Optimal Tariffs with Smuggling:
A Spatial Analysis of Nigerian Rice Policy Options

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Abstract

This paper assesses the difficulties inherent with raising the rice import tariff in Nigeria given the problem of smuggling, and under such conditions, whether there is an optimal tariff rate that the Nigerian government can consider, especially when the effects are likely to vary by location. Using a spatial multi-market model for rice, results show that an optimal tariff rate of 37 percent does exist if smuggling cannot be controlled. The effects of higher tariffs can have different effects on price changes, trade flows, and ultimately, household welfare in different parts of the country. Most notably but not surprising, consumers in the south could face much higher welfare losses, especially in urban areas as prices increase more when imports flow in from the north. On the other hand, smuggled imports in the north actually help dampen the effect of the tariff on prices in this region and in the central region.

Keywords: Optimal tariff, smuggling, spatial market equilibrium model, rice, Nigeria

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1. Introduction

As in many West African countries, rice consumption and imports in Nigeria have grown very rapidly in the last few decades. Rice is now a leading food staple in Nigeria, accounting for 11.2 percent of calories and 6.6 percent of household food expenditures (FAO, 2014 and Gyimah-Brempong and Kuku, 2014). Although production has increased rapidly in recent years, longer term growth rates are low and rice imports have surged, from an average of 590 thousand tons per year in the 1990s to 2.42 million tons from 2010 to 2012 (USDA data; Table 1.1).

Table 1.1: Nigeria Rice Imports, Production, and Domestic Availability, 1960-2012

	Rice Imports (thousand tons)	Rice Production (thousand tons)	Rice Domestic Availability (thousand tons)	Share of Imports in Availability (percent)
1960-69	1	222	201	0.5
1970-79	199	357	520	38.3
1980-89	529	866	1,308	40.4
1990-99	590	1,818	2,226	26.5
2000-04	1,679	1,851	3,346	50.2
2005-09	1,790	2,131	3,653	49.0
2010-12	2,417	2,725	4,869	49.6
Growth rates (1990-99)	16.69	1.76	5.59	
Growth rates (2000-04)	1.43	-0.06	0.49	
Growth rates (2005-12)	5.70	4.23	4.90	

Source: USDA data.
Notes: All quantities are milled rice. Growth rates are based on logarithmic regression coefficients.

This large increase in imports has not gone unnoticed by the Nigerian government, which considers it a major policy concern. In particular, rice features prominently in the government's current agricultural development strategy, the Agricultural Transformation Agenda (ATA). Aside from increasing public investments in the sector to raise productivity, volumes, and quality of output, the ATA strategy has included the introduction of higher rice import tariffs in order to slow the growth in imports. Thus, the government increased the import tariff on rice from 50% in 2012 to 110% by January 2013. However, customs data, price movements and anecdotal evidence from traders suggest that the bulk of rice imports have been diverted from official channels to informal ones, either through customs evasion at the main port in Lagos or through smuggling from neighboring countries (especially Benin and Niger).

In this paper, we analyze the welfare implications of alternative tariff rates given the Nigerian government's goals of spurring domestic production and reducing imports utilizing a spatial multi-market model that explicit takes into account smuggling. Our modeling framework also captures effects on rural and urban prices, production, consumption, economic surplus, and government revenues. Section 2 of this paper presents a brief overview of Nigeria's rice economy, with a focus on trade policy and imports. Section 3 describes the simulation model, data and parameter values. Simulation results of the impacts of a range of import tariffs under alternative assumptions of the extent of smuggling are given in Section 4. Section 5 reviews results from sensitivity analysis of key model assumptions and parameters. We discuss policy implications and conclusions in section 6.

2. Nigeria's Rice Economy and Recent Trade Policy

Rice production in Nigeria has increased substantially since the 1960s, but rice still accounts for a relatively small share of area cultivated, as widely variations in rainfall, soil characteristics and water availability, as well as farmers' risk reduction strategies, all contribute to the widespread cultivation of cassava, yams, maize, sorghum and millet over most of Nigeria (Takeshima and Bakare, 2015). Related to this diversified production pattern, the composition of staple food production also varies across Nigeria, with sorghum and millet consumed widely in northern Nigeria and maize and root crops dominating consumption patterns in the south and middle zones. Overall, five crops each account for about 10 percent of national calorie consumption – rice (11.2 percent), yams (10.1 percent), cassava (10.1 percent), maize (9.9 percent) and sorghum (9.3 percent). Wheat, with very little domestic production, accounts for 6.6 percent of total calorie consumption (FAO, 2014).

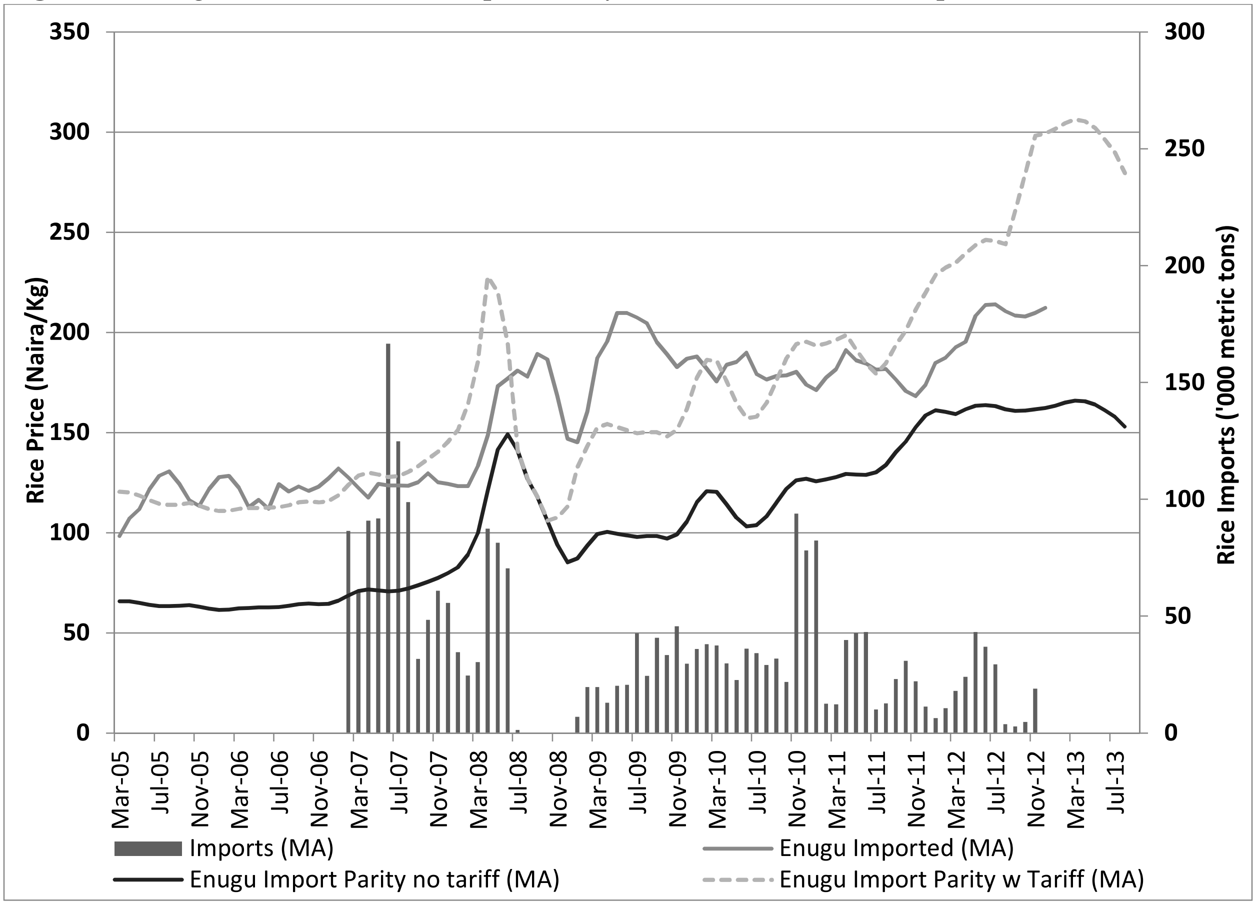
Rice cultivation is concentrated mainly in Nigeria's middle belt, in areas where seasonal flooding or water from streams and rivers provide sufficient water. Government efforts to boost rice production have met with considerable success, as evidenced by a 4.2 percent average growth rate from 2005 to 2012, yet demand growth has continued to outpace increases in domestic production.[1]

FAO data on imports suggest that imports have increased by approximately 1 million tons per decade, each decade since the 1970s (FAO data, Table 1.1). Rice import data is especially uncertain, however. Official customs data indicate that rice imports averaged 384 thousand tons per year from 2009 through 2011. COMTRADE data on total exports of rice to Nigeria for these years indicate that Nigeria's imports were five times larger (1.916 million tons). Customs data on tariff payments are broadly consistent with the rates shown in official tariff schedules (it appears that most imports that are recorded by customs are charged the official tariff rates).

Nigeria has adjusted its rice tariff rate numerous times in recent years. Between 2005 and mid-2007, the country imposed a 100 percent tariff on rice imports. During this period, as illustrated in Figure 2.1, import parity prices (including the import tariff) were broadly stable. International rice prices rose sharply in 2007 and 2008, as did wheat and maize prices, especially following restrictions on rice exports by India and Vietnam that reduced supplies. In order to prevent a large increase in domestic prices of rice, Nigeria reduced its rice import tariff to zero in April 2008.

[1] Note that these is substantial uncertainty regarding agricultural production data in Nigeria, and figures vary considerably by data source.

Figure 2.1: Nigeria Domestic and Import Parity Rice Prices and Rice Imports: 2005-2013



Source: Dorosh and Malek (2014) using Nigerian Bureau of Statistics import data.
Notes: Data are three month lagged moving averages. Monthly import data is unavailable for 2005, 2006 and 2013. The choice of Enugu here was for illustrative purposes of a domestic market not at the port of entry for rice imports.

The rice import parity price dropped to below N 130 (Nigerian naira) per kg by June 2008 while domestic prices remained high. Imports thus appear to have been constrained during the period from mid-2008 through late 2009, a time when there were no official trade restrictions. The large gap between import parity prices and domestic prices suggests that there were substantial excess profits (rents) in this period. By early 2010, import parity prices had risen and were again approximately equal to the domestic price (at Enugu) through the end of 2011. Import tariff rates from 2009 through 2011 averaged 60 percent, but estimated average tariffs collected (adjusting for the gap between official data and COMTRADE data on exports to Nigeria) averaged only 12 percent of import value (Table 2.1).

Table 2.1: Nigeria Rice Imports, Tariffs and Market Prices, 2008-13

	(1) C&F Lagos ($/ton)	(2) Implicit Ad Valorem Tariff	(3) Official / Total Imports	(4) Average Tariff on Total Rice Imports	(5) Pm (w/ tar) Enugu (N/kg)	(6) P Enugu-urban imported* (Naira/kg)	(7) Nominal Rate of Protection (8)/(6)-1	(8) % Diff P_l and P_m (w/tar) (8)/(7)-1
2008	550.2	44%	9%	4%	156.6	161.6	47%	103%
2009	373.4	64%	20%	13%	183.8	194.7	94%	106%
2010	430.0	64%	36%	23%	126.1	179.4	55%	142%
2011	508.2	52%	19%	10%	182.0	179.1	30%	98%
2012	583.9	72%	--	--	260.4	206.7	28%	79%
2013	577.5	100%	--	--	294.8	--	--	--
Ave 2009-11	437.2	60%		12%	164.0	184.4	60%	112%
Jan-Aug 2012	581.8	58%		--	241.2	204.3	27%	85%
Sept-Dec 2012	588.1	100%		--	298.8	211.5	31%	71%

Source: Authors' calculations based on NBS data

Notes: The figures indicate a very low rate of official tariff collection; however, the high prices in retail markets suggest substantial rents (possibly including unofficial payments).
(1) C&F Lagos is calculated as 5% Thai broken rice plus $44.28/ton freight costs (from Anderson et al. (2004) data files.
(2) The implicit ad valorem tariff is based on monthly data of import tariffs collected and declared customs values (2008-11) and on official tariff rates (2012-13).
(4) The average rate of tariffs is the estimated total revenues (implicit average tariff x official imports) / total (USDA est.) rice imports.
(5) Pm(w/tariff) Enugu is calculated as [C&F Lagos + tariffs + port handling charges, transport and marketing costs to Enugu] * (1 + 50% retail margin)
(7) The NRP Enugu Imported rice is calculated as [NBS retail price of imported rice in Enugu / Import Parity Enugu with no tariff] - 1
(8) The % difference between the domestic retail price (P_d) and the imported price P_m (w/tariff).

Thus, the price and tariff collection data suggest that import tariffs are not effectively enforced and have only muted effects on prices, at best. Nonetheless, these tariff policies may have significant effects on incentives for rice millers and large importers, some of whom may pay tariffs (or face other costs associated with rents arising from tariff evasion). In this case, the rice trade policy may actually play a more significant role in promoting industrialization.[2]

3. The spatial multimarket rice model and data sources

In this paper, we use a spatial equilibrium model in the tradition of Takayama and Judge (1964), Harker (1986) and others. These models were originally cast as simple transportation problems and solved using linear programing optimization routines involving minimization of transportation costs between regions given prices and excess supply and demand, or maximizing social welfare (net producer and consumer surplus) subject to transportation cost and the usual demand and supply constraints.[3]

A number of situations have been shown to be more ideal for using complementarity programming. For example, when considering ad-valorem taxes (e.g. on transport), tariffs on trade with the rest of the world, and other quantitative restrictions as noted by Arndt et al. (2000). For ad-valorem taxes, Rutherford (1995) argues, for example, that the resulting solution using a nonlinear programming approaches can be quite inefficient as it would require solving a sequence of nonlinear programs. The complementarity formulation on the other hand is straightforward and more transparent. For investment models, Takayama and Hashimbo (1984) also highlight some advantages of the LCP as having a more direct mechanism to solve for regional market demand quantities that are consistent with market prices, or when supplies are fixed, and overall, tends to respond more smoothly to continuous parameter shocks.

[2] The role of trade policy in development has long been debated, particularly whether trade liberalization or import restrictive policies are effective for promoting industrialization and growth (Krueger, 1999). Many have argued that trade liberalization may not be the best policy due to uncertainty in global prices (Jabara and Thompson, 1982), or domestic capital and labor market failures as in the 'infant industry argument' (Krueger, 1999).

[3] As Rutherford (1995) would show later, the simple linear programming problem could be translated into a complementarity one. This was desirable under certain conditions when the use of linear or non-linear programming approaches proved less efficient.

A key advantage of using the complementarity programming approach for our purposes is that Karush-Kuhn-Tucker conditions (KKT) conditions can be easily applied with direct economic interpretations arising from them. In the process, this has the added advantage of making the problem transparently clear on how it solves for an optimum solution when considering price responsive supply and demand equations (Rutherford, 1995), as we do in this study.

Mathematically, a generalized form of the spatial equilibrium problem is typically solved as a non-linear optimization problem which maximizes social net welfare subject to transportation costs, a world price for imports, and local supply and demand constraints. Net welfare benefits are measured as the integrals of the inverse demand and supply functions.[4] By taking the first order conditions and using the Kuhn Tucker Conditions for a local maximum, the problem can be converted into its complementarity expression as a system of relational inequalities and complementarity variables.

Using this general specification of the complementarity problem, a two-commodity spatial equilibrium rice model is developed for Nigeria to simulate two distinctive rice commodities in all of its 47 states and in two types of markets, rural and urban. The commodities are a standard and premium rice variety. The standard variety is of poorer quality, produced locally, and marketed as loose grains. The premium variety represents either an imported variety from world markets or a locally produced one by large scale milling operations. It is of a much higher quality, packaged and marketed as a branded product. The two varieties are imperfect substitutes with the standard variety more popularly consumed by poorer households and in rural areas as it is cheaper in price.

Trade between regions occurs when the price difference between them reaches the full cost of transporting goods between the regions. Similarly, the commodities are imported when the wholesale price in a region rises as high as the import parity price for that region and they are exported when it falls as low as the region's export parity price. Because Nigeria is an importer that accounts for only 7 percent of world rice imports, we assume the country is a 'small country' and cannot influence the world price. In other words the world rice price is considered an

[4] This is really the net of consumer and producer surplus.

exogenous variable in the model. Imports are allowed to enter two ports in two states, respectively. The first is via Lagos in the South, which is considered the principal port for which an effective import tariff can be successfully introduced. The second is via Kano in the North, for which unofficial imports can enter via the free port of Cotonou in the neighboring country of Benin.

Assuming quadratic demand and supply functions: (Q_{kj}^{d}) in a region j and (Q_{ki}^{s}) for region i for commodity k $(k = 1,2)$, and allowing for some limited cross-price effects, these and their complementarity variables are represented in the model as:[5]

$$Q_{kj}^{d}(P_{kj}) = \alpha_{kj} - \sum_{l} \beta_{lj} P_{lj}\,, \qquad \perp \; Q_{kj}^{d} \geq 0 \quad \forall i,j \in N, \forall k,l = 1,2 \tag{1}$$

$$Q_{ki}^{s}(P_{ki}) = \gamma_{ki} + \sum_{l} \delta_{li} P_{li}\,, \qquad \perp \; Q_{ki}^{s} \geq 0 \quad \forall i,j \in N, \forall k,l = 1,2 \tag{2}$$

Where α_{kj} and γ_{ki} are intercepts, and β_{kj} and δ_{ki}, are slope parameters for demand and supply curves of commodity k $(k = 1,2)$, with $\beta_{kj} < 0$ and $\delta_{ki} > 0$. Equilibrium conditions for excess supply and demand determine the equilibrium prices of each commodity within each region, as follows:[6]

$$Q_{ki}^{d}\big|_{\,k=1} = Q_{ki}^{s} + \sum_{i=1}^{N}\sum_{j=1}^{N}(X_{kji} - X_{kij})\,, \qquad \perp \; P_{kj} \geq 0, \quad \forall ij \in N, \forall k = 1 \tag{3}$$

$$Q_{ki}^{d}\big|_{\,k=2} = Q_{ki}^{s} + M_{ki} + \sum_{i=1}^{N}\sum_{j=1}^{N}(X_{kji} - X_{kij})\,, \qquad \perp \; P_{ki} \geq 0, \quad \forall ij \in N, \forall k = 2 \tag{4}$$

As before, the variable X_{kij} represents trade flows between regions for each commodity, i.e. the quantities of commodity k that is transported between a supply region i and a demand region j. These are constrained as positive, i.e. commodity k can only be transported in one direction at each given time. M_{ki} represents imports of the premium commodity $(k = 2)$. Both X_{kij} and M_{ki} are determined separately by the price relationships in equations (5) and (6) below, respectively.

[5] An additional subscript not shown here is the disaggregation of regions *i* and *j* by rural and urban. This was purposefully left out simply to avoid complicating the presentation. These can be treated the same way as the regions – except now with higher matrix dimensions of the regions as assume trade can occur between rural and urban areas across states.

[6] This is really combining equations (1) and (2) from the more general specification of the spatial equilibrium model.

As market equilibrium conditions, equations (3) and (4) expresses the requirement that supply quantities of commodity 1 and 2 shipped between regions has to equal the quantity demanded in the region receiving the commodity. Similarly, the quantity shipped out by a region cannot be more than what is available in the region to ship, less any quantities demanded locally. Both equations determine the equilibrium prices for each commodity type, P_{1j} and P_{2i}, respectively.

Now, given transportation and marketing costs (c_{ij}, again using the same notation as in the general case) for either commodity, we can now determine the trade flows (X_{kij}) between regions. AS the complementarity variable here, it is determined by the price differential between regions, inclusive of transportation and marketing costs (c_{ij}):

$$P_{ki} + c_{ij} = P_{kj}, \qquad \perp \ X_{kij} \geq 0 \tag{5}$$

Furthermore, since we have added the option for importing commodity 2 from world markets, and we wish to add an import tariff (τ_i) plus an optional transportation or freight cost (α_i) for any imports diverted to another port to evade the tariff, we can express this price relationship as follows:[7]

$$\bar{p}^{w}_{2i^{a,b}}(1 + \tau_{i^a}) + \alpha_{i^b} \ \geq \ P_{2i^{a,b}}, \qquad \perp \ M_{2i} \geq 0 \qquad i^a = Lagos, i^b = Kano \tag{6}$$

Here $\bar{p}^{w}_{2i^{a,b}}$ is the world price at either of the two ports for world imports (a = Lagos; b = Kano), including any port handling charges and fees. This is prior to adding costs of the tariff (at Lagos) and freight costs to evade the tariff (at Kano). For Kano in the northern part of Nigeria, imports are assumed to initially enter through the free port of Cotonou in Benin and then transported overland through Benin and Niger before entering Kano in Nigeria. Equation (6), therefore, is specifically designed to determine the optimal volume of imports from world markets and at which port depending on the final price differential between the two ports given the values of τ_i and α_i. Simply put, if $\bar{p}^{w}_{2i^a}(1 + \tau_{i^a}) + c_{i^a j} \geq \bar{p}^{w}_{2i^b} + \alpha_{i^b} + c_{i^b j}$ in market j, then imports to this market would originate from the Kano port.

[7] An unconventional aspect here is the option to import through non-official channels to avoid the import tariff (τ_i), but with an added freight cost (α_i) to divert the imports.

Finally, in simultaneously solving for the sequence of equations and complementarity relationships in equations (1) through (6), an optimal solution in the variables, $Q_{kj}^{d}, Q_{ki}^{s}, X_{ijk}, M_{2i}$ can be determined, inclusive of regional disaggregation by rural and urban areas. Results are aggregated across six geo-political regions among the 47 states of Nigeria (see Table A.5 in the Appendix).

The data for model parameters and validation are based on various secondary sources and the author's own field work. Production data was taken from the NAERLS (2009) "National Agricultural Extension and Research Liaison Services", demand data at the regional level was from the National Bureau of Statistics (NBS), "Consumption Patterns in Nigeria, 2009/10" and adjusted by population statistics, and prices were also from the NBS for 2012 and 2010 (for local rice and Imported). Nigerian government documents were relied on in defining the country's national objectives and targets for improving the rice sector.

Price elasticities used in the model were initially taken from the recent work by Johnson (2015) but calibrated to the model's spatial disaggregation. The own-price elasticities of demand for both types of commodities (standard and premium) and for urban and rural were derived from Linear Expenditure System (LES) estimates in Gyimah-Brempong and Kuku (2015). These are presented in Table A.1 in the Appendix. The cross-price elasticities in Table A.1 are derived using the demand shares of each type of rice to total rice consumed at the national level in urban and rural areas. Rather than simply ignoring any cross-price effects, we chose to include these to allow for some substitutability between the two types of rice. Own and cross price elasticities of supply were based on some reasonable assumptions about the supply response of producers according to the rice variety they produced but later calibrated to ensure the base model reproduced meaningful results. Table A.2 in the Appendix presents their final values.

For freight and transportation costs – these were calculated using unit costs and actual distances in km between state capitals. Average unit freight costs are presented in Table A.3 in the Appendix. For freight costs to import rice via the Kano port, this is based on overland distance by road from the port of Cotonou in Benin to Kano via Niger (a total distance of 1,684 km) and a unit transportation cost that is assumed to be 50% more than the SW in Nigeria (from port of Lagos), which becomes 33.71 Naira/mt/kg. Later in Section 5 we adjust these transportation costs to test for the sensitivity of model results in terms of the range of tariff rates at which all imports will shift from Lagos to Kano. Due to the unavailability of sufficient data for rural and urban marketing costs, these were weighted by distances between states and weather trade is between urban to urban, urban to rural, rural to urban, and rural to rural. The choice of using distance related costs was to distinguish cost differences in marketing in each state based on source and destination. Within each state, additional costs were added to distinguish between rural and/or urban in either direction (assumed to be asymmetric – with higher costs for rural marketing). Results are presented in Table A.4 in the Appendix. For the NE, costs are doubled to account for its relative isolation (e.g. current security situation) while in the SW costs are assumed to be much lower (at 70 percent below calculated values).

The model is calibrated to reflect the Nigerian rice markets in 2009. Because a tariff rate of 40 percent existed at the time, the model is calibrated to this base case with only small adjustments made to prices and price elasticities in order to ensure model results closely resemble actual observed values. Final prices selected were also checked for their reasonableness based on observed prices for which data was available. Table 3.1 presents the final base case results as compared with actual values of total demand, supply and import quantities for both rice commodities. The model validation is reasonable for the base case scenario, with a percentage difference between observed values and base model results ranging between 1.2 to 6.7 percent in absolute terms for each of the key endogenous variables.

Table 3.1 Comparing base model results with observed quantities of demand (rural and urban), production, imports and total supply (by type of rice)

	Observed	Base Model	% difference
Demand			
Standard, Rural	2,225.7	2,300.0	4.6%
Standard, Urban	582.5	543.8	-6.7%
Premium, Rural	1,198.4	1,141.6	-4.7%
Premium, Urban	1,359.2	1,443.9	6.2%
Production			
Local standard	2,808.2	2,843.8	1.3%
Local premium	748.8	722.0	-3.6%
Imports			
Imported premium [a]	1,808.9	1,863.6	3.0%
Supply			
Production + imports	5,365.9	5,429.4	1.2%

Source: Nigeria Spatial Rice Market Model. *Notes*: [a] The base model results show about 7.4 percent of this amount (about 138,500 metric tons) being imported through Kano, a reasonable result considering traditional trade linkages with Niger among traders in the north.

4. Simulation results

In this section, we present simulation results under two alternative import trade regimes: 1) no smuggling (all rice imports face import tariffs at the border (mainly Lagos port) and 2) cross-border smuggling through the Niger-Nigeria border near Kano. In describing the results for each trade regime, we first discuss national level results, and then describe the regional effects within Nigeria of tariff policies under these alternative trade regimes.

Effects of Tariff Changes with No Smuggling

In the first scenario (no smuggling), increasing rice tariffs results directly in corresponding increases in imported rice prices and reductions in imports (Table 4.1). At a zero tariff, imports reach 3.2 million tons, almost double the level in the base case (40 percent tariff). Imports do not entirely displace production, however, as prices for local varieties in some of the more distant markets would still remain competitive with imports coming from Lagos given high transportation and marketing costs.

Table 4.1: Production, consumption, imports and prices of premium and standard rice by tariff regime (with no smuggling scenario)

	Premium Rice (By tariff regime)			*Percent change*	**Standard Rice** (By tariff regime)			*Percent change*
Region	0	40*	120	*40 -> 120*	0	40*	120	*40 -> 120*
Consumption (,000 metric tons)								
Central	457	351	214	*-38.8%*	337	445	580	*30.3%*
North	1,093	876	648	*-26.0%*	1,079	1,243	1,392	*12.0%*
South	1,929	1,354	481	*-64.5%*	830	1,164	1,639	*40.8%*
National	**3,479**	**2,580**	1,343	***-48.0%***	**2,246**	**2,853**	**3,612**	***26.6%***
Production (,000 metric tons)								
Central	60	161	288	*78.7%*	726	911	1,150	*26.3%*
North	144	342	591	*72.7%*	1,290	1,598	1,980	*23.9%*
South	51	228	464	*103.1%*	231	344	482	*39.9%*
National	**254**	**732**	1,343	***83.5%***	**2,246**	**2,853**	**3,612**	***26.6%***
imports (,000 metric tons)								
Via Lagos	**3,225**	**1,848**	**0**	***-100.0%***	NA	NA	NA	*NA*
Average Urban Prices (Naira/kg)								

Central	113.1	150.7	199.5	*32.3%*	94.9	103.1	113.8	*10.4%*
Northwest	118.7	156.8	201.2	*28.3%*	96.1	104.2	115.1	*10.4%*
Southwest	104.9	143.3	202.3	*41.2%*	98.9	107.2	118.1	*10.2%*
National	**114.8**	**152.5**	201.6	***32.3%***	**97.4**	**105.5**	**116.1**	***10.1%***
Average Rural Prices (Naira/kg)								
Central	127.2	165.6	214.8	*29.7%*	82.2	90.4	101.1	*11.8%*
Northwest	131.4	169.7	213.7	*25.9%*	91.1	99.2	109.8	*10.7%*
Southwest	118.0	156.4	205.5	*31.4%*	93.8	102.1	113.1	*10.7%*
National	**127.5**	**165.6**	212.4	***28.2%***	**89.3**	**97.4**	**108.0**	***10.8%***

Source: Nigeria Spatial Rice Market Model simulations. * This is the base case scenario.

The average domestic price for premium rice in urban areas rises from about 152.5 Naira/kg when the tariff rate is 40 percent to 201.6 Naira/kg when the rate reaches 120 percent. For standard ordinary rice, prices rise but more slowly, from 105.5 to 116.1 in urban areas and 97.4 to 108.0 in rural areas. Given higher domestic prices, domestic production rises, and imports of premium rice are gradually replaced by local premium rice, as domestic production of premium doubles from a base of 0.73 (with 40% tariff) to about 1.34 million metric tons at the tariff rate of 120 percent. Production of ordinary rice also increases, but at a lesser rate, from 2.85 to 3.61 million metric tons, raising total production to 5.0 million tons – equal to total domestic demand at the tariff-induced higher domestic prices.

How prices change by location, and whether urban or rural, as a result of import tariff policies will vary and have important implications on production and demand for each type of rice. Referring back to Table 4.1, as import tariffs for premium rice are raised from the base of 40 percent to 120 percent, domestic prices for this variety rise by 32.3 percent nationally in urban areas (which has the greatest demand) and 28.2 percent in rural areas. The lower rise in prices in rural areas reflect the fact that prices are already higher in rural areas due to transport and marketing costs, so a proportional effect of a change in tariff is smaller since these margins are only affected by the volume traded. Additionally, consumers in rural areas are more likely to shift to local standard varieties relative to urban consumers.

There are also differences between the central, northern and southern regions, as one would expect. Urban prices actually rise slightly less in the north than in the south, 28.3 percent versus almost 41.2 percent in the south. The central region experiences a decline of 29.7 percent.

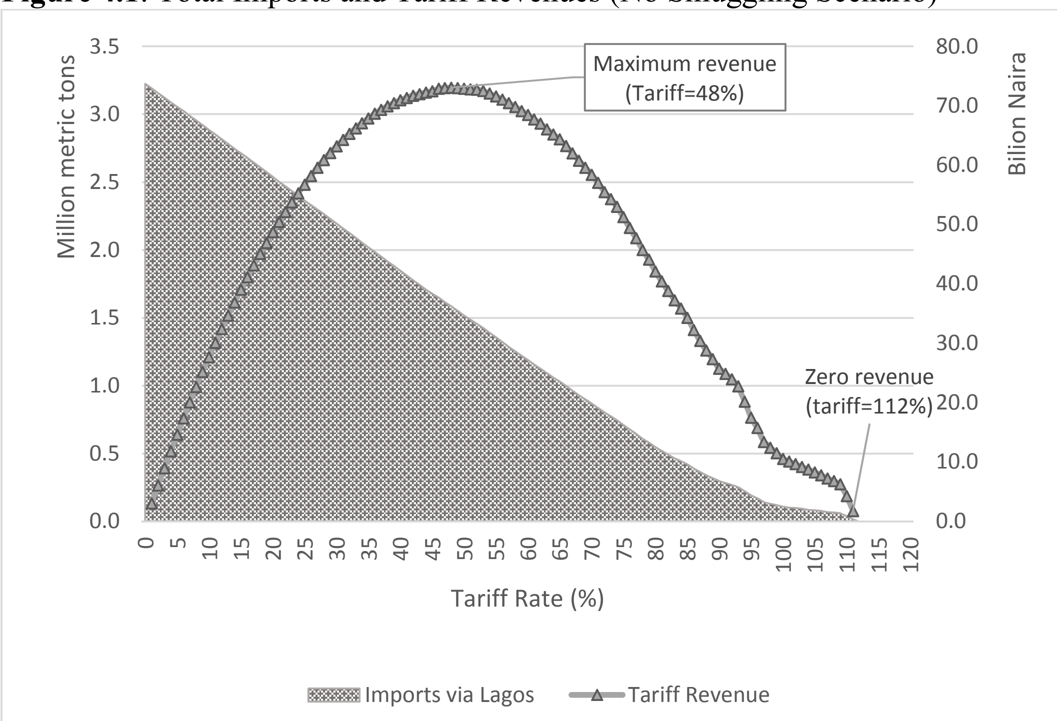
This is because both the central and the north supply a significant amount of locally produced premium rice (especially in Kano) to the central region while the south relies more on imports from the north or the world market, as noted earlier. Rural prices follow similar patterns, although with lower price changes relative to urban areas. This is primarily due to the fixed higher transportation and marketing costs not directly affected by tariffs. Finally, given the assumption of weak substitution between the two types of rice, prices for standard rice rise only marginally relative to premium rice for which the tariff is directly a target for (a change of about 10 to 11 percent). The small change in price is also quite similar across all regions and whether in rural or urban areas.

The impact on production is obviously affected by the effect of the tariff on prices and subsequently demand and which all vary by location. Prices for standard rice rise marginally with higher tariffs. This can be explained by the increase in demand as some consumers switch from premium rice in favor of the cheaper standard variety. At the higher tariff rate, demand for premium declines by 48 percent while it increases for standard rice by 26 percent. Much of the substitution occurs in the south as the region has more to lose when prices rise with higher tariffs.

These changing patterns of quantity demand and equilibrium prices for each type of rice has important implications for household welfare, whether in rural or urban areas. For example, the decline in demand for premium rice as prices rise hurts urban households the most as they are the least likely group of consumers to substitute towards the cheaper standard variety. Only producers of the premium variety – large scale millers in urban areas – benefit. In rural areas, on the other hand, the shift by a majority of consumers towards buying the cheaper alternative lessens the higher tariff's overall negative impact on rural welfare relative to urban areas, and even more so if they are many net sellers of standard rice. However, poorer households who tend to be net buyers will get hurt the most by any small price increases of local standard rice varieties as they have to rely on a much higher proportion of their income for food purchases. The majority of beneficiaries in rural areas will be the net sellers, the rice paddy farmers and small scale millers. The increase in demand and prices of the local standard variety, as consumers shift away from the more expensive premium variety, stimulates this sector to produce more.

Finally, considering the tariff rates at which government can maximize tariff revenues or achieve the self-sufficiency policy goal under our scenario with no smuggling (all imports pass through Lagos), this is 48 percent and 112 percent, respectively (Figure 4.1). Beyond the 48 percent mark, any further increases in tariffs reduces demand for rice imports by a greater percentage than the percentage increase in tariffs. Although the country can achieve the self-sufficiency goal at the tariff rate of 112 percent, this occurs at the expense of consumers who now have to deal with much higher domestic prices.

Figure 4.1: Total Imports and Tariff Revenues (No Smuggling Scenario)



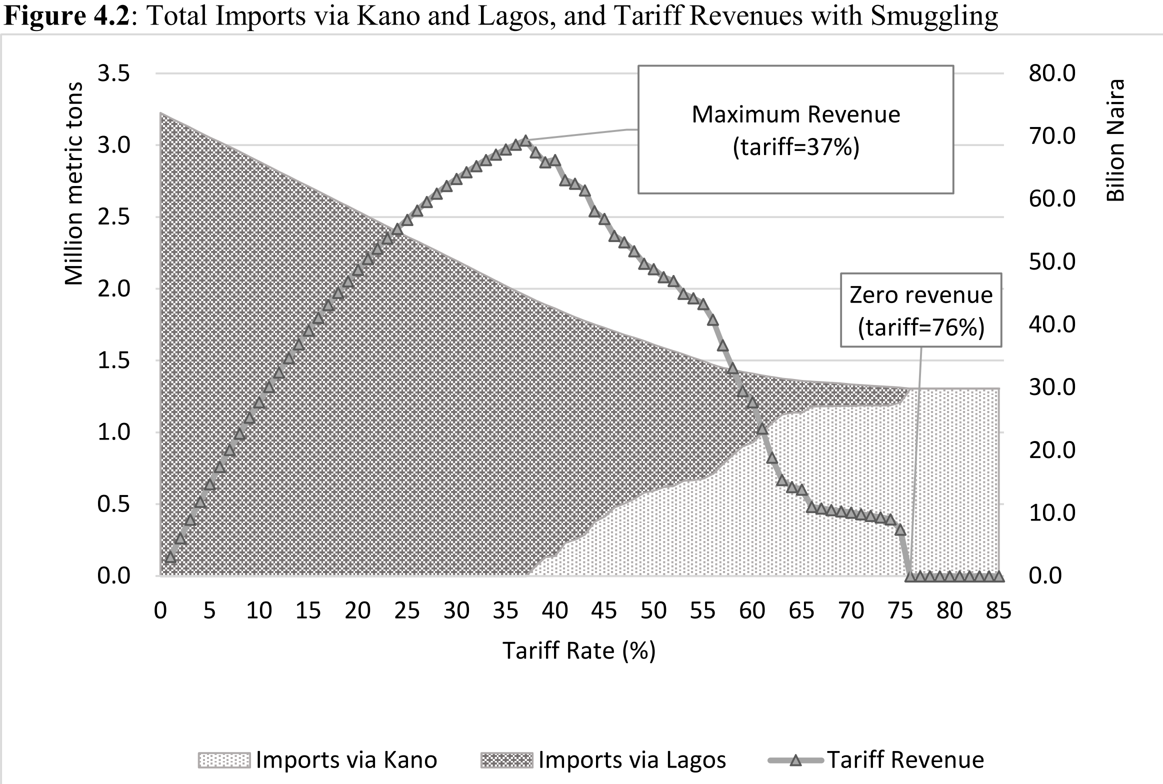
Source: Nigeria Spatial Rice Market Model simulation results.

<u>Effects of Tariff Changes with Smuggling</u>

So far we have considered the situation where a tariff policy is completely effective, i.e. all imports pass through Lagos and are reported, as the official channel. We now introduce the option to divert imports through Kano, a channel that avoids the tariff but pays higher freight costs to ship over land through Benin and Niger. We also look at trade flows between regions in Nigeria, comparing both scenarios of with and without smuggling. At some point, as tariffs rise, the more costly shipping channel that avoids tariffs through Benin and Niger will result in an import parity price in Kano that is lower than that of the rice imported via Lagos. This is a situation that is closer to the reality in Nigeria based on field observations of the authors when tariff rates had increased to 100 percent in 2013.

Figure 4.2 presents the volume of imports through both the Lagos and Kano ports. Initially (at the 40% base tariff), Kano already imports a small amount of premium rice from world markets (but very small amounts). Evidently, a 37% tariff proves to be a critical point when the cost of importing through Kano just equals Lagos (the former mostly in land transportation and marketing costs via Benin and Niger, and the latter affected by the tariff and in land transportation and marketing from the south to north in Nigeria). It is also at this point that tariff revenues are maximized (when there are no leakages). At the 77% tariff rate, all imports come though Kano. Given reductions in the volume of imports through Lagos, tariff revenues decline even faster than in the no smuggling scenarios. In the end, Nigeria is only able to attain a self-sufficiency ratio of about 78 percent, and therefore, unable to achieve its self-sufficiency goal in rice production.

Figure 4.2: Total Imports via Kano and Lagos, and Tariff Revenues with Smuggling



Source: Nigeria Spatial Rice Market Model simulation results.

As in Table 4.1 earlier, Table 4.2 presents a breakdown of production, consumption, imports and prices by region for both premium and standard rice. As before, imports are partially replaced by increased production of local premium rice as prices rise, an increase of 20 percent (722,000 to 863,600 metric tons) at the 76 percent and higher tariff rates (also see Figure 4.2). Total demand decreases less for premium that without smuggling as prices are maintained at lower levels due to smuggling. This time, the substitution away from premium to standard does not occur as much. Evidently, the smaller rise in premium prices causes only a fewer consumers to shift towards the cheaper standard variety.

Table 4.2: Production, consumption, imports and prices of premium and standard rice by tariff regime (with smuggling scenario)

	Premium Rice (By tariff regime)			*Percent change*	**Standard Rice** (By tariff regime)			*Percent change*
Region	0	40[a]	120	*40 -> 120*	0	40[a]	120	*40 -> 120*
Consumption (,000 metric tons)								
Central	457	352	331	*-5.7%*	337	444	448	*0.9%*
North	1,093	885	918	*3.7%*	1,079	1,231	1,159	*-5.9%*
South	1,929	1,349	919	*-31.9%*	830	1,168	1,395	*19.5%*
National	3,479	2,586	2,168	*-16.1%*	2,246	2,844	3,002	*5.6%*
Production (,000 metric tons)								
Central	60	159	190	*19.1%*	785	1,068	1,153	*8.0%*
North	144	337	380	*12.6%*	550	676	699	*3.3%*
South	51	225	294	*30.5%*	884	1,252	1,333	*6.5%*
National	254	722	864	*19.6%*	2,219	2,996	3,185	*6.3%*
Imports (,000 metric tons)								
Imports via Lagos	**3,191**	**1,725**	**0**	***-100.0%***	NA	NA	NA	NA
Imports via Kano	**0**	**139**	**1,305**	***841.8%***	NA	NA	NA	NA
Average Urban Prices (Naira/kg)								
Central	113.1	150.3	160.7	6.9%	94.9	103.1	106.0	*2.8%*
Northwest	118.7	156.3	159.3	1.9%	96.1	104.1	107.3	*3.0%*
Southwest	104.9	143.3	166.3	16.1%	98.9	107.1	110.3	*3.0%*
National	114.8	152.0	163.4	7.5%	97.4	105.4	108.3	*2.7%*
Average Rural Prices (Naira/kg)								
Central	127.2	165.2	174.0	5.3%	82.2	90.3	93.2	*3.1%*
Northwest	131.4	169.0	171.0	1.2%	91.1	99.1	102.0	*2.9%*
Southwest	118.0	156.4	177.7	13.6%	93.8	102.1	105.2	*3.1%*
National	127.5	165.1	175.3	6.2%	89.3	97.3	100.2	*2.9%*

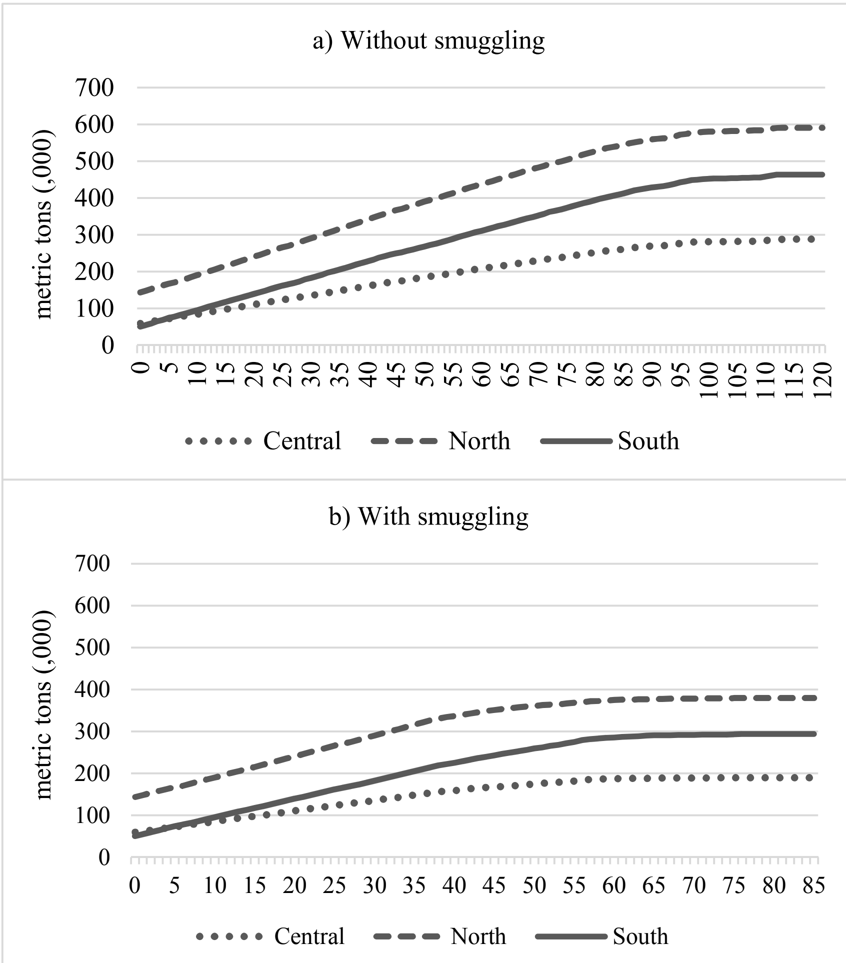
Source: Nigeria Spatial Rice Market Model simulations. *Notes*: [a] This is the base case scenario. The base model results show about 7.4 percent of imports (138,500 metric tons) being imported through Kano, a reasonable result considering observed trade linkages with Niger among traders in the north.

With respect to prices, as import tariffs for the premium variety rises from the base of 40 percent to 120 percent (or at the threshold of 76 percent and above when tariffs are no longer effective), domestic prices for premium in urban areas rise by only about 7.5 percent relative to 24.7 percent previously. However, the south experiences far greater increases in price (16. 1 percent) relative to the north (only 1.9 percent) and the Central region (6.9 percent), especially after the tariff rises above 76% when all imports start coming through Kano. The difference captures the transporting and marketing margins associated with moving the imported premium rice through Kano to markets in the south. A similar trend occurs in rural areas, but at much higher prices.

There is only marginal effects on the price for standard rice in all regions (about a 3 percent increase). The smaller price changes for premium rice in the north are expected as imports flow through the Kano port together with a greater capacity for milling of local premium rice. The additional cost of transporting and marketing this rice to the south explains the higher rate of price increases in the south (as prices are initially lower here). Naturally, the only exception is when tariffs are removed altogether – which would be equivalent in the previous scenario with no smuggling. Under no import restrictions, it is cheaper to import through Lagos.

Given the reduced effect of higher tariffs on prices, production will not respond as much as it does if the tariffs were effective (without smuggling). Figure 4.3 shows total production of local premium rice as tariffs change under both scenarios of with and without smuggling. Higher tariffs provide greater incentives for local producers to expand output when the tariffs are effective while a zero tariff would force many of out of the business. But the size of the effect varies by regions, with the North increasing at more than twice the volume of the south. The Central region, on the other hand, responds at a slower rate despite producing a significant amount of standard local rice (and paddy rice in general). This is because it produces less premium rice as it has fewer numbers of large modern millers than in the North (Johnson et al., 2013). At the same time, the central region is also better able to take advantage of any tariff evasion above the 37% optimal tariff by importing premium rice from the North instead of the South.

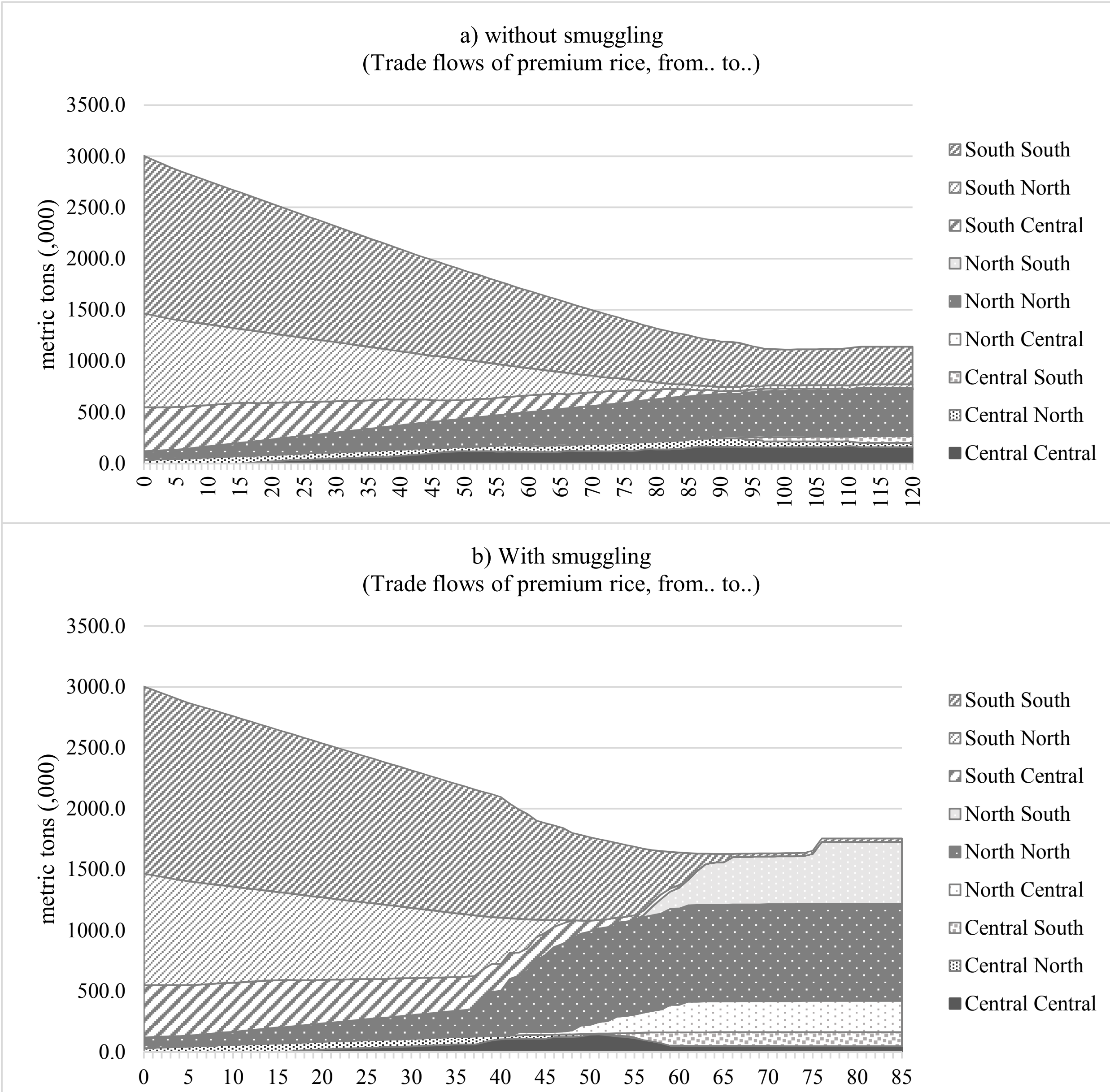
Figure 4.3: Total Production of Local Premium Rice (with and without smuggling)



Source: Nigeria Spatial Rice Market Model simulation results.

The effect of the two scenarios on the volume of premium rice transported between regions to meet demand can also be quite significant, with important implications on the direction of trade, and in particular, for the Central region. Figure 4.4 presents the trade flows for premium rice under both scenarios as tariffs rise. It is important to observe that the totals here will be less than in Figures 4.1 and 4.2 because here we are only measuring the amount transported from one area to another (e.g. urban to rural within a state where it is produced, and transported out of state whether to rural or urban areas).

Figure 4.4: Volume of premium rice transported between major regions as tariffs change under both scenarios (with and without smuggling)



Source: Nigeria Spatial Rice Market Model simulation results. Note: The shaded portions in the figure reflect total volumes (in million metric tons) of trade flows in premium rice. For each shaded portion, the first region is the source and the second region is the destination. If the source and destination regions are similar, this simply implies the rice is produced (or is the port of entry or pass through of global imports) and consumed in the same region.

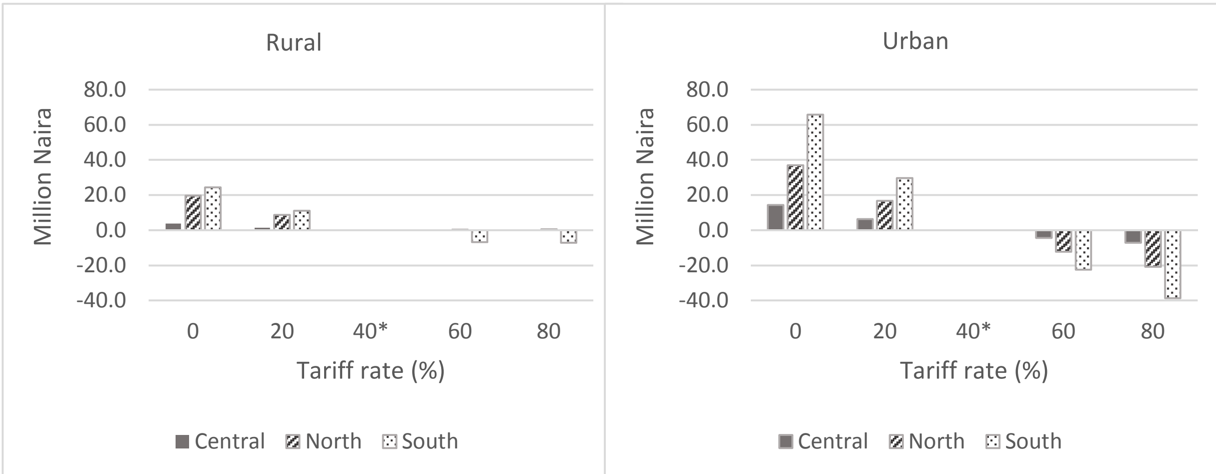
Premium exports from the north increases substantially until the 76 percent tariff rate, from a combination of the excess supply in imported and locally produced rice. This time, the north also ships over half a million metric tons to the south compared with only 17,200 metric tons when all imports passed through Lagos. As before, the south shifts from a net export to a net importer – but this time doing so at a lower tariff rate of 80 percent, instead of 120 percent with no smuggling. For standard rice, exports from north to south do not rise as much as in the previous example, from 0.823 to just a little over 1.0 million metric compared with 1.16 million (a difference of about 160,000 metric tons). It is less profitable to ship rice to some areas since prices do not rise as much as they do when tariffs are effective. All in all, the total volume of interregional trade increases because of the diversion of imports via Kano and small changes in the trade flows for standard varieties.

A striking result in Figure 4.4 is the increased flow of premium transported from (to) the Central region within a tariff range of 37% to 60%. This is a range when the region begins to shift from importing premium rice from the south (when tariffs are less than 37%) to importing from the north (when tariffs are great than 60%). The North experiences increasing volumes of trade within its region when tariffs reach 37%, and then exporting more volumes of premium rice to the other two regions as tariffs continue to rise. The kink at the 76% mark (in total volumes) occurs as all imports start coming through Kano only and caused by an increase in the volume of rice transported to the south.

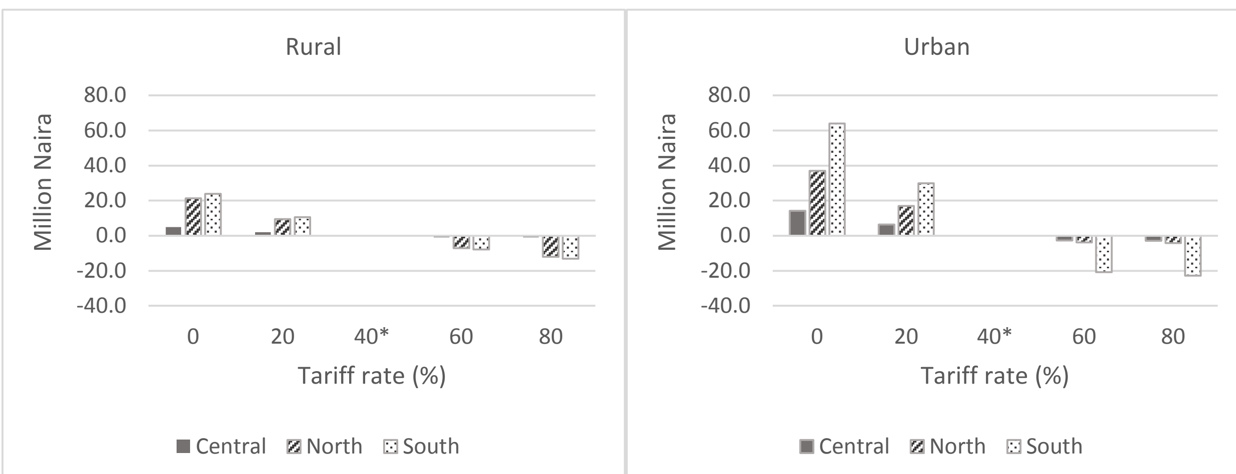
The policy goal of achieving self-sufficiency is not possible with smuggling, but even without smuggling, the import barrier of imposing 112 percent tariff rate does not necessarily lead to improved economic welfare, in either urban or rural areas. Figure 4.5 presents the net change in economic welfare by urban and rural, both with and without smuggling. First, there are significant economic gains in both urban and rural areas from simply removing the tariffs altogether. The gains are much higher in urban areas as would be expected given consumers are far more sensitive to prices changes, especially for the premium rice. As tariffs rise, however, economic gains will vary depending on whether there is smuggling or not. In particular, net economic losses due to rising prices are not felt as deeply as they are without smuggling, especially in the north and central regions, including in both urban and rural areas. However, the south still experiences relatively higher economic losses than the other two regions as prices for premium rise to levels higher than in the north. Demand for premium rice in the south is increasingly met by transporting imported rice from the north.

Figure 4.5 Change in net economic welfare (rural v. urban) due to tariff changes (million Naira), under both conditions of 'without' and 'with' smuggling.

a) without smuggling



b) with smuggling



Source: Model results. *Note*: * The initial tariff rate was 40%, hence the absence of any change in welfare.

5. Sensitivity analysis

The challenge in using spatial equilibrium simulation models is ensuring results are credible and robust given the model's underlying assumptions and parameter values. To check for this, several simulations were conducted by changing key parameters in the model. More specifically, parameter values were increased up to 50 percent (and reduced up to 50 percent), from their initial values and in partial increments (or reductions) of 10 percent. This was done under the "with smuggling" scenario. The selected parameters were: a) Own and cross price elasticities of demand; b) own and cross price elasticities of supply; c) freight and transportation costs over land (via Benin and Niger); and d) internal marketing costs for intra-regional trade. Percent root mean square errors (%RMSE) were computed in comparing the results from the range of changes in each parameter value relative to model results with their initial values.

First, changing the values of own and cross price elasticities of demand equally across regions results in very little change in the results at any given tariff rate, aside from producer welfare in rural areas. This is most likely due to our higher cross-price elasticities of demand in rural versus urban areas. Nevertheless, it has no effect on the shifting of imports from Lagos to Kano, nor the tariff rate at which revenues or the self-sufficiency ratio is maximized. Because we are more confident of the source for the demand elasticity estimates, and considering the effects on welfare changes are limited relative to the percent changes in the elasticity values, we are confident the parameter values are reasonable.

With regard to own and cross price supply elasticity values used in the model, small incremental changes were found to have more significant effects on model results. Average percent root mean square errors (%RMSE) were highest for premium rice production in urban areas, ranging between 16.1 and 25.6 percent. On the other hand, the producer welfare in rural areas was more affected, with %RMSEs ranging between 12.1 to 19.7 percent. Hardly any change occurs with regard to the tariff rate at which all imports flow through Kano, aside from the rate at which a maximum self-sufficiency ratio is achieved, which occurs at tariff rates 10 to 20 percent lower when compared with initial model results. These higher sensitivities appear primarily because of our assumption of higher cross-price elasticities between standard and premium rice. A positive cross-price elasticity implies that a small change in the price of one type of rice affects the supply of the other as well. Setting them to zero results in much lower effects in model results overall. Evidently, while the assumptions we make on cross-price elasticity values of supply are critically important for determining producer welfare and the maximum achievable self-sufficiency ratio, model results on when all import flows shift to Kano are less affected. Further research is needed to estimate their correct empirical values in the Nigerian case.

Of particular relevance to our model results is the cost of overland freight charges for imports flowing through Kano as these will naturally affect the tariff rate at which imports will increasingly become diverted through the north (via the Kano port). Tables 5.1 and 5.2 illustrate how quickly this occurs in the model.

Table 5.1 Sensitivity of Shifts in Import Flows via Kano by Tariff Rate due to Changes in Overland Freight Costs via Benin and Niger

	Tariffs (t)			%RMSE	
	Initial Freight Costs	-50% Freight Costs	+50% Freight Costs	Tariff<40	Tariff>40
Imports begin via Kano	38	7	74	0.0	68.7
All imports via Kano	76	47	105	17.5	0.0
Max tariff revenue	37	28	45	18.0	148.8
Max Self-Sufficiency(t = 120)	75	52	70	n.a.	n.a
Min Self sufficiency (t = 0)	44	40	39	n.a.	n.a

Source: Model results. *Notes*: n.a. = not applicable.

Table 5.2 Sensitivity of Changes in Demand, Production, and Consumer and Producer Welfare due to Changes in Overland Freight Costs via Benin and Niger (%RMSE)

	Demand premium rice		Production of rice		Consumer Welfare		Producer Welfare	
	Tariff<40	Tariff>40	Tariff<40	Tariff>40	Tariff<40	Tariff>40	Tariff<40	Tariff>40
Urban								
Central	0.7	6.5	3.8	21.4	41.4	-88.1	-45.5	94.5
North	2.5	6.7	5.4	22.3	66.3	-127.4	-68.8	132.2
South	1.5	12.2	3.5	23.6	18.5	-66.4	-27.2	80.0
Rural								
Central	2.3	19.2	1.0	7.6	45.5	-91.3	-33.9	79.3
North	3.7	14.5	1.5	7.8	69.8	-136.7	-38.3	81.2
South	1.2	39.4	0.9	11.1	26.8	-74.1	-31.5	77.5

Source: Model results

From Table 5.1, lowering the freight costs by 50 percent dramatically reduces the tariff rate at which imports begin to flow through Kano, from 38 to 7 percent. All imports flow through Kano at a tariff rate of 47 percent compared with the initial 76 percent. Furthermore, maximum tariff revenues occur at a lower tariff rate, 28 percent compared with 37 percent. The opposite occurs if freight costs are raised. Producer and consumer welfare is also affected as shown in Table 5.2, especially in the central region, as the shift in imports from Lagos to Kano occurs at much lower tariff rates (with lower freight costs) and at higher tariff rates (with higher freight costs). This highly sensitive nature of the model to changes in overland freight costs for imports flowing through Kano is to be expected as it defines the import parity price of imported rice from this source in a particular local market. If this price is lower relative to the import parity price of rice imported in this market through official channels in Lagos (hence inclusive of the tariff), then consumers would prefer to purchase the lower priced imports coming through Kano.

Finally, we also consider the sensitive of our assumed marketing costs for intra-regional trade in rice. Evidently, at lower tariff rates, urban producers of premium rice are more effected as they sell a significant portion of their rice to rural areas which is highly sensitive to transport and marketing costs. This can be observed by the greater sensitivity of rice production and producer welfare in urban areas, and overall consumer welfare in both urban and rural areas. Production of standard rice is less affected sine much of it is consumed where it is produced and then mostly in rural areas. The tariff rate at which import flows occur though Kano is less affected.

6. Conclusions and Policy Implications

In Nigeria, the introduction of higher import tariffs for rice have not resulted in stimulating local production, capturing maximum tariff revenues, nor in achieving the country's self-sufficiency policy goal. We have shown that this has been due to under-invoicing of imports and/or the diversion of imports by smuggling through the country's porous borders as pointed out by Dorosh and Malek (2014). Under these conditions, Nigerian policy makers face a dilemma in their desire to promote domestic rice production, reduce the high dependency on imports, and strive towards becoming self-sufficient in rice production altogether. The objective of this paper has been to assess the difficulty inherent with raising the import tariff given the threat of smuggling across Nigeria's porous borders, and given this knowledge, whether there is an optimal tariff that the Nigerian government can consider under such conditions, especially when regional effects within the country are likely to vary as well. This was accomplished by using a spatial multi-market model for rice developed specifically for Nigeria.

Results show that an optimal tariff rate of 37 percent does exist for maximizing tariff revenues if smuggling cannot be controlled and if our estimates of overland freight costs are correct. Otherwise, this rate will vary in a range between 28 and 45 percent if we overestimated or underestimated the actual freight costs by 50 percent, respectively. The overall effects of the tariff under these conditions also showed us to have important impacts on price changes, trade flows, and ultimately therefore, economic welfare across regions. Most notably, consumers in the south would face much higher welfare losses, especially in urban areas as prices increase more when imports flow from the north. On the other hand, the smuggled imports from the north actually help to dampen the effect of the tariff on prices in this region and the central region.

In summary, the findings clearly show how tariff rates for rice beyond 37 percent do not raise substantial government revenue due to tariff evasion (most likely through under-invoicing of imports or evasion of customs altogether). Combining this with the dampening effect of the tariff evasion on domestic prices, suggests that a tariff policy set at rates greater than 37 percent is a blunt instrument for raising revenues and has only a muted effect on domestic prices. Even if smuggling can be controlled, an optimal tariff rate for maximizing government revenue would not be far off, at about 48 percent. On the other hand, it would require a much higher tariff rate of about 112 percent if the country wishes to achieve its self-sufficiency policy goal. However, this is hardly likely considering the significant policing that would need to be put in place to curb any potential smuggling along the country's large porous borders. Additionally, the resulting higher prices would simply place an even bigger burden on poorer consumers and overall economic welfare, with urban residents suffering the most. If smuggling cannot be prevented under the present state of affairs, a practical policy option for achieving self-sufficiency (at least in the long run) is to invest now in improving the productivity and competiveness of local rice production in Nigeria from revenues collected from an optimal tariff rate, which we have estimated could range from 28 to 45 percent.

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Appendix: Additional tables of model parameters and initial data

Table A.1 Own and cross price elasticities of demand (ε_{dij})[8]

Region	ε_{d11}	ε_{d12}	ε_{d21}	ε_{d22}
Rural				
C	-0.223	0.360	0.829	-0.446
NE	-0.334	0.540	0.982	-0.529
NW	-0.446	0.720	1.113	-0.600
SE	-0.183	0.296	0.387	-0.208
SS	-0.372	0.602	0.782	-0.421
SW	-0.241	0.389	0.509	-0.274
*Weighted Ave**	*-0.329*	*0.531*	*0.855*	*-0.460*
Estimated	*-0.330*			*-0.460*
Urban				
C	-0.088	0.205	0.177	-0.412
NE	-0.132	0.307	0.186	-0.434
NW	-0.176	0.409	0.211	-0.492
SE	-0.101	0.236	0.092	-0.215
SS	-0.176	0.411	0.167	-0.389
SW	-0.114	0.265	0.109	-0.253
*Weighted Ave**	*-0.131*	*0.306*	*0.146*	*-0.341*
Estimated	*-0.129*			*-0.340*
National				
*Weighted Ave**	*-0.288*	*0.484*	*0.708*	*-0.436*
Estimated	*-0.240*			*-0.470*

Note: $\varepsilon_{dij} = \left[\frac{dQD_i}{dP_j}\frac{P_j}{QD_i}\right], \forall ij = 1{,}2$ (where 1 = standard local rice, and 2 = premium rice, local and imported).

*Weighed by share of total demand.

[8] C=Central Region, includes Benue, FCT-Abuja, Kogi, Kwara, Nasarawa, Niger and Plateau; NE = North East Region, includes Aamawa, Bauchi, Gombe, Taraba and Yobe; NW = North West Region, includes Jigawa, kaduna, Kano, Katsina, Kebbi, Sokoto and Zamfara; SE = South East Region, in cludes Abia, Anambra, Bayelsa, Ebonyi and Enugu; SS = South South Region includes Akwa-Ibom, Cross River, Delta, Ekiti, Imo and Osun; SW = South West Region, includes Edo, Lagos, Ogun, Ondo, Oyo and Rivers.

Table A.2 Own and cross price elasticities of supply (ε_{sij})

	Standard (rural)		Premium (urban)	
Region	ε_{s11}	ε_{s12}	ε_{s21}	ε_{s22}
North	0.900	2.351	0.275	0.800
South	0.900	0.985	0.162	0.800

Note: $\varepsilon_{sij} = \left[\frac{dQS_i}{dP_j}\frac{P_j}{QS_i}\right], \forall ij = 1,2$ (where 1 = standard local rice, and 2 = premium rice, local and imported). The cross price elasticities were calculated using the own price elasticities and the shares of each type of rice to total rice production, as follows: $\varepsilon_{s12} = \varepsilon_{s11} \cdot \left({}^{S_1}/{}_{S_2}\right)$; $\varepsilon_{s21} = \varepsilon_{s22} \cdot \left({}^{S_2}/{}_{S_1}\right)$, where s_1 and s_2 are the shares of standard (c1) and premium (c2) in total rice production, respectively.

Table A.3 Unit freight costs (Naira/mt/km)

C	NE	NW	SE	SS	SW
17.96	12.21	13.18	15.13	18.09	22.47

Source: Johnson et al 2013

Table A.4: Final rural and urban marketing costs (Naira/MT)

	Standard		Premium	
Region	rural	urban	rural	urban
Rural				
C	10.8	14.4	17.4	21.6
NE	14.7	19.5	23.6	29.3
NW	7.9	10.5	12.8	15.8
SE	9.1	12.1	14.6	18.2
SS	10.9	14.5	17.5	21.7
SW	9.4	12.6	15.2	18.9
Urban				
C	14.4	10.8	21.6	7.9
NE	19.5	14.7	29.3	10.7
NW	10.5	7.9	15.8	5.8
SE	12.1	9.1	18.2	6.7
SS	14.5	10.9	21.7	8.0
SW	12.6	9.4	18.9	6.9

Source: Calculated by author

Notes: These were purposefully kept low due to lack of sufficient data. They are calculated based on distances between state capitals (from Johnson et al. 2013) to serve as weights and unit costs of 0.75 Naira/kg (rural to rural marketing), 0.55 (urban to urban), and 1.00 Naira/kg (rural to urban), and 1.50 Naira/kg (urban to rural).

Table A.5: Baseline local production (QS) of standard and premium rice varieties (,000 MT)

	Standard (local)		Premium (Local)	
	Rural	Urban	Rural	Urban
Benue	217.2	0.0	0.0	115.2
FCT-Abuja	4.4	0.0	0.0	0.0
Kogi	75.3	0.0	0.0	0.0
Kwara	49.7	0.0	0.0	0.0
Nasarawa	71.0	0.0	0.0	57.6
Niger	401.8	0.0	0.0	0.0
Plateau	78.7	0.0	0.0	0.0
Adamawa	156.1	0.0	0.0	0.0
Bauchi	33.0	0.0	0.0	0.0
Borno	185.3	0.0	0.0	0.0
Gombe	66.6	0.0	0.0	0.0
Taraba	176.9	0.0	0.0	0.0
Yobe	53.5	0.0	0.0	0.0
Jigawa	41.6	0.0	0.0	0.0
Kaduna	454.1	0.0	0.0	57.6
Kano	262.8	0.0	0.0	230.4
Katsina	21.2	0.0	0.0	0.0
Kebbi	52.9	0.0	0.0	57.6
Sokoto	45.8	0.0	0.0	0.0
Zamfara	24.8	0.0	0.0	0.0
Abia	2.7	0.0	0.0	0.0
Anambra	1.9	0.0	0.0	0.0
Ebonyi	183.6	0.0	0.0	115.2
Enugu	55.5	0.0	0.0	57.6
Imo	0.6	0.0	0.0	0.0
Akwa-Ibom	1.4	0.0	0.0	0.0
Bayelsa	0.3	0.0	0.0	0.0
CrossRiver	1.8	0.0	0.0	0.0
Delta	1.3	0.0	0.0	0.0
Edo	11.7	0.0	0.0	0.0
Rivers	0.0	0.0	0.0	0.0
Ekiti	36.0	0.0	0.0	0.0
Lagos	4.6	0.0	0.0	0.0
Ogun	6.0	0.0	0.0	57.6
Ondo	26.3	0.0	0.0	0.0
Osun	1.7	0.0	0.0	0.0
Oyo	0.1	0.0	0.0	0.0

Note: Production of standard (local) rice occurs in rural areas while production of premium occurs in urban only.
Source: NAERLS, 2009