8-2019

Estimating Demand Elasticities for Rice in Benin

Ogoudele Simon Codjo
University of Arkansas, Fayetteville

Estimating Demand Elasticities for Rice in Benin

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science in Agricultural Economics

by

Ogoudele Simon Codjo
University of Parakou
Agricultural Economics Engineer Diploma, 2011

August 2019
University of Arkansas

This thesis is approved for recommendation to the Graduate Council.

_____
Alvaro Durand Morat, Ph.D.
Thesis Director

_____   _____
Lawton Lanier Nalley, Ph.D.   Rodolfo N. Nayga, Jr., Ph.D.
Committee Member   Committee Member

_____
Eric J. Wailes, Ph.D.
Committee Member

ABSTRACT

Rice consumption in Benin is increasing along with shifting consumer demand toward higher quality rice. In this context of changing demands, experimental estimation methods provide an effective way to estimate the current state of consumer preferences. We conducted a hypothetical choice experiment in 15 open markets in Benin to analyze the demand for rice and its substitutes. The results reveal that consumers value quality rice, even those in the low-income class. While high income consumers are more likely to choose high quality imported rice, low- and middle-income consumers are more likely to select high quality domestic rice among the set of rice available. In the high-income group, the demand for high quality imported and domestic rice is price inelastic. High quality domestic rice is almost as likely as high quality imported rice to be selected by urban consumers. In the rural area, consumers are highly responsive to rice price change. Whereas, the demand for rice in the urban area is price inelastic. Consumers are not responsive to corn price changes across the three income groups, although corn is the most likely commodity to be chosen by low- and middle-income consumers. The results suggest that any increase in rice prices could have an untoward effect on rice consumption in urban area.

ACKNOWLEDGEMENTS

DEDICATION

To my father, Ogoudaré Samuel Codjo;

to my mother, Salomé Bola Etienne;

to my Spouse, Irene Ayaba Noudehou, and

to my son, Ayomidé Nael Albert Codjo.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

In Benin, rice consumption is growing faster than that of any other food commodity. Between 1992 and 2002, per capita rice consumption increased by 25.25% and between 2003 and 2013, it surged to 150.42% (FAOSTAT, 2018). This rapid growth in total rice consumption is linked to urbanization, increasing incomes, and shifting urban consumer preferences that favor rice consumption (Fofana, Goundan, & Domgho, 2014; Demont & Neven, 2013). According to FAOSTAT (2018), rice is the main source of calories for consumers in Benin and contributed in 2013 approximately 21% of the daily caloric intake, followed by yam, corn, and cassava, which provide around 16%, 13%, and 12% of the daily caloric intake, respectively. Accordingly, rice plays a vital role in maintaining food security in Benin, and any shock that negatively affects rice price and availability might result in social instability (Seck et al, 2013), and worsen food insecurity. In Benin, 9.6% of households are food insecure and 42% are at the edge of food security, meaning that they can become food insecure when severe shocks occur (WFP, 2017).

Despite the formidable growth in rice production in the last decade since the rice market crisis of 2007/08, domestic production supplies only a quarter of the national rice demand since 2014 (USDA, 2018). One of the major reasons for the dependence on imports is the low investments in the domestic rice sector needed to increase production. West African countries endowed with ports, including Benin, find it more affordable to import rice instead of investing in the domestic rice sector (Rutsaert, Demont, &Verbeke, 2013; Aker et al, 2010; Bezemer & Headey, 2008). Such reliance on imports may jeopardize long run food security, making the domestic market vulnerable to global rice price volatility (Laroche, Dupraz & Postolle, 2013). A blatant example is the 2007 food crisis that exacerbated food insecurity in both rural and urban areas of developing countries (Demont & Neven, 2013). However, policies protecting domestic

production can negatively affect households' welfare, primarily low-income households that use a large share of income on food, especially if prices rise as a result of the policies (Gyimah-Brempong & Kuku-Shittu, 2016). Price-related shocks could adversely affect Benin's rural and urban consumers since they spend about 51% and 47 % of their income on food, respectively (WFP, 2014). Hence, policy makers need to have appropriate information to design sound and balanced rice policies to expand domestic production without compromising consumers' welfare.

The design of suitable rice policies that ensures households' food security and enhance their welfare requires a clear understanding of rice consumption patterns and the welfare implications of sectoral policies. According to Lusk and Tonsor (2016), new dimensions of demand might arise over time along with new information and economic conditions. The fast-growing rice consumption in Benin requires the understanding of the new dynamic of rice demand that can help in the formulation of more effective interventions. Moreover, the impact of changes in households' purchasing power requires an understanding of the differences in consumer preferences by income groups. (Leathers & Foster, 2004; Pinstrup-Andersen and Caicedo, 1978, Cuevas et al, 2016; Lusk and Tonsor, 2016). Elasticity estimates for population's income profiles could aid policymakers in the formulation of better policies that account for the possible differences/sensibilities across income groups. Despite the rapidly changing and growing rice market, there are no recent studies on rice demand estimation in Benin.

One of the challenges of estimating a food demand system in Benin is the quality and availability of data. Systematic historical information on food prices and consumption in Benin are not available, but this shortcoming can be addressed using a consumer survey approach such as choice experiment (Lusk and Tonsor, 2016). In addition, aggregate disappearance data might not be perfectly correlated with actual consumption and may not exhibit much information on

preferences heterogeneity (Piggott and Marsh 2004; Tonsor, Mintert, and Schroeder 2010). According to Unnevehr et al (2010), new methods such as experimental survey have cropped up in recent years to improve the prediction of consumers' preferences and choices. As a result, changes in consumers' preferences can be identified and the effect of policies on consumers' welfare predicted. The fast-growing Benin rice consumption and the rapidly changing consumers preference suggest that the use of demand estimation method, like experimental modelling, can be the most appropriate approach to assess consumer preferences. This study uses data from a hypothetical choice experiment to: (i) estimate the own and cross price elasticities of demand for staple foods in Benin; (ii) evaluate consumers substitution pattern between the different staples; and (iii) determine the variation of substitution pattern across income groups in Benin and between rural and urban area.

2 DATA AND METHODOLOGY

2.1 Source of data

A consumer survey was conducted in January 2019 in fifteen open markets, including seven urban markets, across the southern, central, and northern regions of Benin (Figure 1). In southern Benin, the surveys were mainly conducted in Cotonou, the main rice consumption area. In the central Benin, the Collines department, the second largest rice production area in the country, was selected. The northern areas selected for this study encompasses some minor rice production zones, such as Barienou and Kolokondé. A total of three hundred and three (303) consumers were interviewed. Table 1 presents the distribution of the respondents in the sample.
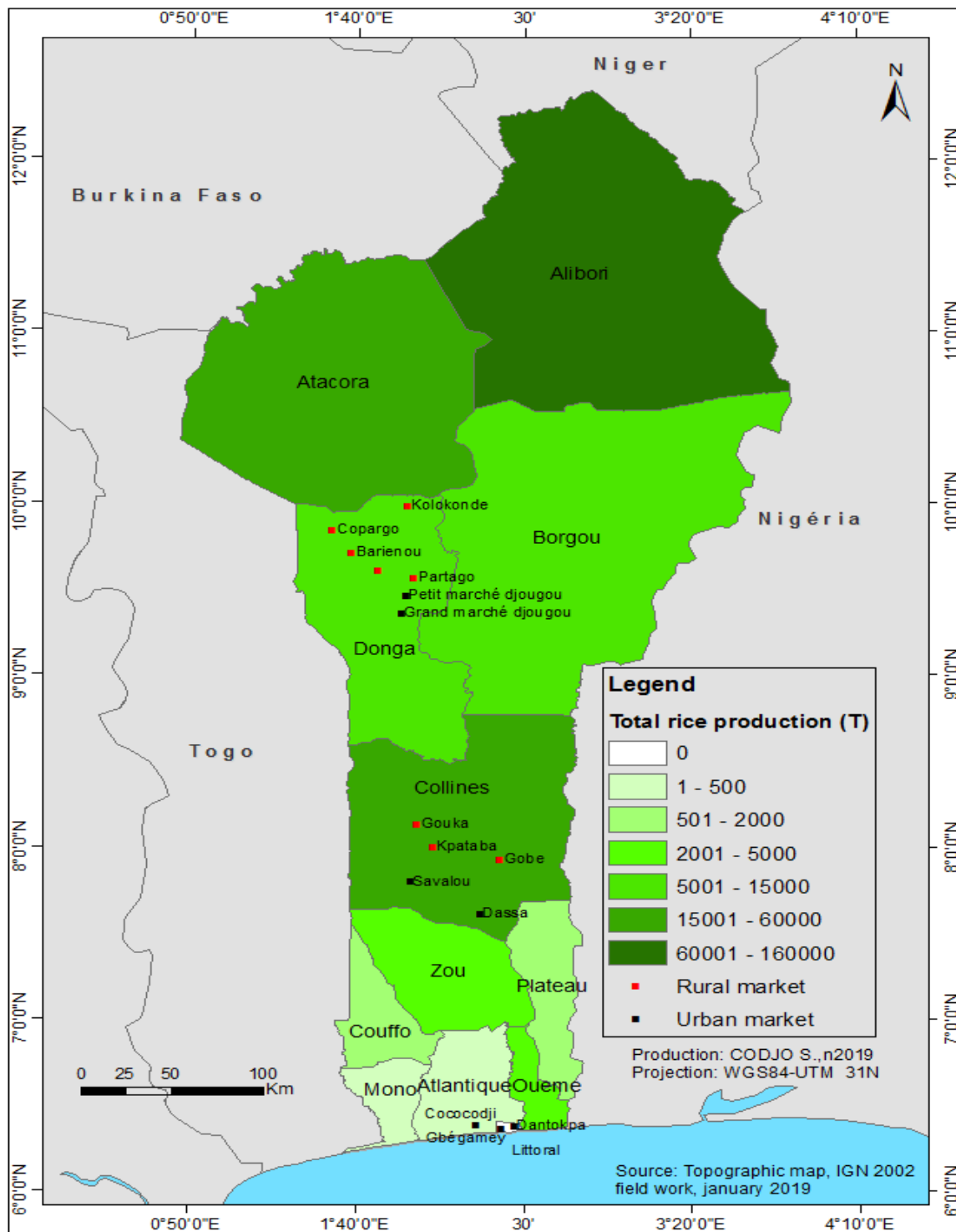
Figure 1: Geographical distribution of rice production in 2017 and selected urban and rural markets included in the survey based on Benin direction of agricultural statistics data.

Table 1. Distribution of the Respondents Across the Fifteen Markets Surveyed in Benin

Region	Total	Location	Market names	Number of respondents	Total
Southern	107	Urban	Dantokpa	40	107
			Gbegamey	37	
			Cococodji	30	
Central	104	Urban	Savalou	24	50
			Dassa	26	
		Rural	Gobé	25	54
			Kpataba	11	
			Gouka	18	
Northern	92	Urban	Grand marché Djougou	21	27
			Petit marché Djougou	06	
		Rural	Paparapanga	16	65
			Kolokonde	13	
			Barienou	12	
			Copargo	14	
			Partago	10	
Total	303			303	303

2.2 Experimental design

This study uses a hypothetical choice experiment to gather data on consumer preferences for the selected staple foods, including rice and its substitutes. Respondents were presented with nine choice sets and were asked to select one option from each choice set. Each choice set has seven

alternatives: high quality imported rice, high quality domestic rice, standard quality domestic rice, yam, corn, cassava, and a "no purchase" alternative. Following Demont, Fiamohe, and Kinkpe (2017), we considered the variety Nerica 2, IR841, and Gino rice as the standard quality rice, high-quality domestic rice, and high-quality imported rice, respectively. The variety IR841 is processed using modern milling technology. However, the variety Nerica is processed using the traditional milling equipment. Gino is the most popular imported rice brand in urban areas and is notorious for its high quality (Demont, Fiamohe, and Kinkpe, 2017). The samples of the rice used in this study underwent physical analysis in the rice lab of Food Science Department of University of Arkansas. The lab analysis of the physical attributes of Nerica 2, IR841, and Gino rice are presented in table 2. Based on International Rice Research Institute (IRRI) grain classification system, the rice considered are all long grain rice However, the high-quality imported rice is classified as slender and both qualities domestic rice are of intermediate shape. In addition, imported rice displays less chalk and broken rate than the high and standard quality domestic rice.

Table 2. Physical Quality Indicators of the Rice Used in the Choice Experiment

Rice	Length[1] (mm)	Width (mm)	Shape[2] (Length/width)	Chalk impact	Broken rate (%)
High quality imported (Gino)	6.72	2.14	3.14	0.6	1.6
High quality domestic (IR841)	6.79	2.38	2.85	5.12	7.4
Standard domestic (NERICA2)	6.04	2.39	2.53	19.63	17.7

[1] Rice grain length classification based on IRRI classification system: short (< 5.50 mm), medium/intermediate ($5.51–6.60$ mm), long ($6.61–7.50$ mm), and very long (> 7.50 mm).
[2] Rice grain shape classification based on IRRI classification system: bold (< 2.0), medium ($2.1–3.0$), and slender (> 3.0)

Each choice set displays the same alternatives, but different prices levels. The substitutes and the no-buy alternative are purposely included in the choice experiment to allow rice

consumers to shift out of rice into other food alternatives or a no buy alternative as part of their choice, thus reflecting real market experiences more accurately (Lusk and Tonsor, 2016).Three levels of prices were considered for each product (low, mid, and high price). The mid-price is the average market price of the product published by the National Institute of Statistic and Economic Analysis from November 12 to November 18 (INSAE, 2018). For some products, such as standard quality rice, which are not included in the market aforementioned report, we estimated the market price from a survey of 3 open markets conducted in Cotonou in, in Glazoué, and Djougou in November of 2018. The December market prices of the products were not used because of the possible distortion in price due to the Christmas and new year celebration. To obtain the low and high price of each product, 200 CFA francs (FCFA) were subtracted from and added to the mid-price. Table 3 presents the details of the price levels of the products used for the choice experiment.

Table 3. Prices Used for the Choice Experiment Design (FCFA/kg)

Products	Low	Mid	High
High quality imported rice	900	1100	1300
High quality domestic rice	300	500	700
Standard quality domestic rice	150	350	550
Corn	50	200	400
Cassava	75	250	450
Yam	100	300	500

Average exchange rate December 2018 = 576 FCFA/US$

An orthogonal factorial experimental design was used to develop 27 choice tasks. Three blocks of nine choices were constructed using the 27 choice tasks, and each respondent was randomly

assigned to one block. Throughout the survey, the order of the alternatives was randomly varied across respondents.

2.3 Field experiment

To ensure that the survey accurately reflected market experiences, we conducted face-to-face surveys in market stands selling staples in the selected open markets. We compensated stand owners for shelf space to display the six staple foods considered in this study. We standardized the presentation of the products (e.g., the containers used to hold the staples were of the same color and size) to make the experiment condition homogenous. We randomly selected consumers that came to the market to buy staples, but before they completed the purchase. The invitation consisted of explaining the objective of the study to the respondent and the benefit of participating in the experiment. Participants received 1,500 FCFA (US$3) as compensation for their time. Each participant was randomly assigned a choice task block and responded nine choice sets question. Respondents were allowed to visually inspect the six staple foods, but were not told about the quality indicators of the different kind of rice considered in this study. Respondents completed a socioeconomic questionnaire before conducting the choice experiment.

2.4 Econometric model

Random utility maximization (RUM) model is used as guidelines for the choice data analysis (McFadden 1973). The RUM model presumes that agent utility is composed of a deterministic component and a stochastic unobserved error component. Given this framework, the utility U_{ij} that a decision maker i derives from consuming alternative j may be portioned into a deterministic and observed component, V_{ij}, and a stochastic and unobserved component, ε_{ij}, such that:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \tag{1}$$

The choice of the model of estimation of U_{ij} depends on assumptions about the distribution of the unmodeled component, ε_{ij} . Assuming that the ε_{ij} follow a type 1 extreme value distribution and are independently and identically distributed (IID) across i and j, then the conventional multinomial logit model (MNL) can be used to model the choice probability associated with alternative j. Equation 2 presents the choice probability of alternative j:

$$Prob(i\ choose\ j) = \frac{e^{V_{ij}}}{\sum_{k=1}^{7} e^{V_{ik}}} \tag{2}$$

The observed component, V_{ij} , is assumed to be linear in parameters such that:

$$V_{ij} = \beta_j x_{ij} \tag{3}$$

Where x_{ij} is a vector of observed variables describing alternative j, and β_j are the coefficients associated with these variables. The MNL exhibits two main limitations in its use for elasticities computation (Luck and Tensor, 2016). First, all cross-price elasticities for an alternative are identical because of the independence of the irrelevant alternative (IIA) property of the MNL. Second, the deterministic component of the utility function, V_{ij}, assumes that the marginal utility of a price change is constant and identical for all alternatives. A less restrictive utility function can be obtained by modifying the functional form of V_{ij} as follows:

$$V_{ij} = \beta_j + \alpha P_j \tag{4}$$

Where P_j is the price of alternative j, α is the marginal utility of price change, and β_j is the alternative specific constant associated with alternative j. Although equation 4 is less restrictive, the IIA assumption of the MNL still prevails. One option to relax the IIA assumption is to use a random parameter logit (RPL) which assumes that preferences may vary across

9

respondents (Henser, Rose, and Greene, 2015). Moreover, the RPL model can approximate any RUM model (McFadden and Train, 2000). It allows for the variation of random taste, substitution patterns without restriction, and unobserved factors correlation (Train, 2009). In this study, we adopted the following functional form of the observed utility function:

$$V_{ij} = \beta_j + \sum_{t=1}^{6} \omega_{jt} d_{it} + \alpha_j P_j \tag{5}$$

Where, as before, β_j represents the alternative specific constant associated with alternative j, P_j is the price of alternative j, and α_j the marginal utility of price change associated with alternative j. The terms $d_{it} \sim N(0,1)$ and ω_{jt} are the elements of the lower triangular Cholesky matrix associated with the covariance matrix of the random parameters.

2.5 Estimation of price elasticity of demand for rice

This study focusses on both the own and the cross-price demand elasticities. In this econometric framework, the own-price demand elasticity is assessed as the percentage change in the likelihood of selecting alternative *j* in the choice set with respect to the percentage change in the price of *j*. Similarly, cross-price elasticities are estimated as the percentage change in the likelihood of selecting alternative *j* in the choice set with respect to the percentage change in the price of alternative *k* (Louvier et al, 2000). To estimate these elasticities, we first estimated the market share as the probability of purchase for individual i and food option j at different price levels. Second, the demand curve is constructed using the market share as a function of price. Finally, the elasticity or percentage change in the market share of good *j* that results from a 1% increase in the price of good *k* is calculated.

i) Estimation of market share

The market shares are estimated by plugging the observable component of utility, $\widehat{V_{ij}}$, in the probability equation (2):

$$S_{ij}|d_i = \frac{e^{\widehat{V_{ij}}}}{\sum_{k=1}^{7} e^{\widehat{V_{ik}}}} \tag{6}$$

Where S_{ij} is the market share or probability of purchase for individual i and food option j, and d_i is a vector containing the terms d_{it}. Equation 6 cannot be directly evaluated because it contains the random terms $d_{it} \sim N(0,1)$, and simulation must be used to approximate the mean share. For a set of N draws from $d_{it} \sim N(0,1)$, the unconditional market share for food option j, S_j, can be approximated as follows:

$$S_j = \frac{1}{N} \sum_{t=1}^{N} \frac{e^{\widehat{V_{ij}}}}{\sum_{k=1}^{7} e^{\widehat{V_{ik}}}} \tag{7}$$

ii) Construction of demand curve

The demand curve for good j is constructed by evaluating equation (7) at different good $j's$ prices holding the price of other goods at their mean value. For instance, we build the demand curve for standard quality rice by evaluating its market share at 150, 250, 350, 450, and 550 FCFA kg^{-1}, keeping the price of high quality imported rice, high quality domestic rice, yam, cassava, and corn at 1100, 500, 350, 300, 250, 200 FCFA. The prices considered for each staple food should vary within the price range used in the experimental design. The implied demand curve for each staple food is constructed by plotting the prices and associated market shares.

iii)　Estimation of elasticities or change in market share

The final value of the elasticity, defined as the percentage change in the share of good j that results from a 1% increase in the price of good k is calculated as:

$$e_{jk} = \frac{S'_j - \bar{S}_j}{\bar{S}_j} \frac{1}{0.1} \tag{8}$$

Where e_{jk} the arc elasticity of demand for good j, or percentage change in the share of good j that results from a 1% increase in the price of good k, $\bar{S}_j$ is the market share of good j evaluated at the midpoint price level, and S'_j is the new market share of good j resulting from a 10% increase in the price of good k.

3 RESULTS

3.1 Characteristics of respondents by income group and by location

Table 4 presents the socio-economic characteristics of the respondents by income group. We grouped respondents into low, middle, and high-income groups following the distribution presented in the report of the Benin global analysis of vulnerability and food security (WFP, 2014). The categorization per income group in this study suggests that 45%, 39%, and 16% of the respondents are in the low, middle, and high-income groups, respectively. Thus, our sample resembles the national distribution reported by AGSVA (2014), by which 40%, 40%, and 20% of households are in the low, middle, and high-income categories. A Kruskal-Wallis test revealed that there is a significant (P<0.01) difference in the rice purchase price, per capita rice consumption, and household size across income groups. The average purchase price of rice increases from the low to the high-income class: high-income consumers pay 41.2% and 35.7% more than low and middle-income households. The average annual per capita consumption of rice is estimated at 29 kg, which is less than the 42 Kg per capita per year estimated by Fiamohe

and Kinkpe (2016). High income respondents consume more rice than low- and middle-income consumers. The average household size is 4.98, 6.00, and 6.02 for low, middle, and high-income consumers, respectively. The average respondents' household size is 5.55, which is close to the national average of 5.85 (RGPH, 2013). Twenty eight percent of the respondents did not have any formal education. The high-income class presents the highest proportions of university level respondents, while the low-income respondents had the highest proportion of illiterate.

A Wilcoxon test revealed that there is a significant (P<0.01) difference between the rice purchase price, per capita rice consumption, and the size of rural and urban households. Rice is much cheaper in rural areas, which may be explained by the fact that cheaper domestic rice may be more popular in rural areas than in urban areas. Rural households display a larger size, which reflects the national profile of households distribution. The national average households' size is estimated at 5.01 and 6.08 for urban and rural areas, respectively. Likewise, urban area households consume more rice than rural area households. This may be explained by urbanization that stimulates the consumption of foods, such as rice, that are easier to cook and need less preparation time. With urbanization, the opportunity cost of women's time increases since they have a greater chance to work outside home. Furthermore, many people have their lunch outside home and rice is a convenient food. Lastly, urban households are more literate than their rural counterpart.

Table 4. Socioeconomics Characteristics of Respondents by Income Group and by Location

		Income Group			Location	
	Pooled	**Low Income[1]**	**Middle Income[2]**	**High Income[3]**	**Rural Area**	**Urban Area**
Rice price (FCFA/kg)	525	484.9	504.9	684.9	433.78	584.13
	(236.07)	(214.9)	(205.5)	(289.6)	(154.35)	(260)
Rice consumption (kg/capita)	28.95	29.09	27.87	31.21	25.38	31.27
	(17.55)	(19.73)	(14.25)	(18.23)	(14.03)	(19.14)
Household size	5.55	4.98	6.00	6.02	6.1	5.19
	(2.49)	(2.14)	(2.51)	(2.94)	(2.7)	(2.27)
Formal education (%)						
Yes	72.27	62.23	73.95	95.92	62.19	78.80
No	27.72	37.77	26.05	4.08	37.81	21.19
Marital status (%)						
Yes	74.25	67.41	81.51	75.51	77.31	72.28
No	25.75	32.59	18.49	24.49	22.69	27.77
Number of respondents	303	135	119	49	119	184

Standard deviation in parenthesis; MI=Monthly income in FCFA; Average exchange rate December 2018 = 576 FCFA/US$
[1]. Monthly income $\leq$ 100,000. [2]. 100,000 < monthly income $\leq$ 200,000. [3]. Monthly income > 200,000.

3.2 Results of the random parameter logit model by income group and by location

Since the RPL model yielded a better fit than the MNL model for all the specifications used in this study, and given the advantages of RPL over MNL discussed above, we focus the discussion on the RPL model estimates. The Bayesian information criterion (BIC), Akaike information criterion (AIC), and likelihood ratio (LR) test suggest that the RPL model with a correlated alternative specific constant yields better results than the uncorrelated RPL model.

The sum of the log likelihood values of the three income group models is compared to the pooled model log likelihood function value to see if the model parameters are the same across income groups (Lusk and Tonsor, 2016). The comparison yields a chi-squared value of 224.36 with 78 degrees of freedom and an associated p-value less than .001. Accordingly, preferences are different across income groups since the hypothesis that the model parameters are identical across income categories is rejected.

Table 5 presents the results of the correlated RPL model for the pooled data set and for the three income groups. The results indicate that all the parameters depict the expected signs and are statistically significant (P<0.01). In the pooled model, the high-quality domestic rice presents a coefficient of 8.089, which is the highest among the three types of rice. This coefficient indicates that the average consumer receives 8.089 more utility from high quality domestic rice than from the no buying option. High quality domestic rice provides 4.484 (8.089-3.605) more utility than high quality imported rice. We identify important differences in the utility derived from the different types of rice by household income levels. High-quality domestic rice shows the highest utility among the three types of rice for both low- and middle-income households, while high-quality imported rice provides the highest utility to the average high-income consumer. Low-income consumers derive no utility (coefficient statistically not

different from zero) from high-quality imported rice. For staples other than rice, the average consumer across all income levels derives the highest utility from corn and lowest from cassava.

The price coefficients in Table 4 report the marginal utility of price change. For example, the coefficient of -0.008 for high quality domestic rice in the pooled model indicates that an increase of FCFA 100 in the price of high-quality domestic rice will decrease utility by 0.8. For all staples (including the three types of rice) and income groups, the marginal utility is negative and significantly different from zero. We use the variance and the covariance of the alternative specific constant to assess heterogeneity across consumers. For example, the standard deviation for high quality domestic rice in the pooled sample is 2.5 and significantly different from zero, which means that we should expect that 68% of the consumers in that income group derive a utility from high quality domestic rice of between 5.59 and 10.59 (8.089 ± 2.5). Appendix Table 2 shows the correlation matrix for random parameters implied by the variance-covariance matrix.

Similarly to the case of income categories, we test the null hypothesis that the models are the same across locations (rural and urban). The likelihood test yields a chi-squared of 217.52 with 78 degrees of freedom and an associated p-value less than .001, which leads to the rejection of the null hypothesis. The results of the correlated RPL model for rural and urban area show that all the parameters have the expected signs and are statistically significant, except for the marginal utility of price for cassava, which is not statistically different from zero. High quality domestic rice gives the highest utility to rural and urban households among the rice alternatives. Concerning the food commodities other than rice, corn provides the highest utility for consumers in both locations. The significance of the variance of the alternative specific constants for all rice alternatives highlights the heterogeneity in preferences among rural and urban households.

Table 5. Estimates of Random Parameter Model per Income Group and by Location

		Income Group			Location	
	Pooled	**Low Income[1]**	**Middle Income[2]**	**High Income[3]**	**Rural Area**	**Urban Area**
Alternative Specific Constants						
HQIR[4]	3.605**	-6.238	7.309 ***	7.117***	0.84	10.09 ***
	(1.293)	(3.799)	(1.902)	(2.001)	(3.63)	(1.47)
HQDR[5]	8.089***	6.383***	9.466 ***	3.103**	9.2 ***	10.59 ***
	(0.58)	(0.669)	(0.865)	(1.1)	(0.82)	(1.78)
SQDR[6]	7.73***	6.075***	7.674 ***	4.9***	8.47 ***	9.71 ***
	(0.562)	(0.661)	(0.752)	(0.919)	(0.68)	(1.67)
Yam	8.468***	6.22***	8.438 ***	5.856***	9.27 ***	10.56 ***
	(0.582)	(0.604)	(0.732)	(0.829)	(0.7)	(1.45)
Cassava	7.391***	5.983***	6.168 ***	5.186***	11.37	9.49 ***
	(0.585)	(0.654)	(0.762)	(1.42)	(22.79)	(1.58)
Corn	8.816***	6.639***	8.805 ***	6.302***	9.35 ***	10.88 ***
	(0.582)	(0.609)	(0.738)	(0.856)	(0.7)	(1.54)
Price Effects						
HQIR	-0.006***	-0.007***	-0.008 ***	-0.005**	-0.007 **	-0.006 ***
	(0.001)	(0.002)	(0.002)	(0.002)	(0)	(0)
HQDR	-0.008***	-0.007***	-0.013 ***	-0.006***	-0.014 ***	-0.006 ***
	(0.001)	(0.001)	(0.001)	(0.002)	(0)	(0)
LQDR	-0.011***	-0.01***	-0.015 ***	-0.014***	-0.018 ***	-0.009 ***
	(0.001)	(0.001)	(0.001)	(0.002)	(0)	(0)
Yam	-0.013***	-0.014***	-0.016 ***	-0.011***	-0.021 ***	-0.011 ***
	(0.001)	(0.001)	(0.001)	(0.001)	(0)	(0)

Table 5. (Continued).

	Pooled	Income Group			Location	
		Low Income[1]	Middle Income[2]	High Income[3]	Rural Area	Urban Area
Price Effects						
Cassava	-0.026***	-0.026***	-0.024 ***	-0.035***	-0.087	-0.02 ***
	(0.002)	(0.004)	(0.004)	(0.008)	(0.3)	(0)
Corn	-0.017***	-0.016***	-0.021 ***	-0.019***	-0.025 ***	-0.014 ***
	(0.001)	(0.001)	(0.001)	(0.002)	(0)	(0)
Standard deviation of alternative specific constants						
HQIR	8.31 ***	14.55 ***	4.97 ***	5.78**	6.74 ***	10.17 ***
	(0.82)	(2.72)	(0.91)	(2.01)	(0.9)	(1.79)
HQDR	2.5 ***	1.89 ***	2.53 ***	3.33	2.19 ***	4.55 ***
	(0.36)	(0.53)	(0.6)	(1.7)	(0.51)	(1.24)
LQDR	3 ***	2.12 ***	3.14 ***	3.82*	1.49 **	5.05 ***
	(0.31)	(0.5)	(0.41)	(1.66)	(0.49)	(1.07)
Yam	3.68 ***	2.85 ***	3.03 ***	2.85*	2.81 ***	5.83 ***
	(0.32)	(0.47)	(0.4)	(1.25)	(0.45)	(0.94)
Cassava	2.86 ***	1.84 ***	2.51 ***	4.76**	2.16 ***	4.81 ***
	(0.37)	(0.37)	(0.46)	(1.6)	(0.41)	(0.97)
Corn	3.88 ***	2.57 ***	4.05 ***	2.65	2.99 ***	5.99 ***
	(0.35)	(0.57)	(0.44)	(1.44)	(0.41)	(1.07)
N	303	135	119	49	119	184
Log Likelihood	-2563.1	-1161.6	-911.69	-377.67	-806.54	-1647.8

Standard errors in parenthesis; '***','**', '*', significance at 1, 5, and 10%.
[1]. Monthly income $\leq$ 100,000. [2]. 100,000 < monthly income $\leq$ 200,000. [3]. Monthly income > 200,000.
[4]. High quality imported rice. [5]. High quality domestic rice. [6]. Standard quality domestic rice.

3.3 Estimation of market shares by income group and by location

The comparison of parameters across income classes may be inappropriate since it may be confounded by the discrepancy between variances (Lusk and Tonsor, 2016). However, the market shares, which indicate the probability of purchasing a product, can be compared across income groups. Table 6 presents the distribution of market shares across income groups and location. High income class consumers are almost 3 and 5 times more likely to choose high quality imported rice than low- and middle-income classes consumers. High quality domestic rice is more likely to be selected by both low- and middle-income households than high quality imported rice and standard quality domestic rice. Corn has the largest market share among the low- and middle-income classes, and high-quality imported rice has the largest share among high-income households. Among all the products, cassava is less likely to be chosen across all income groups.

Urban households are 50% more likely to choose rice than rural household. Actually, rice accounts for 51% of the market share of urban consumers versus 34% for rural consumers. The market share of high-quality imported rice among rural households is very small, while it is the largest for urban households. Urban households have a similar market share for the three rice alternatives. Corn has the largest market share among all the food products in both rural and urban area. The probability of no purchase is small across income groups and urban and rural households.

Table 6. Estimated Market Shares (%) per Income Group and by Location

Products	Pooled	Income group			Location	
		Low Income [1]	Middle Income [2]	High Income[3]	Rural	Urban
HQIR[4]	11.39	9.32	6.05	30.05	4.32	18.46
HQDR[5]	18.41	23.00	16.52	10.33	16.45	17.35
SQDR[6]	17.86	21.63	16.19	11.56	13.68	15.76
Yam	23.75	19.27	27.38	27.33	30.39	21.12
Cassava	1.84	1.04	2.29	2.97	0.01	5.73
Corn	25.80	24.76	31.02	15.99	34.04	21.58
No purchase	0.93	0.97	0.55	1.77	1.13	0.01

[1]. Monthly income $\leq$ 100,000. [2]. 100,000 < monthly income $\leq$ 200,000. [3]. Monthly income > 200,000.
[4]. High quality imported rice. [5]. High quality domestic rice. [6]. Standard quality domestic rice.

3.4 Estimation of direct and cross elasticities by income group and by location

Table 7 presents the own and cross-price elasticities of demand by income group and by location. Overall, the demand for all rice alternatives is elastic across income groups, except for high quality imported and domestic rice for high-income consumers. A 10% decrease in the price of standard quality domestic rice will result in a 4.1% decrease in the high-quality domestic rice consumption among low-income consumers. Similarly, the demand for high quality domestic rice by middle income consumers is expected to decrease by 4.4% as a result of 10% decrease in high quality imported rice price. Hence, high-quality domestic rice is the most preferred rice by low- and middle-income consumers. Looking at high-income consumers, a 10% increase in the price of high-quality imported rice will result in 9.6%, 0.4%, and 0.5% decrease in the

20

consumption of high-quality imported rice, high quality domestic rice, and standard quality domestic rice respectively. Rural consumers are highly responsive to food price changes. A 10% decrease in the price of standard quality domestic rice will result in the 9.6% reduction in the consumption of high-quality domestic rice in the rural areas. However, a 10% fall in the price of standard quality domestic rice will lead to only 1.3% decrease in the consumption of high-quality domestic rice consumption in urban area. Among urban households, the demand for all rice alternatives is inelastic. Accordingly, rice is more a staple food in urban area than in rural area.

Looking at the products other than rice, corn demand is inelastic across income groups and locations. Interestingly, corn is a closer substitute for domestic high-quality rice among low and middle-income households: the cross-price elasticity of corn for high quality domestic rice, the most preferred rice alternative among low and middle-income households, is the largest among all staples. A 10% increase in price of rice regardless the quality, will result in a 3% to 3.8% increase in corn consumption for low income consumers, 4.6% to 10.6% among middle income consumers, and 1.4% to 4.1% among high-income consumers. The demand for yam is elastic for low- and middle-income consumers but inelastic for high-income respondents. However, the demand for cassava is elastic across the income groups. Standard quality domestic rice presents the largest cross price elasticity of cassava demand among low- and middle-income consumers. Thus, these consumers will substitute more standard quality domestic rice to cassava than the other commodities.

Table 7. Arc Price Elasticities by Income Group and by Location

% Change in price	% Change in quantity					
	HQIR	HQDR	SQDR	Yam	Cassava	Corn
Low Income[1]						
HQIR[4]	-1.08	-0.03	-0.03	-0.43	-0.08	0.3
HQDR[5]	0.1	-1.48	0.38	0.24	0.15	0.38
SQDR[6]	0.06	0.41	-1.89	0.39	0.12	0.34
Yam	0.07	0.49	0.55	-2.48	-0.09	0.44
Cassava	0.13	0.52	0.68	0.84	-4.67	0.39
Corn	0.16	0.6	0.46	0.48	0.01	-0.82
No purchase	0.41	0.61	0.47	0.7	-0.06	0.54
Middle Income[2]						
HQIR	-2.69	0.44	-0.07	0.26	-0.38	1.06
HQDR	0.16	-2.28	0.47	0.64	0.2	0.74
SQDR	0.08	0.51	-1.79	0.24	0.18	0.46
Yam	0.24	0.25	0.45	-1.46	0.25	0.3
Cassava	0.29	0.41	0.96	0.32	-3.1	0.18
Corn	0.12	0.39	0.13	0.5	-0.01	-0.8
No purchase	0.24	1.27	0.88	1.2	0.35	0.51
High Income[3]						
HQIR	-0.91	-0.04	-0.05	0.19	0.07	0.19
HQDR	0.63	-0.94	0.04	0.53	0.23	0.23
SQDR	0.17	0.15	-1.67	0.42	0.29	0.58
Yam	0.48	0.3	0.33	-0.95	0.25	0.27
Cassava	-0.04	0.07	-0.23	0.43	-3.15	0.16

Table 7. (Continued).

Change in price	Change in quantity					
	HQIR	HQDR	SQDR	Yam	Cassava	Corn
High Income[3]						
Corn	0.27	0.01	0.48	0.28	-0.07	-1.02
No purchase	0.32	0.37	0.32	0.85	0.55	0.86
Rural area						
HQIR	-2.09	-0.08	0.45	0.79	0.21	0
HQDR	-0.04	-2.96	0.69	0.99	-0.15	0.81
SQDR	-0.02	0.93	-2.97	0.97	0.19	1.01
Yam	0.27	0.42	0.34	-1.8	-0.02	0.85
Cassava	-2.18	-0.8	4.92	-1.72	-9.55	1.18
Corn	0.04	0.37	0.21	0.39	-0.01	-0.94
No purchase	-0.04	1.18	1.64	1.43	0.16	0.99
Urban area						
HQIR	-0.96	0.2	-0.09	0.05	0.17	0.14
HQDR	0.06	-0.66	0.17	0.37	0.24	0.41
SQDR	0.46	0.13	-0.85	0.41	0.04	0.16
Yam	0.15	0.17	0.3	-0.83	-0.02	0.1
Cassava	0.58	0.25	0.18	0.2	-1.44	0.1
Corn	0.1	0.02	0.18	0.1	0.09	-0.59
No purchase	3.46	2.03	2.06	5.32	2.21	1.24

[1]. Monthly income $\leq$ 100,000. [2]. 100,000 < monthly income $\leq$ 200,000. [3]. Monthly income > 200,000.
[4]. High quality imported rice. [5]. High quality domestic rice. [6]. Standard quality domestic rice.

3.5 Implied demand curves for rice by income group and by location

The rice demand curves by income class and location are constructed using the market shares in the range of the prices used for the experimental design (Figure 2). All the demand curves depict a downward slope as expected according to the law of demand. The demand curves of the high-quality imported rice (HQIR) reveal that there is a gap between the demand of this rice at the lowest price (900 FCFA) across income groups and between rural and urban area. The likelihood of purchasing HQIR at the 900 FCFA is exceedingly higher for high income and urban area consumers. At the highest price of HQIR, the probability of choosing this rice is still substantially higher for high income and urban consumers than the probability of selecting this rice by rural and low-income consumers at the lowest price. Accordingly, HQIR may be more consumed in the urban areas and by high-income consumers even at the higher prices.

The demand for high quality domestic rice (HQDR) at its lowest price is higher for low- and middle-income consumers than that of high-income consumers. Similarly, the likelihood of choosing this rice in rural area is higher than in urban area at its lowest price. However, as the HQDR price increases, rural, low, and middle-income consumers' demand fall quickly, which is not the case for high-income consumers. Accordingly, the demand for HQDR is elastic in rural area and for low- and middle-income consumers as suggested by the elasticities estimates (Table 8). At the highest price of HQDR, the likelihood of choosing this rice by low-income consumers is higher than that of middle- and high-income consumers. This shows that consumers, even those of low-income profile, are aware of rice quality.

The demand for standard quality domestic rice (SQDR), is elastic across income groups and for rural consumers. In opposite, urban consumers have an inelastic demand for SQDR as shown by the shape of its demand curve. At the highest price of SQDR, low-income consumers

depict the biggest demand for standard quality rice. Accordingly, low-income households may consume more standard domestic quality rice.
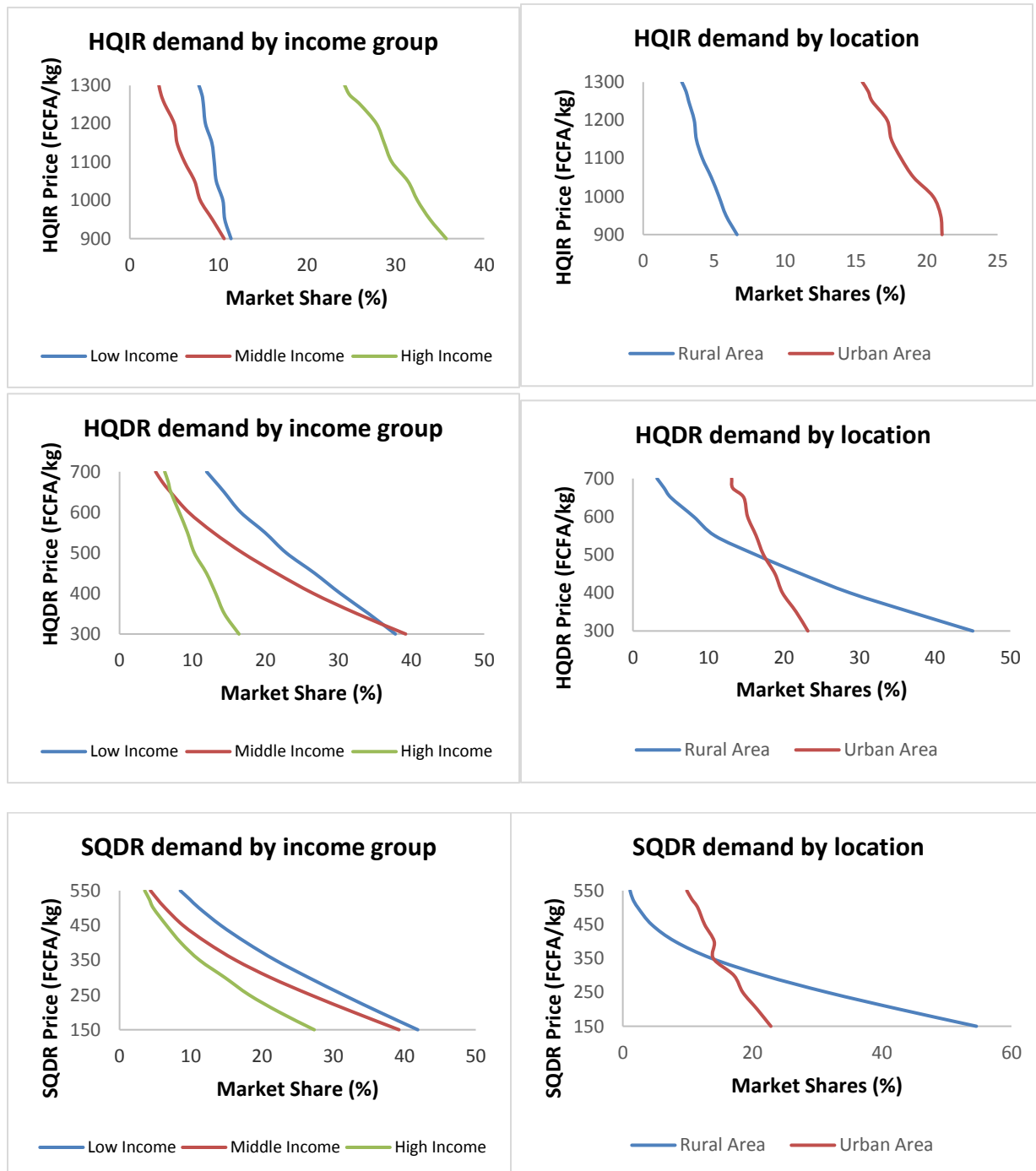

Figure 2: Implied Demand Curves for Rice by Income Group and by Location

4 DISCUSSION AND CONCLUSION

Rice represents a significant food commodity in households' consumption in Benin and the understanding of its demand pattern is pivotal to design appropriate food policies. One of the main limitations in Benin is the lack of information to conduct a rigorous food demand analysis. To our knowledge, Benin has not conducted a household income and expenditure survey in the last decade, a time when food consumption, especially rice, changed significantly. We collected primary information via a consumer survey and used experimental methods to model the demand for rice in Benin. The results revealed several interesting and novel demand patterns. First, regardless of income level, consumers value/prefer high quality rice. This result is congruent with previous studies that suggest that rice consumers, even those of low-income class, are increasingly becoming aware of food quality (Rutsaert, Demont, & Verbeke, 2013; Demont, Fiamohe, & Kinkpe, 2017). Second, consumers in general are more sensitive to changes in rice prices than what the scarce existing literature suggests. To illustrate, Seale, Regmi, and Berstein (2003) estimated an unconditional own price elasticity of demand for bread and cereals, including rice, at -0.459, which is significantly lower than the estimates generated in this study. Third, the own price demand elasticity varies significantly by income group and location. High-income consumers exhibit an inelastic own price demand for high quality imported rice, their preferred option among all staples with a market share of 30 percent, while middle and low-income consumers show an elastic response to the price of high quality domestic rice, their preferred rice option. Likewise, urban consumers have inelastic demands for all three rice options, while rural consumers are highly sensitive to changes in the price of high quality domestic rice, their preferred rice option. Lastly, substitution between imported and domestic rice is limited as evidenced by the small cross-price elasticity values, but varies by income level.

Low-income consumers are less willing to substitute imported for domestic rice than middle and high-income consumers.

Since the rice crisis of 2007/08, Benin along with many other African countries have embarked in a plan to improve its rice supply chain and rice self-sufficiency. Benin developed its National Rice Development Strategy (NRDS) in 2011with the overarching goal of becoming rice self-sufficiency by 2018, but despite progress since then domestic production covers only around a quarter of domestic consumption. The findings of this study can help with the formulation of sound sectoral policies aimed at fostering the growth of the domestic rice sector by providing basic information to facilitate the impact analysis of relative changes in the price of imported and domestic rice.

Our findings suggest that a rice development strategy based on import market protection will not generate a large push in the demand for domestic rice, and will actually hurt consumers, primarily those from the high-income and urban groups. Table 8 shows the change in the demand for staple foods resulting from a 10 percent increase in the price of high quality imported rice. Demand for imported rice is estimated to decrease significantly by 17 percent nationwide while the demand for high quality domestic rice, its closest substitute, increases by 2 percent. The results show that such a policy intervention will have a clear bias against high-income groups that consume more imported rice, while it will have much smaller impacts on middle and low-income groups.

Table 8: Percentage Change in the Demand of the Selected Staples Due to a 10% Increase in the Price of High Quality Imported Rice

	HQIR[4]	HQDR[5]	SQDR[6]	Yam	Cassava	Corn
Low Income[1]	-11%	0%	0%	-4%	-1%	3%
Middle Income[2]	-27%	4%	-1%	3%	-4%	11%
High Income[3]	-9%	0%	-1%	2%	1%	2%
All income groups[†]	-17%	2%	-1%	0%	-2%	6%

[1]. Monthly income ≤ 100,000. [2]. 100,000 < monthly income ≤ 200,000. [3]. Monthly income > 200,000.
[4]. High quality imported rice. [5]. High quality domestic rice. [6]. Standard quality domestic rice.
[†]. The aggregation across income groups is based on the population shares by income group from AGSVA (2014)

On the other hand, policies aimed at lowering the production cost and retail price of domestic rice can generate a sizable increase in the demand for domestic rice. As Table 9 shows, the demand for domestic high and standard quality rice increases by 13 percent and 15 percent, respectively, due to a 10% decrease in the price of domestic rice, while the demand for imported rice decreases by 3 percent. Also, we can expect that the benefits from lower domestic rice prices be more evenly distributed across income groups.

Table 9 : Percentage Change in the Demand of the Selected Staples Due to a 10% Decrease in the Price of Domestic Rice

	HQIR[4]	HQDR[5]	SQDR[6]	Yam	Cassava	Corn
Low Income[1]	-2%	11%	15%	-6%	-3%	-7%
Middle Income[2]	-2%	18%	13%	-9%	-4%	-12%
High Income[3]	-8%	8%	16%	-10%	-5%	-8%
All income groups[†]	-3%	13%	15%	-8%	-4%	-9%

[1]. Monthly income ≤ 100,000. [2]. 100,000 < monthly income ≤ 200,000. [3]. Monthly income > 200,000.
[4]. High quality imported rice. [5]. High quality domestic rice. [6]. Standard quality domestic rice.
[†]. The aggregation across income groups is based on the population shares by income group from AGSVA (2014)

Finally, our findings highlight the importance of improving the quality of domestic rice to bring it up to par with imported rice. Based on the representative rice qualities used in this study, our findings suggest that changes in relative prices can improve demand for domestic rice only so much, and that quality upgrades to domestic rice are a must if Benin intends to significantly improve its rice self-sufficiency.

REFERENCES

Arinloye, D. D. A. A (2006). Analysis of factors determining rice demand in center and south of Benin. Thesis of Agricultural Engineer, University of Abomey-Calavi, Benin.

Aker, J. C., Block, S., Ramachandran, V., & Timmer, C. P. (2010). West African experience with the world rice crisis, 2007–2008. The rice crisis: markets, policies and food security, 143-162.

Bezemer, D., & Headey, D. (2008). Agriculture, development, and urban bias. World Development, 36(8), 1342-1364.

Cuevas, R. P., Pede, V. O., McKinley, J., Velarde, O., & Demont, M. (2016). Rice grain quality and consumer preferences: a case study of two rural towns in the Philippines. PloS one, 11(3), e0150345.

Demont, M., Fiamohe, R., & Kinkpe, A. T. (2017). Comparative advantage in demand and the development of rice value chains in West Africa. World Development, 96, 578-590.

Demont, M., & Neven, D. (2013). Tailoring African Rice Value Chains to Consumers. Realizing Africa's Rice Promise, 303.

Diagana, B., Akindes, F., Savadogo, K., Reardon, T. and Staatz, J. (1999) Effects of the CFA franc devaluation on urban food consumption in West Africa: overview and cross-country comparisons. Food Policy 24, 465–478.

Dupraz, C. L., & Postolle, A. (2013). Food sovereignty and agricultural trade policy commitments: How much leeway do West African nations have? Food Policy, 38, 115-125.

FAOSTAT (2018). Data base accessed on March, 15 2018.

Fiamohe, R. E., & Kinkpé, A. T. (2016, September). Analyzing potential demand for local rice in West Africa. In 2016 AAAE Fifth International Conference, September 23-26, 2016, Addis Ababa, Ethiopia (No. 249281). African Association of Agricultural Economists (AAAE).

Fofana, I., Goundan, A., & Domgho, L. V. M. (2014). Impact simulation of ECOWAS rice self-sufficiency policy, IFPRI Discussion Paper 1405. Washington, DC: International Food Policy Research Institute, http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/128894.

Gyimah-Brempong, K., & Kuku, O. (2016). Evolution of consumption and demand patterns. The Nigerian Rice Economy: Policy Options for Transforming Production, Marketing and Trade, 21-50.

Gustavsen, G.W. (2015). Consumer Cohorts and Demand Elasticities. European Review of Agricultural Economics. 42: 217–37.

INSAE (2018). Evolution hebdomadaire de prix des produits de grande consommation au Benin

RGPH (2013). Principaux indicateurs socio-démographiques et économiques. Accessible at http://benin.opendataforafrica.org

Laroche Dupaze, C. and Postelle, A. (2013). Food sovereignty and agricultural trade policy commitments: how much leeway do West African nations have. Food policy, 38, 115-125.

Leather, H. D., & Foster, P. (2004). The World Food Problems towards Ending Undernutrition in the Third Word.

Lusk, J. L. & Tonsor G. T. (2016). How Meat Demand Elasticities Vary with Price, Income, and Product Category. Applied Economic Perspectives and Policy (2016) volume 38, number 4, pp. 673–711.

McFadden, D., & Train, K. (2000). Mixed MNL models for discrete response. Journal of applied Econometrics, 15(5), 447-470.

Mhlanga, S. (2010). Economic analysis of consumer based attributes for rice in Benin (Master's Thesis, McGill University).

Naseem, A., Mhlanga, S., Diagne, A., Adegbola, P. Y., & Midingoyi, G. S. K. (2013). Economic analysis of consumer choices based on rice attributes in the food markets of West Africa—the case of Benin. Food security, 5(4), 575-589.

World Food Program, WFP (2014). Analyse Global de la Vulnérabilité et de la Sécurité Alimentaire (AGVSA, 2013). Service de l'Analyse de la Sécurité Alimentaire (VAM), 142p.

World Food Program, WFP (2017). Analyse Global de la Vulnérabilité et de la Sécurité Alimentaire (AGVSA, 2017). Service de l'Analyse de la Sécurité Alimentaire (VAM), 173p.

Piggott, N. E., and T. L. Marsh (2004). Does Food Safety Information Impact US Meat Demand? American Journal of Agricultural Economics 86: 154–74.

Pinstrup-Andersen, P., & Caicedo, E. (1978). The potential impact of changes in income distribution on food demand and human nutrition. American Journal of Agricultural Economics, 60(3), 402-415.

Reardon, T. (1993). Cereals demand in the Sahel and potential impacts of regional cereals protection. World Development 21, 17–35.

Rutsaert, P., Demont, M., & Verbeke, W. (2013). Consumer Preferences for Rice in Africa. In Realizing Africa's rice promise (pp. 294-302). CABI.

Seale Jr., J., Regmi, A., and Berstein, J. (2003). International Evidence on Food Consumption Patterns. United States Department of Agriculture, Economic Research Service. Technical Bulletin Number 1904

Seck, P. A., Touré, A. A., Coulibaly, J. Y., Diagne, A., & Wopereis, M. C. (2013). Africa's rice economy before and after the 2008 rice crisis. Realizing Africa's rice promise, 24-34.

Tonsor, G. T., Mintert J., and Schroeder T. C. (2010). U.S. Meat Demand: Household Dynamics and Media Information Impacts. Journal of Agricultural and Resource Economics 35: 1–17.

Train, K. E. (2009). Discrete choice methods with simulation. Cambridge university press.

Unnevehr, L., Eales, J., Jensen, H., Lusk, J., McCluskey, J., & Kinsey, J. (2010). Food and consumer economics. American Journal of Agricultural Economics, 92(2), 506-521.

USDA (United State Department of Agriculture). 2005 International Food Consumption Patterns estimation.

APPENDIX

Table 1: Covariance of Alternative Specific Constants for Random Parameters models by income group and location

| | Pooled | Income Groups | | | Locations | |
		Low Income	Middle Income	High Income	Rural Area	Urban area
HQI, HQD	0.097	1.537*	0.311	3.298.	0.22	1.92 *
	(0.345)	(0.694)	(0.631)	(1.735)	(0.48)	(0.84)
HQI, LQD	0.01	0.464	0.806	3.318.	0.05	1.37 *
	(0.357)	(0.7)	(0.751)	(1.73)	(0.46)	(0.65)
HQI, Yam	1.59***	0.278	0.793	1.751	2.27 ***	2.76 ***
	(0.369)	(0.616)	(0.735)	(1.676)	(0.54)	(0.64)
HQI, CAS	0.825.	0.218	0.265	2.04	1.03 *	1.91 **
	(0.448)	(0.626)	(0.801)	(1.814)	(0.47)	(0.65)
HQI, Corn	0.463	0.313	0.815	2.188	1.44 **	1.62 **
	(0.411)	(0.627)	(0.757)	(1.665)	(0.55)	(0.62)
HQD, LQD	2.205***	1.386	0.902	1.883**	0.4	4.4 ***
	(0.377)	(0.872)	(0.636)	(0.717)	(0.52)	(1.1)
HQD, Yam	1.844***	0.648	0.568	1.993**	0 (0.53)	4.06 ***
	(0.367)	(0.939)	(0.49)	*(0.564)		(1.09)
HQD, CAS	1.283**	0.109	0.402	3.715**	1.1 .	3.35 **
	(0.414)	(0.853)	(0.596)	(1.192)	(0.57)	(1.08)
HQD, Corn	2.849***	1.004	2.018 ***	0.433	1.14 *	5.14 ***
	(0.399)	(0.883)	(0.593)	(0.592)	(0.56)	(1.11)
LQD, Yam	2.125***	1.618***	2.392 ***	0.608	1.66 ***	2.53 ***
	(0.224)	(0.37)	(0.366)	(0.501)	(0.42)	(0.49)
LQD, CAS	2.106***	1.682***(	2.355 ***	1.222.	0.29	2.62 ***
	(0.257)	0.37)	(0.455)	(0.727)	(0.51)	(0.41)
LQD, Corn	1.67***	1.074**	2.78 ***	0.788	1.76 ***	1.86 ***
	(0.187)	(0.361)	(0.333)	(0.507)	(0.38)	(0.38)
Yam, CAS	0.473.	0.695*	0.564	1.776*	0.97 *	0.86 ***
	(0.261)	(0.321)	(0.367)	(0.761)	(0.47)	(0.25)
Yam, Corm	1.854***	2.015***(	1.674 ***	1.159**	1.19 **	1.79 ***
	(0.173)	0.249)	(0.327)	(0.356)	(0.38)	(0.19)
CAS, Corn	0.168	0.311	0.469 .	0.3	1.04 ***	0.14
	(0.207)	(0.229)	(0.28)	(0.409)	(0.25)	(0.17)

Standard errors in parenthesis; '***','**', '*', significance at 1, 5, and 10%.

HQIR: High quality imported rice; HQDR: High quality domestic rice; SQDR: Standard quality domestic rice; CAS: Cassava.

Table 2: Correlation Matrices for Random Parameters Implied by the Variance-Covariance Matrix

Pooled	HQI	HQD	LQD	Yam	CAS	Corn
HQI	1	0.0047	0.0004	0.052	0.0347	0.0144
HQD	0.0047	1	0.294	0.2004	0.1794	0.2937
LQD	0.0004	0.294	1	0.1925	0.2455	0.1435
Yam	0.052	0.2004	0.1925	1	0.0449	0.1298
CAS	0.0347	0.1794	0.2455	0.0449	1	0.0151
Corn	0.0144	0.2937	0.1435	0.1298	0.0151	1
Low income						
HQI	1	0.0559	0.015	0.0067	0.0081	-0.0084
HQD	0.0559	1	-0.3459	-0.1203	0.0313	-0.2067
LQD	0.015	-0.3459	1	0.2678	0.4312	0.1971
Yam	0.0067	-0.1203	0.2678	1	0.1325	0.2751
CAS	0.0081	0.0313	0.4312	0.1325	1	0.0658
Corn	-0.0084	-0.2067	0.1971	0.2751	0.0658	1
Middle income						
HQI	1	0.0247	0.0516	-0.0527	-0.0212	0.0405
HQD	0.0247	1	0.1135	0.0741	-0.0633	0.1969
LQD	0.0516	0.1135	1	0.2514	0.2988	0.2186
Yam	-0.0527	0.0741	0.2514	1	0.0742	0.1511
CAS	-0.0212	-0.0633	0.2988	0.0742	1	-0.0461
Corn	0.0405	0.1969	0.2186	0.1511	-0.0461	1
High income						
HQI	1	0.1713	0.1503	0.1063	0.0741	0.1428
HQD	0.1713	1	0.148	0.21	0.2344	0.0491
LQD	0.1503	0.148	1	0.0558	-0.0672	-0.0778
Yam	0.1063	0.21	0.0558	1	-0.1309	0.1535
CAS	0.0741	0.2344	-0.0672	-0.1309	1	0.0238
Corn	0.1428	0.0491	-0.0778	0.1535	0.0238	1
Rural area						
HQI	1	0.0149	-0.005	0.1199	0.0707	0.0715
HQD	0.0149	1	0.1226	0	0.2325	-0.1741
LQD	-0.005	0.1226	1	0.3965	0.0901	0.3951
Yam	0.1199	0	0.3965	1	-0.1598	0.1416
CAS	0.0707	0.2325	0.0901	-0.1598	1	-0.161
Corn	0.0715	-0.1741	0.3951	0.1416	-0.161	1
Urban area						
HQI	1	0.0415	0.0267	0.0465	0.039	0.0266
HQD	0.0415	1	0.1915	0.1531	0.1531	0.1886
LQD	0.0267	0.1915	1	0.0859	0.1079	0.0615
Yam	0.0465	0.1531	0.0859	1	0.0307	0.0513

Table 2. (Continued).

Urban area	HQI	HQD	LQD	Yam	CAS	Corn
CAS	0.039	0.1531	0.1079	0.0307	1	0.0049
Corn	0.0266	0.1886	0.0615	0.0513	0.0049	1

HQIR: High quality imported rice; HQDR: High quality domestic rice; SQDR: Standard quality domestic rice; CAS: Cassava.

Table 3: Main Effects Orthogonal Design Used in the Choice Experiment Survey (FCFA/kg)

Question	HQIR	HQDR	SQDR	Yam	Cassava	Corn	Block
1	900	300	150	100	75	50	1
2	900	500	350	500	75	200	1
3	900	700	550	300	75	400	1
4	1300	700	350	100	250	50	1
5	1300	300	550	500	250	200	1
6	1300	500	150	300	250	400	1
7	1100	500	550	100	450	50	1
8	1100	700	150	500	450	200	1
9	1100	300	350	300	450	400	1
10	1300	500	550	500	75	50	2
11	1300	700	150	300	75	200	2
12	1300	300	350	100	75	400	2
13	1100	300	150	500	250	50	2
14	1100	500	350	300	250	200	2
15	1100	700	550	100	250	400	2
16	900	700	350	500	450	50	2
17	900	300	550	300	450	200	2
18	900	500	150	100	450	400	2
19	1100	700	350	300	75	50	3
20	1100	300	550	100	75	200	3
21	1100	500	150	500	75	400	3
22	900	500	550	300	250	50	3
23	900	700	150	100	250	200	3
24	900	300	350	500	250	400	3
25	1300	300	150	300	450	50	3
26	1300	500	350	100	450	200	3
27	1300	700	550	500	450	400	3

HQIR: High quality imported rice; HQDR: High quality domestic rice; SQDR: Standard quality domestic rice