Policies and Strategies for Promoting Food Security in Sierra Leone

Evan F, 2008. An Equilibrium Displacement Model of the Australian Sheep and Wool Industries.

Franz S, et al. 1999. Utilising Equilibrium Displacement Model to Evaluate the Market Effects of Countryside Stewardship Policies Method and Application

Kim S. et al. 2017. Policy Measures in Response to the Soaring Food Prices – The Government of Sierra Leone

National Revenue Authority, 2010. Annual report – Sierra Leone

Wilson et al, 2009. Economics of Rice Production in Sierra Leone

Philippine Rice Research Institute, 2016. University of the Philippine

Saeed et al, 1983. Rice Crop Production Policies and Food Supply in Bangladesh.

Salami et al, 2011. Challenges, Policies and the role of the Africa Development Bank AFDB Africa Economic Brief Volume 2, issue 2.

## **ANNEX 1**

### **Demand Equations**

$$Q_d^L = f(p, p^I) \text{ -----} 1$$

$$Q_d^I = f(p^I, p^L) \text{ -----} 2$$

Demand for locally produced rice depends on the prices of both local and imported rice.

#### **1.2.1.1 Supply Equations**

$$C_{QL}(Q_L, Q_{QI}, w^L, w^f, w^{Lb}, w^O) = P^{QL} \text{ -----} 3$$

$$C_{QI}((Q_L, Q_{QI}, w^L, w^f, w^{Lb}, w^O) + a = P^{QI} \text{ -----} 4$$

#### **1.2.1.2 Output Constant**

$$C_{wL} = L \text{ -----} 5$$

$$C_{wLb} = Lb \text{ -----} 6$$

$$C_{wF} = F \text{ -----} 7$$

$$C_{wO} = O \text{ -----} 8$$

#### **1.2.1.3 Input Supply**

$$L = g(w^L, w^f, w^{Lb}, w^O) \text{ -----} 9$$

$$F = g(w^L, w^f, w^{Lb}, w^O) \text{ -----} 10$$

$$Lb = e(w^L, w^f, w^{Lb}, w^O) \text{ -----} 11$$

$$O = f(w^L, w^f, w^{Lb}, w^O) \text{ -----} 12$$

#### **1.2.1 Log-linear comparative static equations**

Using log-linear comparative statics, the above equations are transformed to a system of 12 equations expressed as elasticities, shares and measures of market and welfare changes.

#### **These are presented below:**

The following is a key describing the variables presented in the equations below:

$Q^L$  = Equilibrium quantity of Local Rice

$Q^I$  = Equilibrium quantity of Imported Rice

$P^{QL}$  = Equilibrium Price of Local Rice

$P^{QI}$  = Equilibrium Price of Imported Rice

$W^L$  = land prices

$W^{Lb}$  = price of labour

$W^F$  = price of fertilizer

$W^O$  = price of other inputs.

$L$  = Total Land used by local rice producers

$O$  = other inputs used by the local rice producing industry

Lb = Labor

F = Fertilizer

#### 1.2.1.1 Demand Equations (H=Elasticity)

$$d\ln Q^L = H_{QL/P}^{QL} d\ln P^{QL} + H_{QL/P}^{QI} d\ln P^{QI} \dots\dots\dots 1$$

$$d\ln Q^I = H_{QI/P}^{QI} d\ln P^{QI} + H_{QI/P}^{QL} d\ln P^{QL} \dots\dots\dots 2$$

Equations one to two represent demands for local and imported rice respectively.

#### 1.2.1.2 Supply Equations ( $\Sigma$ =Elasticity)

$$(\Sigma_{QL/P}^{s,QL})^{-1} d\ln Q^{Ls} + (\Sigma_{QI/P}^{s,QI})^{-1} d\ln Q^{Is} + (\Sigma_{W^L/P}^{L,QL})^{-1} d\ln W^L + (\Sigma_{W^O/P}^{O,QL})^{-1} d\ln W^O + (\Sigma_{W^F/P}^{F,QL})^{-1} d\ln W^F + (\Sigma_{W^{Lb}/P}^{Lb,QL})^{-1} d\ln W^{Lb} = d\ln P^{QL} \dots\dots\dots 3$$

$$(\Sigma_{QL/P}^{s,QI})^{-1} d\ln Q^{Ls} + (\Sigma_{QI/P}^{s,QI})^{-1} d\ln Q^{Is} + (\Sigma_{W^L/P}^{L,QI})^{-1} d\ln W^L + (\Sigma_{W^O/P}^{O,QI})^{-1} d\ln W^O + (\Sigma_{W^F/P}^{F,QI})^{-1} d\ln W^F + (\Sigma_{W^{Lb}/P}^{Lb,QI})^{-1} d\ln W^{Lb} + t+a = d\ln P^{QI} \dots\dots\dots 4$$

On the supply side, two cost functions will be used. One for local rice production,  $C_{QL}(Q_L, W^L, W^F, W^{Lb}, W^O)$  and another for imported rice production  $C_{QI}(Q_I, W^L, W^F, W^{Lb}, W^O)$ .

#### 1.2.1.1 Output Constant Derived Demand

$$Z_{L/QL} d\ln Q^{Ls} + Z_{L/W^L} d\ln W^L + Z_{L/W^O} d\ln W^O + Z_{L/W^{Lb}} d\ln W^{Lb} + Z_{L/W^F} d\ln W^F = d\ln L \dots\dots\dots 5$$

$$Z_{O/QL} d\ln Q^{Ls} + Z_{O/W^L} d\ln W^L + Z_{O/W^O} d\ln W^O + Z_{O/W^{Lb}} d\ln W^{Lb} + Z_{O/W^F} d\ln W^F = d\ln O \dots\dots\dots 6$$

$$Z_{Lb/QL} d\ln Q^{Ls} + Z_{Lb/W^L} d\ln W^L + Z_{Lb/W^O} d\ln W^O + Z_{Lb/W^{Lb}} d\ln W^{Lb} + Z_{Lb/W^F} d\ln W^F = d\ln Lb \dots\dots\dots 7$$

$$Z_{f/QL} d\ln Q^{Ls} + Z_{f/W^L} d\ln W^L + Z_{f/W^O} d\ln W^O + Z_{f/W^{Lb}} d\ln W^{Lb} + Z_{f/W^F} d\ln W^F = d\ln f \dots\dots\dots 8$$

**Using Shephard's lemma, the above output constant equations were derived. The general forms are:  $C_{wL} = L$ ;  $C_{wO} = O$ .**

#### 1.2.1.2 Supply and Market Clearing Conditions

$$d\ln L = \Omega_L^{T/W^L} d\ln W^L + \Omega_L^{T/W^O} d\ln W^O + \Omega_L^{T/W^{Lb}} d\ln W^{Lb} + \Omega_L^{T/W^F} d\ln W^F \dots\dots\dots 9$$

$$d\ln O = \Omega_O^{T/W^O} d\ln W^O + \Omega_O^{T/W^L} d\ln W^L + \Omega_O^{T/W^{Lb}} d\ln W^{Lb} + \Omega_O^{T/W^F} d\ln W^F \dots\dots\dots 10$$

$$d\ln Lb = \Omega_{Lb}^{T/W^{Lb}} d\ln W^{Lb} + \Omega_{Lb}^{T/W^O} d\ln W^O + \Omega_{Lb}^{T/W^L} d\ln W^L + \Omega_{Lb}^{T/W^F} d\ln W^F \dots\dots\dots 11$$

$$d\ln f = \Omega_f^{T/W^F} d\ln W^F + \Omega_O^{T/W^L} d\ln W^L + \Omega_L^{T/W^{Lb}} d\ln W^{Lb} + \Omega_L^{T/W^O} d\ln W^O \dots\dots\dots 12$$

The above market clearing conditions were used to derive the input supply equations.

**Table 1: Matrix of Elasticities and Shares**

$d\ln Q_L$	$d\ln Q_I$	$d\ln P_{QL}$	$d\ln P_{QI}$	$d\ln W_L$	$d\ln W_{Lb}$	$d\ln W_f$	$d\ln W_o$	$d\ln L$	$d\ln L_b$	$d\ln f$	$d\ln O$		
-1	0	$HQL/p_{QL}$	$HQL/P_{QI}$	0	0	0	0	0	0	0	0	$d\ln Q_L$	0
0	-1	$HQI/P_{QL}$	$HQI/P_{QI}$	0	0	0	0	0	0	0	0	$d\ln Q_I$	0
$(\Sigma Q_{bs}/P_{Qb})-1$	0	-1	0	$(\Sigma W_L/P_{Qb})^{-1}$	$(\Sigma W_o/P_{Qb})^{-1}$	$(\Sigma W_L/P_{Qb})^{-1}$	$(\Sigma W_o/P_{Qb})^{-1}$	0	0	0	0	$d\ln P_{QL}$	0
0	$(\Sigma Q_{fs}/P_{Qf})-1$	0	-1	0	0	0	0	0	0	0	0	$d\ln P_{QI}$	0
$Z_L/Q_L$	0	0	0	$Z_L/W_L$	$Z_L/W_{Lb}$	$Z_L/W_f$	$Z_L/W_o$	-1	0	0	0	$d\ln W_L$	0
$Z_{Lb}/Q_L$	0	0	0	$Z_{Lb}/W_L$	$Z_{Lb}/W_{Lb}$	$Z_{Lb}/W_f$	$Z_{Lb}/W_o$	0	-1	0	0	$d\ln W_{Lb}$	
$Z_f/Q_L$	0	0	0	$Z_f/W_L$	$Z_f/W_{Lb}$	$Z_f/W_f$	$Z_f/W_o$	0	0	-1	0	$d\ln W_f$	0
$Z_O/Q_L$	0	0	0	$Z_O/W_L$	$Z_O/W_{Lb}$	$Z_O/W_f$	$Z_O/W_o$	0	0	0	-1	$d\ln W_o$	0
0	0	0	0	$-\Omega_L/W_L$	$-\Omega_L/W_{Lb}$	$-\Omega_L/W_f$	$-\Omega_L/W_o$	-1	0	0	0	$d\ln L$	0
0	0	0	0	$-\Omega_{Lb}/W_L$	$-\Omega_{Lb}/W_{Lb}$	$-\Omega_{Lb}/W_f$	$-\Omega_{Lb}/W_o$	0	-1	0	0	$d\ln L_b$	0
0	0	0	0	$-\Omega_f/W_L$	$-\Omega_f/W_{Lb}$	$-\Omega_f/W_f$	$-\Omega_f/W_o$	0	0	-1	0	$d\ln f$	0
0	0	0	0	$-\Omega_O/W_L$	$-\Omega_O/W_{Lb}$	$-\Omega_O/W_f$	$-\Omega_O/W_o$	0	0	0	-1	$d\ln O$	