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DOMESTIC OR IMPORTED? AN ANALYSIS OF RICE DEMAND IN SENEGAL

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Authors: Ndèye Fatou Faye, Amy Faye, Mouhamed Rassoul Sy, Seungmin Lee, John McPeak

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AUTHORS

Ndèye Fatou Faye

Research Fellow, PhD

Senegalese Institute of Agricultural Research. Route des Hydrocarbures, Dakar, Sénégal

Amy Faye

Post-doctoral Researcher

Center for Development Research (ZEF)

Dept. Economic and Technological Change. University of Bonn

Mouhamed Rassoul Sy

Statistician-Economist, MSc

FAO, ROMA. Teleworking in Dakar

Seungmin Lee

Ph.D. Student in Applied Economics and Management

The Charles H. Dyson School, Cornell University

340D Warren Hall, Cornell University, Ithaca, NY 14853 USA

John McPeak

Professor, Department of Public Administration and International Affairs

333 Eggers Hall, Syracuse University, Syracuse, New York, 13244

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ABSTRACT

Rice is among the most important cereals for African countries which absorb more than half of worldwide exports. West African countries depend particularly on rice imports in order to achieve food security. For this reason, many policy measures are implemented by governments to regulate the market and reduce the import dependency. This paper contributes to the rice policy debate by analyzing the demand side using the case study of Senegal in West Africa. We analyzed detailed data on rice consumption using a large primary survey of 6,328 rural and urban households in Senegal, with the QUAIDS model. Qualitative data were also collected and analyzed to better interpret results. We found that rural households consume far less local rice than their urban counterparts, meaning that location is a determinant of local rice consumption. We also show that types of rice consumed differ between rural and urban consumers. Urban households consume relatively more whole grain local rice while rural households consume more broken imported rice. Thus, to increase consumption of local rice, efforts should thus be made on the availability of broken local rice for both urban and rural consumers. Our results indicate no substitutability between domestic rice and imported rice in urban households and weak substitutability in rural households. In addition, results show that rice demand is price inelastic. Thus, price policies like subsidies or taxes may not be good shifters of domestic rice consumption.

Keywords: rice, consumption, elasticities, urban, rural, QUAIDS

JEL:C01, D12, D40, Q13

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ACRONYMS AND ABBREVIATIONS

AFRE	Department of Agricultural, Food, and Resource Economics
AIDS	Almost Ideal Demand System model
BAME	Bureau d'Analyses Macroeconomiques
EASI	Exact Affine Stone Index
FCFA	Franc de la Communauté Financière Africaine
FSG	Food Security Group
IFPRI	International Food Policy Research Institute
ISRA	Institut Sénégalais de Recherches Agricoles
MSU	Michigan State University
MT	metric tons
PAPA	Projet d'Appui aux Politiques Agricoles
PIGLOG)	Price-Independent Generalized Logarithmic
PNAR	National Program for Rice Self-Sufficiency
PRACAS	Program for Accelerating the growth Rate of Agriculture in Senegal
PRCI	Policy Research, Capacity, and Influence
QUAIDS	Quadratic Almost Ideal System
SDG1	Sustainable Development Goal 1
SDG2	Sustainable Development Goal 2
USAID	United States Agency for International Development

INTRODUCTION

Rice is one of the three major crops cultivated worldwide, along with wheat and corn (OECD-FAO, 2018). In many developing countries, rice plays a determining role in achieving food security and political stability. Global consumption in 2018 was estimated at more than 414 million metric tons (MT) of milled rice (GIZ, 2018). In Sub-Saharan Africa, rice is the main staple food in many countries, both in urban and rural areas. Indeed, global rice exports in 2018 were estimated at 34.234 million metric tons with about 10.772 million tons (i.e., 31.46%) destined for Africa. In 2017, 56% of all rice imports in Africa were from West African countries (Arumugan et al., 2020) which depend for over 40% of their rice supplies on imports, mainly from Asia (Thailand, Vietnam and India) (CSEA-CIRES-IPAR, 2015).

Nigeria and Côte d'Ivoire remain the top import-dependent countries of milled-rice in the region between 2014 and 2019 (FAOSTAT, 2021). Like their neighbors, countries such as Senegal are also net importers of milled rice. Imports were valued at FCFA 210 billion (318 million dollars) in 2019 (ANSD, 2019). This dependency not only increases the budget allocated to rice in these countries but also exposes them to world market shocks as was the case during the surge in international rice prices in the 2007–08 food crisis. Also, during the Covid19 pandemic, rice-exporting countries such as Vietnam, Myanmar, India and Philippines have placed restrictions on rice exports (USDA-FAS, 2020). Such shocks can increase domestic prices in importing countries and compromise food security and poverty which are the main targets of SDG2 and SDG1. The 2007–08 food crisis affected West African countries, particularly vulnerable households in urban areas (Mendez del Villar et al. 2011).

To reduce this dependency supply side measures to boost production via fertilizer subsidies, improved seeds, investing in large-scale irrigation have been implemented with the state objective to attain national self-sufficiency in rice. These supply focus policies implicitly assume that consumers will readily substitute imported for domestic rice (Demont et al., 2017) which has been shown not to be the case in urban areas. For instance, in Senegal, the majority of urban consumers are willing to pay quality premiums for local rice showing the importance of investments in post-harvest rice quality (Demont et al, 2013). As a response, supply-side policies were coupled with trade measures and efforts to increase local rice competitiveness by improving its quality through the introduction of new rice varieties and interventions on the processing segment, although still insufficient. Indeed, in West Africa, upgrading involves milling technologies, contract farming and vertical integration which are still a challenge (Soullier et al, 2020).

This paper contributes to the rice policy debate by analyzing the demand side using the case study of Senegal in West Africa where supply and demand policies are equally important in the quest for reducing import dependency.

In Africa, two main complementary strands of literature exist in the analysis of demand. The first and more investigated strand mainly focuses on consumers' preferences using standard regression analysis based on survey data to investigate the determinants of consumers' stated preferences (Sedem Ehiakpor et al., 2017 in West Africa) or experimental auctions to analyze revealed preferences (Demont et al, 2017 in West Africa; Etoa et al., 2016 in Central Africa; Demont and Ndour, 2015 in West, Central and East to Southern-East Africa; Demont et al., 2013 in West Africa). This strand assumes that supply-side measures only are not sufficient as the import dependency has led to a preference for imported rice over African rice for urban consumers (Demont et al., 2017). In general, this strand of literature mainly helps to analyze the non-price competitiveness of local rice and found results showing that demand is sensitive to local rice quality improvements (Diagne et al., 2017; Sedem Ehiakpor et al., 2017; Demont and Ndour, 2015; Demont et al., 2013) and interventions should pay key attention to the location of the end-market that plays a key role in depicting what type of policy should prevail. On one hand, Proximity of the end-market to the port calls for investments that aim at lifting demand of domestic rice through quality improvement, branding, and promotion to make it more competitive against imported rice. On the other hand, closeness to centers of cultural heritage, endows rice value chains with a "comparative advantage in demand," requiring less investment in demand-lifting and leaving more room for supply-shifting investments (Demont et al., 2017).

Another, less studied strand mainly looks at the demand system at the household level and gives more insights on the price-competitiveness of local rice. The importance of this second strand lies first in its ability to quantify the degree of substitutability between different types of rice but also between rice and other important cereals in the West African context. Second, it also helps to analyze how different income levels interact with rice expenditures. Finally, welfare effects of pricing policies can be assessed using this type of analysis. This strand of literature has mainly been applied to countries such as Nigeria (Ojogho and Erhabor, 2011; Akinbode, 2015; Onyeneke et al., 2020). However, these studies mainly used a Linear Approximate Almost Ideal Demand System (Ojogho and Erhabor, 2011; Akinbode, 2015) while linear systems implicitly assume linear Engel curves which constitutes a strong assumption in the case of rice. In addition, many of the did not target rice specifically (Akinbode, 2015).

Therefore, this second strand has been hardly investigated in the literature on rice demand in West Africa, despite being useful for the design of rice policies in the region. Also, most of the studies covering West Africa mainly targeted urban areas (Demont et al., 2013; Demont et al, 2017, Demont and Ndour, 2015; Diagne et al., 2017) while preferences for rice may vary between countries but also within countries between rural and urban areas (Diagne et al, 2017). Consequently, there is scant disaggregate analysis of demand between urban and rural households in the region. Finally, in the specific case of Senegal, demand analyses have mainly looked at the preferences and not sufficiently at the quantification of the degree of substitutability between imported and local rice and how income enters into the equation.

This paper tries to fill these gaps by analyzing how rice expenditures are affected by prices, income and household location by disaggregating the analysis between urban and rural households. To that end, we estimate a demand system using the Quadratic Almost Ideal Demand System.

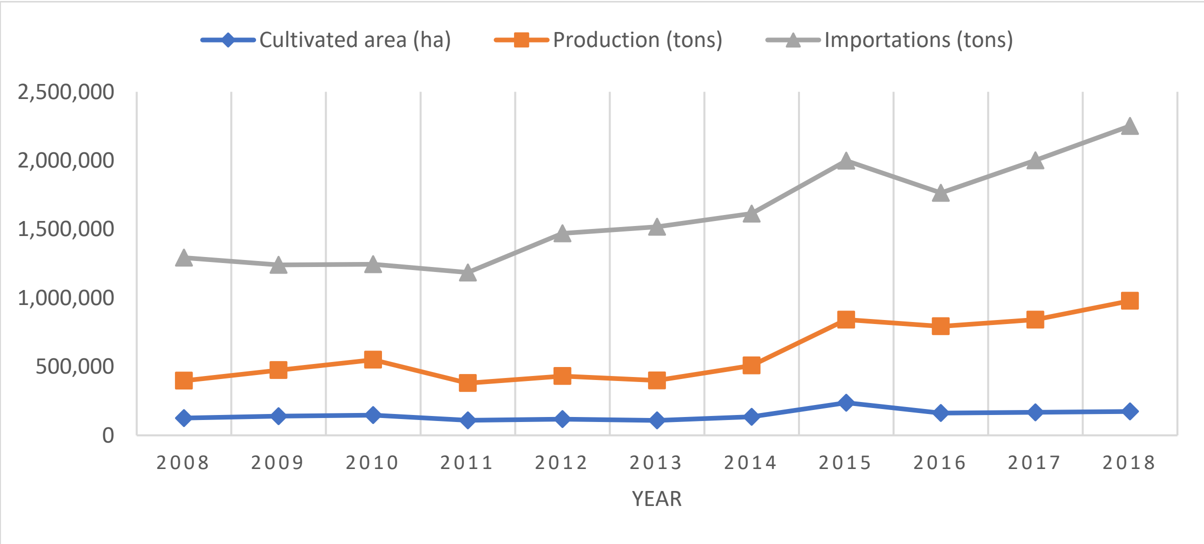
RICE IN SENEGAL

Rice is the most consumed cereal in Senegal, surpassing the consumption of more traditional crops such as sorghum and millet, in both urban and rural areas (Colen et al., 2013; IPAR, 2018). The share of rice in total cereals consumption is estimated at 77% in urban areas and 59% in rural areas (IPAR, 2018). According to Colen et al. (2013), the importance of rice consumption started with the large and cheap imports of broken rice from Asia, during the French colonial era. In addition, the low processing and cooking costs of rice as well as the tendency of consuming out of home increased the preference for rice in urban areas (Reardon, 1993). Because of urbanization and population growth, rice demand is still increasing.

In Senegal, the main feature of rice demand is the strong preference for broken rice, particularly broken imported (Gergely and Baris, 2009; Fall,2015). This preference for broken rice (which is considered an inferior product on the international market) is much more pronounced in urban than in rural areas (Colen et al, 2013). It is widely perceived as better suited to the preparation of the so-called national dish "ceebu jën" (rice and fish) (Fall, 2015). Concerning local rice, in recent years, Senegalese consumers, particularly urban dwellers, have become demanding about quality (Demont and Ndour, 2015; Diagne et al., 2017), while remaining attentive to the price/quality ratio. However, this depends on the market segments considered (Colen et al, 2013; Fall, 2015) : (1) the market in Saint Louis and the Senegal River Valley, which is already used to consuming local rice, largely grown on irrigated fields; (2) the urban market outside the River Valley (and particularly the Dakar market), which is more demanding in terms of quality and may or may not be familiar with local rice; (3) the rural market outside the River Valley, which is unfamiliar with local rice but less demanding in terms of quality, and particularly grain homogeneity. To satisfy this demand for quality, significant progress has been made in processing, with village mills and huskers being largely equipped for cleaning and de-stoning paddy. As a result, local rice consumption is increasing despite strong competition from imported rice (IPAR, 2018).

However, given the large demand, rice consumption still exceeds domestic production and Senegal relies heavily on imports. India, Thailand, and Brazil are the largest suppliers of rice to the Senegalese market (USDA-FAS, 2019). To satisfy this demand and reduce imports, The National Program for Rice Self-Sufficiency (PNAR) was implemented in 2008. It organizes and plans Senegal's way towards self-sufficiency in rice with a production target of 1.5 million tons of paddy rice, equivalent to 1 million tons of white rice. Several measures were implemented to reach this goal such as input subsidies (seeds and fertilizer), development of arable rice fields and support to producers of rainfed rice which is intended to be one of the drivers of the increase in production, following the adoption of high yield varieties. In 2014, the Program for Accelerating the growth Rate of Agriculture in Senegal (PRACAS) was implemented and had the target of rice self-sufficiency. These policies may have some positive effects because, as shown in figure 1, there has been a sharp increase in production since 2008. The Senegal River Valley is the main supplier in the market of local rice, accounting for around 70% of national production (Fall, 2015). Stagnation in imported quantities have also been noticed in the period 2008-2011, at the end of which, they started to increase.

Figure 1. Evolution of rice area harvested, production and imports



Source: Authors' calculations based on FAOSTAT data

DATA TYPES AND SAMPLING METHODS

This study relies on quantitative and qualitative data. The quantitative data was collected under the Agricultural Policy Support Project (2015-2019), led by the Senegalese Ministry of Agriculture. The sample has a total of 6,328 households from two different surveys (urban and rural). The urban survey was conducted in 2017 and the dataset is composed of 2,014 households located in 19 major Senegalese cities (Dakar, Pikine, Rufisque, Guediawaye, Touba, Mbour and the 13 regional capitals). Rural data, collected in 2018, cover 4,314 rural households located in areas where agriculture is mostly rainfed. For both surveys, a nation-wide stratified two-stage random sampling was used. Primary units were Enumeration Areas (EAs) and secondary units were the households drawn from the EAs of the first stage.

Urban dataset is nationally representative and rural dataset is representative of three of the five agroecological zones in Senegal. The agroecological zones which are not present in the rural sample are the areas of irrigated agriculture composed of: i. the Niayes, covering the coastal area from Dakar to St-Louis, which is the main production area of horticulture crops and ii. the Senegal River Valley which is the main rice production area and the second zone of horticultural production. The consequence of the absence of these agroecological zones is that consumption of own produced rice, fruits and vegetables may be underestimated in our data.

The questionnaires contained detailed information about household sociodemographic characteristics (size, age and sex of household head, education level of household head, cultivated area, presence of a person with a chronic disease in the household, etc.), food and non-food expenditures, food consumption in quantities and perceptions on food quality. The household head and at least one woman in the household were interviewed because women know more about food expenditures. They were asked to recall food consumption and expenditures in the past month, including both food consumed away from home and food consumed at home that came from purchases, own-production, and in-kind payments or gifts.

Household food expenditures were computed as the sum of expenditures over all food items. The latter are classified in 8 categories which are local rice, imported rice, other cereals, legumes, fruits and vegetables, meat-fish and poultry, dairy products and other foods. Categories were defined according to nutritional status of food groups, preceding studies (Liverpool-Tasie et al., 2020; Dolislager, 2017) and the minimization of observations with zero expenditures. Unit prices were constructed dividing total expenditures by purchased quantities. Then for each cluster, price indices for each food group were computed as a weighted average of prices of the items constituting the group (stone price index). The formula is as follows:

$$p_{ic} = \sum_{t=1}^{k_i} w_{it} \frac{p_{itc}}{\bar{p}_{it}}$$

where p_{itc} is the price of product t in group i in each geographical cluster c (commune, department or region); $\bar{p}_{it}$ is the sample median of p_{it} across clusters; $w_{it}$is the budget share of product t in group i; k_i is the number of items in group i.

Given that location implies differences in preferences (Demont et al, 2017), we account for spatial variability by grouping urban households into geographic strata. We have three strata based on the population size and/or location of the towns. They are: (i) Greater Dakar (towns of Dakar, Pikine, Guediawaye, Rufisque); (ii) Valley (Saint-Louis and Matam); (iii) Secondary towns (Thies, Mbour, Touba) and (iii) Other towns. For rural areas, households were grouped into peri-urban, intermediate and hinterland depending on their distance to the nearest town. Specifically, we used GPS information, available in the dataset, to calculate the distance of each household from the center point of the nearest main town. For each household, the nearest main town is that of the closest "arrondissement"[1]independently of whether or not the household belongs to that "arrondissement". Using the calculated distances, we grouped households into terciles. The first tercile with an average of 4.7km is categorized as peri-urban and is composed of households that are located to a distance between 0.3km and 8.5km to the nearest town. The second tercile, with an average of 11.7km is categorized as intermediate and is composed of households that are located to a distance between 8.6 and 15km to the nearest town. The second tercile, with an average of 24.5km is categorized as hinterland and is composed of households that are located to a distance between 15.1 and 80.1km to the nearest town. Table 1 shows the number of observations per geographic strata for the whole dataset.

Table 1. Number of observations, by geographic strata:

Strata	Number of observations	Proportion (%)
Greater Dakar	757	12.0
Valley	160	2.5
Secondary towns	262	4.1
Other towns	835	13.2
Periurban	1,443	22.8
Intermediate	1,435	22.7
Hinterland	1,436	22.7
Total	6328	100

Source: PAPA surveys, 2017 and 2018

Descriptive statistics related to food groups, disaggregated by rural and urban strata, are presented in table A1 in the appendix.

In addition to the quantitative data, a focus group was conducted to better understand and explain the quantitative results. It was done on the 9th of November 2021, with six participants with various backgrounds, including researchers, agents from development projects and from government bodies, and wholesalers. Discussions were around rice consumption patterns in Senegal, imports regulations and the effectiveness of price related policies.

[1] In Senegal, the word "arrondissement" refers to an administrative subdivision of a department. The latter is an administrative subdivision of a region. The country is composed of 14 regions, subdivided into 45 departments, themselves subdivided into 133 "arrondissements".

ECONOMETRIC APPROACH

To compute price and income elasticities, we estimate a food demand system, focusing on two types of rice (local and imported), and other food groups.

In the literature, many models have been used to analyze the demand structure. Apart from the original linear expenditure system, studies have mainly used the Rotterdam model, the translog model (Song et al., 2013), the Almost Ideal Demand System model (AIDS) (Deaton and Muellbauer, 1980), and its extended Quadratic Almost Ideal System (QUAIDS) (Banks et al., 1997; Poi, 2002, 2008) and the Exact Affine Stone Index (EASI) model. The AIDS model is part of the Price-Independent Generalized Logarithmic (PIGLOG) class of demand models and has budget shares that are linear functions of log total expenditure. Banks et al. (1997), however, show that using AIDS can be misleading if there is nonlinearity in the budget share equations and thus developed QUAIDS, which has quadratic budget shares that are in log of total expenditure. In this paper, we will apply the QUAIDS model.

Following Banks et al. (1997), QUAIDS has indirect utility functions (V) of the form

$$ln\, V = \left\{\left[\frac{ln\, m - ln\, a(p)}{b\,(p)}\right]^{-1} + \lambda\,(p)\right\}^{-1},$$

where *m* represents total food expenditure and *p* a vector of food prices. The term in squared brackets is the indirect utility function of a demand system of the PIGLOG preference class. The functions ln a(p) and b(p) are, respectively, the translog and the Cobb-Douglas price aggregator functions. They are defined by:

$$\ln a(p) = \alpha_0 + \textstyle\sum_{i=1}^{n} \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln p_j, \tag{1}$$

$$b(p) = \prod_{i=1}^{n} p_i{}^{\beta_i}$$

The price aggregator function $\lambda(p)$ is given by:

$$\lambda(p) = \textstyle\sum_{i=1}^{n} \lambda_i \ln p_i$$

where $\sum_i \lambda_i = 0$.

If we apply Roy's identity to equation (X), food budget shares for each food group can be expressed as:

$$w_i = \alpha_i + \textstyle\sum_{j=1}^{n} \gamma_{ij}\, ln\, p_j + \beta_i\, ln\left[\frac{m}{a(p)}\right] + \frac{\lambda_i}{b(p)} \left\{ln\left[\frac{m}{a(p)}\right]\right\}^2. \tag{2}$$

Differentiating the food budget share equations with respect to expenditure *(m)* and price *(p)* gives the following expenditure and price elasticities, respectively:

$$\mu_i \equiv \frac{\partial w_i}{\partial\, ln\, m} = \beta_i + \frac{2\lambda_i}{b(p)} \left\{ln\left[\frac{m}{a(p)}\right]\right\}.$$

$$\mu_{ij} \equiv \frac{\partial w_i}{\partial\, ln\, p_j} = \gamma_{ij} - \mu_i \left(\alpha_i + \sum_k \gamma_{jk}\, lnP_k\right) - \frac{\lambda_i \beta_j}{b(p)} \left\{ln\left[\frac{m}{a(p)}\right]\right\}^2$$

In terms of μ_i, expenditure elasticities are given by

$e_i = 1 + \frac{\mu_i}{w_i}$.

Similarly, the Marshallian or uncompensated price elasticities of demand can be expressed as

$$e_{ij}^{u} = \frac{\mu_{ij}}{w_i} - \delta_{ij}, \tag{3}$$

where δ_{ij} is the Kronecker delta taking the value of 1 if $i=j$ and 0 otherwise. Using the Slutsky equation, the Hicksian, or compensated price elasticities are given by

$$e_{ij}^{c} = e_{ij}^{u} - w_j e_i, \tag{4}$$

Theoretical restrictions of adding up, homogeneity, and Slutsky symmetry are imposed by setting

$$\sum_i \alpha_i = 0, \sum_i \beta_i = 0, \sum_i \gamma_{ij} = 0, \sum_j \gamma_{ij} = 0, \sum_i \lambda_i = 0, \gamma_{ij} = \gamma_{ji}. \tag{5}$$

We estimated the system of nonlinear budget share equations specified in equation (2) using Stata command "aidsills" by Lecocq and Rubin (2015).

Dealing with missing data on prices and quantities

Missing prices

Because missing data on prices can introduce a substantial amount of bias, we have applied mean imputations for each missing stone price index while applying the approach of the nearest neighbor. In fact, if subject to consumption within the smallest administrative region (i.e., Village or District), we replace the missing price by the average price in the village. Otherwise, we go up an administrative level and apply the mean of the communes, then regions and the national sample.

Zero expenditures

In the literature zero expenditures have been reported as being caused by two phenomena: no consumption and infrequency of purchase (Beatty, 2006; Hasegawa et al., 2008). No consumption is observed when consumers prefer not to purchase or consume a given commodity. This is typically a corner solution to the utility maximization problem. Regarding the infrequency of purchase, it happens when a commodity is actually consumed but purchases have not been recorded although they happen. In the PAPA datasets, these reasons lead to some households reporting zero purchase or consumption. Thus, missing consumption was imputed using predicted values of a linear regression. Dependent variables are consumption shares to impute and regressors are socioeconomic characteristics, prices and income, the latter being operationally measured by with total expenditures.

DESCRIPTIVE RESULTS

Rice consumption and expenditures patterns

Table 2 shows the per capita consumption of rice. An average Senegalese consumes 88 kg of rice per year. Of the 88 kg per capita, 41 kg (46.6%) are produced locally while the rest, representing a little more than half, comes from imports. The locally sourced share of this consumption is evenly split between broken and whole rice, while imported rice is mostly broken.

Per capita rice consumption is higher among urban dwellers. This is understandable given the fact that there are other staple cereals in rural areas such as millet, maize and, to a lesser extent, sorghum. In addition, the systematic integration of rice into the dietary habits of rural people is a recent and evolving phenomenon, except for traditional production areas such as Casamance, Anambé or the Senegal River Valley.

Local rice consumption is higher in urban areas. This could be related to lack of supply in rural areas except where rice is cultivated. Overall, urban households seem to prefer broken rice to whole rice since the former is more consumed. Broken down into local-imported, whole rice dominates in local rice consumption, while broken rice dominates in imported rice consumption.

Table 2. Per capita annual consumption (kg) of different rice types, by urban and rural households

Rice consumption per capita by rural and urban	National	Urban	Rural
Rice	88	91	83
Imported rice	47	41	57
Broken	30	25	39
Whole grain	17	17	18
Local rice	41	49	27
Broken	20	23	13
Whole grain	21	26	13

Source: Authors' calculations based on PAPA surveys, 2017 and 2018

The share of rice in cereal consumption is 53% in the country according to Table 3. It was 50% in 2009 (AFD, 2009) and 34% between 1991 and 1993 (Kite, 1991; Kelly al., 1993). These results confirm the growing importance of rice in the food habits of Senegalese consumers, hence its strategic importance. This trend is even more rapid among rural households. Indeed, Kelly et al. (1993) indicated that the share of rice in cereal consumption was 54% for urban and 24% for rural people, whereas it is currently 64% and 40% respectively, showing an increase of 10 percent for urban households and 16 percent for rural households.

Table 3. Shares of cereals and different rice types in total consumption (ratio of quantities)

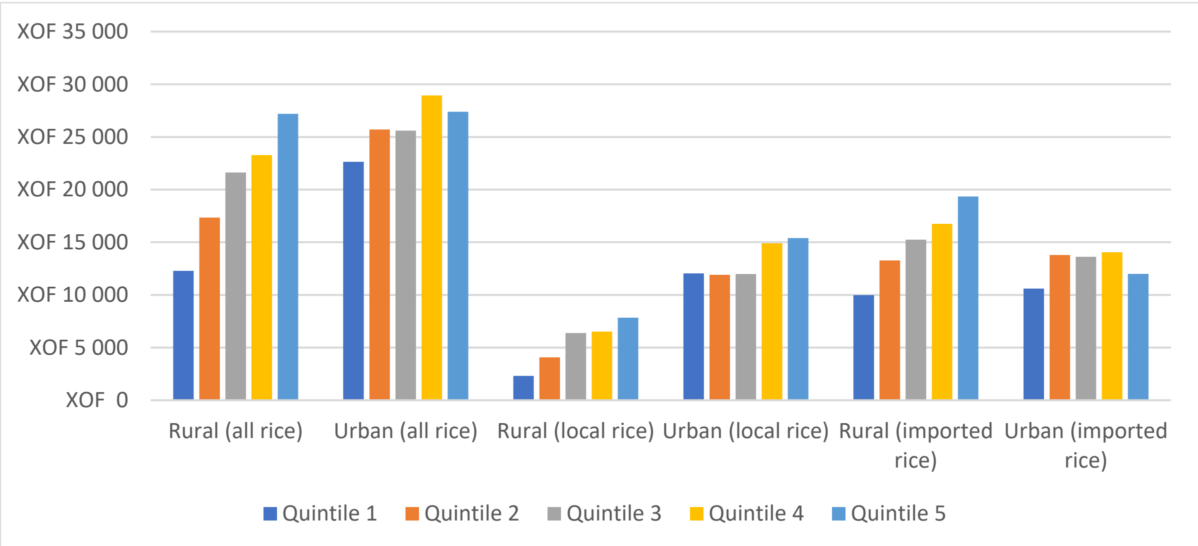
Variable	Urban	Rural	National
Cereals/Food	**44%**	**60%**	**50%**
Rice/Cereals	**64%**	**40%**	**53%**
Imported rice/Total Rice	46%	68%	53%
Broken rice/Total Rice	53%	63%	56%
Broken local/Local	48%	51%	48%
Broken imported/Imported	60%	68%	64%

Source: Authors' calculations based on PAPA surveys, 2017 and 2018

In Senegal, rice expenditures per annum are evaluated at 24,302,FCFA (around $44) per capita and per year, at national level (figure 2). This figure is higher for urban households where it amounts to 26,263 FCFA. At national level, per capita expenditures in imported rice represent 56% of total rice expenditures. For urban households, the share goes down to 49% while for rural household, imported rice accounts for 73% in total per capita rice expenditures. The difference is quite big and suggest that in rural areas rice expenditures are mainly driven by imported rice. One explanation may be the fact that local rice consumed in rural areas could be of lower quality and thus cost less than imported rice. The supply of good quality local rice is mainly destined to urban areas where consumers are more demanding in terms of homogeneity and cleanness (Fall, 2015).

Data in figure 2 show also that, for both urban and rural households, per capita rice expenditures increase as we move from income quintile 1 to income quintile 5. However, this positive income effect is not as clear when we break down expenditures into local and imported rice. For example, for urban households, per capita expenditures in imported rice are lower for quintile 1 and quintile 5. Regarding local rice, richer households seem to spend more on it.

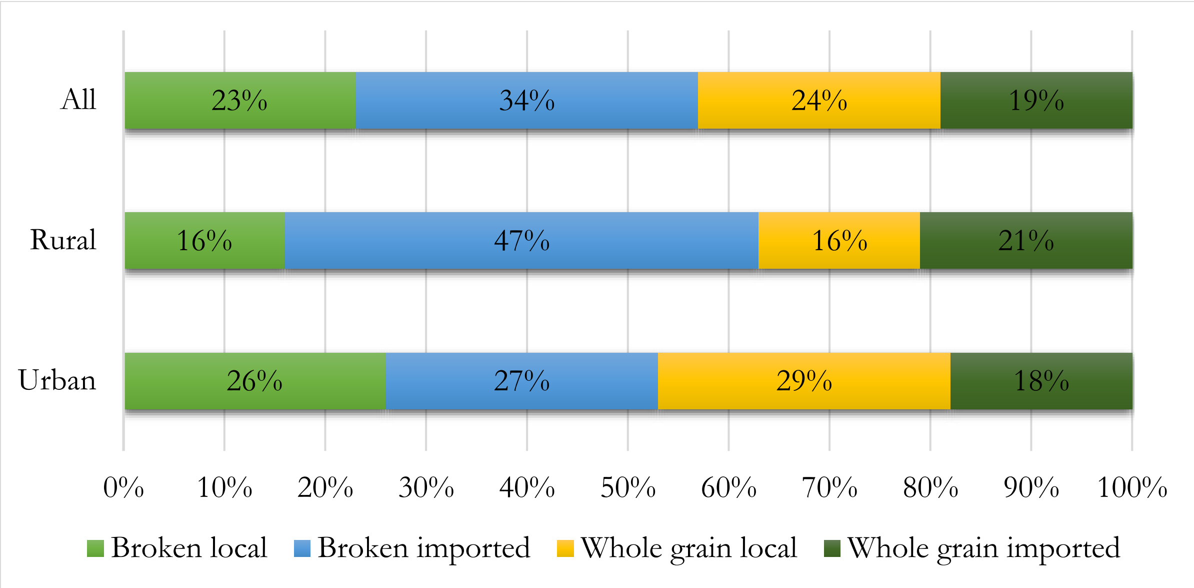
Figure 2. Per capita annual expenditures of rice, by income and geographic groups



Source: Authors' calculations based on PAPA surveys, 2017 and 2018
Note: 1 CFA equals around $0.002

Senegalese households spend relatively more in broken imported rice than any other rice type (figure 3). It accounts for 34% of total rice expenditures. However, results are different for urban and rural households. For urban consumers, whole grain local rice has the highest share in total rice expenditures while for rural households, it is the broken imported rice that has the highest share. This suggests opposite patterns in rice expenditures between rural and urban households. For the former, lack of good quality local rice supply and change in diets (less consumption of traditional cereals like millet, sorghum and maize) may explain higher expenditures in broken imported rice. For the latter, improvements in local rice quality (branding, grain homogenization, taste, cooking time, etc.) and the sake of nutritional benefits may justify the highest share of whole grain local rice in total rice expenditures.

Figure 3. Share of different rice types in total rice expenditures, by geographic group



Source: Authors calculations based on PAPA surveys, 2017 and 2018

Descriptive statistics on expenditure shares and prices

Table 4 shows descriptive statistics on food expenditures shares and prices which will enter the demand system, in addition to household demographic characteristics presented in table 5. First, rural households spend relatively more on cereals and rice (local+imported) which have the same food expenditures shares. Second, in urban areas, the highest budget share goes to fruits and vegetables (27%) and animal-sourced proteins such as fish, meat, and poultry (25%) while rice represents 15% of food expenditures. Considering that, on average, urban households in our sample have higher incomes, this result can be related to Benett's law which states that: "*as people become wealthier, they switch from simple starchy plant-dominated diets to a more varied food input that includes a range of vegetables, fruit, dairy products, and especially meat.*" (Charles and Godfray, 2011). The results on rice consumption confirm findings in preceding studies, according to which, consumption of rice was not limited to urban areas and the trend was observed for the middle class as well as for the poor (Kelly et al., 1996; Reardon et al., 2020). Finally, table 4 also shows that all expenditure shares and prices are significantly different between rural and urban areas, except the price of dairy products and other foods (null hypothesis is rural=urban).

Table 4. Descriptive statistics of model variables (discriminated by urban vs rural)

		Rural		Urban		T-test
Variables	**Description**	**Mean**	**Std**	**Mean**	**Std**	
Local_rice	Expenditure share of local rice	0.05	0.09	0.08	0.10	***
Imported_rice	Expenditure share of imported rice	0.13	0.12	0.07	0.09	***
Cereals	Expenditure share of other cereals	0.18	0.12	0.09	0.10	***
Legumes	Expenditure share of legumes	0.11	0.09	0.05	0.05	***
Fruits_Veg	Expenditure share of fruits and vegetables	0.17	0.09	0.27	0.09	***
Meat_Fish Poultry	Expenditure share of meat/fish/poultry	0.16	0.12	0.25	0.12	***
Dairy	Expenditure share of diary products	0.03	0.04	0.05	0.05	***
Other_foods	Expenditure share of other foods	0.16	0.09	0.15	0.08	***
Price1	Stone price of local rice	0.14	0.08	0.13	0.11	***
Price2	Stone price of imported rice	0.18	0.13	0.13	0.12	***
Price3	Stone price of other cereals	0.20	0.14	0.09	0.11	***
Price4	Stone price of legumes	0.12	0.12	0.05	0.05	***
Price5	Stone price fruits and vegetables	0.14	0.09	0.22	0.13	***
Price6	Stone price of meat/fish/poultry	0.09	0.07	0.15	0.14	***
Price7	Stone price of diary products	0.04	0.04	0.04	0.04	
Price8	Stone price of other goods	0.16	0.09	0.16	0.08	
Observations		**4,314**		**2,014**		

*** p<0.01, ** p<0.05, * p<0.1

Source: Authors' computations based on data from the PAPA survey, Senegal (2017-2018)

Table 5 presents descriptive statistics of the socio-demographic variables included in the QUAIDS model. In the sample, households are more frequently headed by men, but this pattern is higher in rural areas (93 percent of households) compared to urban areas (77 percent of households). Household size is slightly higher in rural areas than urban areas which can be explained by higher fecundity rates in rural areas. The percentage of rural household heads not educated is higher compared to urban ones which was expected given the higher presence of educational infrastructures in urban areas

Table 5. Descriptive statistics of model variables (discriminated by urban vs rural) continued

Variables	Description	Rural		Urban		Ttest
		Mean	Std. Dev.	Mean	Std. Dev.	
Head male	=1 if household head is male	0.93	0.25	0.76	0.42	***
Size	Household's size	10.04	5.42	9.15	4.69	***
Age	Age of household Head	53.35	13.41	57.64	16.52	***
No_school	=1 if household head has never been at formal school (reference variable for schooling))	0.63	0.48	0.41	0.49	***
High_school	=1 if household head has high school level	0.14	0.34	0.25	0.43	***
Elementary	=1 if household head has elementary school level or lower	0.13	0.33	0.23	0.42	***
University	=1 if household head has university level	0.10	0.31	0.09	0.29	
Other_school_level	=1 if household head has other school level	0.00	0.06	0.01	0.12	***
Women	Number of women in the household	4.80	3.15	4.79	2.80	
Children	Number of children in the household	3.93	3.21	2.90	2.55	***
Married	=1 if household head is married	0.93	0.26	0.80	0.40	***
Refrigerator	Number of refrigerators			0.51	0.65	
Car	Number of cars			0.11	0.40	
TV	Number of TVs			1.49	1.23	
Greater Dakar	=1 if household lives in Greater Dakar			0.37	0.48	
Secondary Towns	=1 if urban household lives in secondary towns			0.13	0.34	
Other Towns	=1 if urban household lives in other towns			0.41	0.49	
Valley	=1 if urban household lives in Senegal River Valley (regions of Matam and Saint-Louis) (reference variable for urban location)			0.08	0.27	
Periurban	=1 if rural household lives in periurban zone (reference variable for rural location)	0.33	0.47			
Intermediate	=1 if rural household lives in intermediate zone	0.33	0.47			
Hinterland	=1 if rural household lives in hinterland zone	0.33	0.47			
Observations		**4,314**		**2,014**		

*** p<0.001, ** p<0.01, * p<0.05. Source: Authors' computations based on data from the PAPA survey, Senegal (2017-2018).

REGRESSION RESULTS

The QUAIDS estimation results for rural and urban households are presented in table A2 in the appendix. Here, we analyze elasticities which are presented in tables 8 and 9 for urban and rural households.

Expenditure elasticities

The expenditure elasticities are all significantly positive, indicating that none of the food groups are inferior goods and that as income rises, the demand rises for all the food groups. For urban households, local rice has the smallest expenditure elasticity (0.65).

In general, animal-sourced foods (meat, fish, and poultry), and dairy products can be unequivocally categorized as superior goods as their demand increase by more than one percent when households' income increases by one percent.

For urban households, local rice can be categorized as a normal good as the increase in demand is far less than one percent while imported rice is closer to being a superior good since the demand increases by more than one percent when the income increases by one percent. For rural households, both products can be categorized as normal goods, although the increase in demand is only slightly less than one percent.

Overall expenditures elasticities are higher for rural households indicating that a marginal increase in income leads to a higher increase in demand for these households compared to urban households. This result is quite expected given the higher poverty level in rural areas. In addition, as expected per Bennett's Law, the share of staple food in total food consumption decreases with total expenditure (as a proxy for income)

Own price elasticities

All estimated Marshallian own-prices elasticities are significant and negative suggesting that food items in both urban and rural areas are non-Giffen goods. The only exception is local rice which demand increases with price for rural households. This result may be explained by the fact that local rice sold in rural areas is often of low quality. Therefore, a price increase may reflect improvements in quality which will increase demand. Overall, rural households seem to be more responsive to price changes than their urban counterparts.

For urban households, cereals and legumes are the most inelastic (more inelastic than rice) while their budget shares are the lowest. It might be because households consume small but fixed amounts of cereals/legumes which implies that they are relatively insensitive to the price changes. For rural households, cereals are the most elastic and this relates to the higher share of this category in total food consumption.

Cross price elasticities

The cross-price elasticities are generally smaller in absolute terms compared to the own-price elasticities, suggesting that food is more responsive to own-price changes than prices of substitutes or complements.

Statistically significant compensated cross-price elasticities indicate net substitutability or complementarity between food groups. Results show that all (compensated) cross-price elasticities are negative with a small magnitude, indicating that food groups are not close substitutes for one another. For urban households, imported rice is not found to be a substitute of domestic rice. Lazaro (2016) found the same result for Tanzanian households. However, both local and imported rice are found to be substitutes of meat/fish/poultry. The substitutability is higher for imported rice. Specifically, a 1% increase in the price of imported rice is estimated to increase demand for meat/fish/poultry by 0.17 %. Local rice is found to be a weak complement of fruits and vegetables while imported rice is a weak substitute of this category.

For rural households, local and imported rice are weak complements. Typically, a 1% increase in the price of local rice is estimated to decrease demand for imported rice by 0.1%. On the other hand, a 1% increase in the price of imported rice involves a 0.23% decrease in the demand for local rice. Imported rice is found to be a substitute for all food categories, except cereals. Local rice is a substitute for meat/fish/poultry even if the absolute value of the elasticity is quite low.

Table 6. Expenditure elasticities for rural and urban households

Food groups	Urban	Rural
Local rice	0.648***	0.998***
	(0.046)	(0.039)
Imported rice	1.022***	0.939***
	(0.047)	(0.017)
Cereals	0.918***	0.930***
	(0.028)	(0.010)
Legumes	1.032***	1.013***
	(0.029)	(0.012)
Fruits and Vegetables	0.932***	0.970***
	(0.009)	(0.008)
Meat/Fish/Poultry	1.225***	1.280***
	(0.013)	(0.012)
Dairy	1.305***	1.082***
	(0.031)	(0.026)
Other_foods	0.834***	0.837***
	(0.012)	(0.008)

Standard errors in parentheses
*** $p<0.001$, ** $p<0.01$, * $p<0.05$

Table 7. Compensated price elasticities (urban)

Food groups	Local rice	Imported rice	Cereals	Legumes	Fruits and Vegetables	Meat/Fish/Poultry	Dairy	Other_foods
Local rice	-0.085*	-0.062	0.038	-0.001	-0.057	0.130***	0.016	0.020
	(0.042)	(0.039)	(0.022)	(0.029)	(0.042)	(0.029)	(0.028)	(0.037)
Imported rice	-0.072	-0.091	-0.007	-0.035	0.076	0.173***	-0.041	-0.003
	(0.041)	(0.047)	(0.024)	(0.031)	(0.046)	(0.032)	(0.031)	(0.040)
Cereals	0.034	-0.006	-0.178***	0.013	0.061*	0.061**	0.036*	-0.021
	(0.025)	(0.025)	(0.018)	(0.019)	(0.027)	(0.019)	(0.018)	(0.024)
Legumes	-0.002	-0.049	0.024	-0.122***	0.083**	0.131***	-0.019	-0.045
	(0.025)	(0.026)	(0.015)	(0.023)	(0.028)	(0.020)	(0.019)	(0.025)
Fruits and Vegetables	-0.017*	0.019*	0.020***	0.015*	-0.267***	0.155***	0.041***	0.033***
	(0.008)	(0.009)	(0.005)	(0.006)	(0.009)	(0.006)	(0.006)	(0.008)
Meat/Fish/Poultry	0.039***	0.045***	0.020**	0.024**	0.160***	-0.406***	0.041***	0.077***
	(0.012)	(0.012)	(0.007)	(0.009)	(0.013)	(0.009)	(0.009)	(0.011)
Dairy	0.024	-0.052	0.060***	-0.018	0.209***	0.203***	-0.504***	0.076**
	(0.028)	(0.029)	(0.016)	(0.021)	(0.031)	(0.022)	(0.021)	(0.027)
Other_foods	0.011	-0.001	-0.012*	-0.014	0.060***	0.133***	0.027***	-0.202***
	(0.010)	(0.011)	(0.006)	(0.008)	(0.012)	(0.008)	(0.008)	(0.010)

Standard errors in parentheses
*** $p<0.001$, ** $p<0.01$, * $p<0.05$

Table 8. Compensated price elasticities (rural)

Food groups	Local rice	Imported rice	Cereals	Legumes	Fruits and Vegetables	Meat/Fish/Poultry	Dairy	Other_foods
Local rice	0.178***	-0.237***	0.019	0.007	-0.036	0.137***	-0.007	-0.062
	(0.045)	(0.034)	(0.026)	(0.024)	(0.032)	(0.031)	(0.027)	(0.039)
Imported rice	-0.098***	-0.028	0.020	0.037***	0.035*	0.085***	-0.026*	-0.026
	(0.016)	(0.017)	(0.012)	(0.011)	(0.014)	(0.014)	(0.012)	(0.018)
Cereals	0.006	0.015	-0.244***	0.040***	0.070***	0.065***	0.003	0.046***
	(0.009)	(0.009)	(0.007)	(0.006)	(0.008)	(0.008)	(0.007)	(0.010)
Legumes	0.003	0.045***	0.066***	-0.244***	0.065***	0.049***	-0.007	0.022
	(0.011)	(0.010)	(0.008)	(0.009)	(0.010)	(0.010)	(0.009)	(0.012)
Fruits and Vegetables	-0.011	0.027***	0.073***	0.041***	-0.288***	0.130***	0.016**	0.012
	(0.008)	(0.007)	(0.006)	(0.005)	(0.007)	(0.007)	(0.006)	(0.008)
Meat/Fish/Poultry	0.045***	0.067***	0.071***	0.032***	0.135***	-0.440***	0.024**	0.067***
	(0.012)	(0.011)	(0.009)	(0.008)	(0.010)	(0.010)	(0.009)	(0.013)
Dairy	-0.011	-0.107***	0.018	-0.023	0.085***	0.127***	-0.107***	0.019
	(0.024)	(0.023)	(0.018)	(0.016)	(0.021)	(0.021)	(0.023)	(0.026)
Other foods	-0.022**	-0.022**	0.054***	0.015**	0.014*	0.072***	0.004	-0.115***
	(0.007)	(0.007)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.009)

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05

CONCLUSION AND POLICY IMPLICATIONS

In this paper, we analyzed detailed data on rice consumption using a large primary survey of 6,328 rural and urban households in Senegal. The results contributed to addressing gaps in the rice consumption literature for Africa related to the lack of systematic analysis of: (i) the determinants of local rice consumption (outside of quality related factors); (ii) expenditures on different rice types; (iii) rice expenditures over spatial and income categories; (iv) income and price elasticities of different rice types. They each carry important policy implication for urban and rural households rice consumers in Senegal.

First, we find that location is an important determinant of local rice consumption. We showed that rural households consume far less local rice than their urban counterparts. We suspect this is more a problem of access than preferences issues. This result is consistent with the literature on access to markets for rural households Thus, policy interventions should seek to address the access to a good quality local rice for rural households through investments to increase rice production and develop local value chains.

Second, our results show increasing share of rice in the Senegalese cereals' consumption. This increase is even more rapid among rural people, going from a proportion of 24% of cereals consumption (Kelly et al.,1990) to 40% in our data.

Third, we find that types of rice consumed differ between rural and urban consumers. For urban consumers, whole grain local rice has the highest share in total rice expenditures while for rural households, it is the broken imported rice that has the highest share. This shows different diet patterns in rural and urban areas. For rural consumers, there might be a decline of dry cereals (millet, maize, sorghum) which are replaced by imported broken rice. In urban areas, the highest share of whole grain local rice may be related to higher domestic supply of this rice type and change in food habits. To increase consumption of local rice, efforts should thus be made on the availability of broken local rice for both urban and rural consumers.

Fourth, our results indicate different levels of substitutability between domestic and imported rice, depending on the location. We find there is no substitutability between domestic rice and import rice in urban households. This result may be explained by the fact that urban households consume more whole grain rice type when it is domestic and when it is imported, they consume more broken rice type. For rural households, we find that imported and domestic rice are substitutes, but the degree of substitution is weak. These results suggest that policy makers should consider rice types in policies related to prices. We hypothesize that an import ban on whole grain rice may not decrease consumers' welfare if domestic supply is sufficient. However, reducing imports of broken rice may be harmful unless local production is considerably increased through high adoption of aromatic varieties and quality requirements met.

Sixth, we find that a reduction in the price of domestic rice will result in a less than proportionate increase in its demand because the own-price elasticity is significantly less (in absolute value) than unity. The results are similar for imported rice. Thus, price policies like subsidies or taxes may not be good shifters of demand of domestic rice. Following our preceding results, we think that rising incomes and increased urbanization are more likely to accelerate this shift.

While in this study we provide empirical information on trade and food security policy, some limitations must be highlighted. First, we did not include detailed preferences information due to data availability. Second, we did not analyze consumption of more disaggregated rice categories due to a high proportion of zero consumption. Third, consumption of own-consumed rice is probably underestimated with non-inclusion of irrigated-rice farm households. Despite these limits, overall, our results show that rice imports are still necessary to Senegalese consumers, especially rural households.

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APPENDICES

Table A1: Food groups descriptive statistics (urban households

Food group	% of household consuming the product	Per capita annual expenditures (FCFA)	Share in household food expenditure
Local rice	62.5%	202 091	7%
Imported rice	54.8%	173 221	6%
Other cereals	96.4%	238 001	8%
Legumes	94.6%	129 486	5%
Fruits and Vegetables	100.0%	767 992	27%
Meat/Fish/Poultry	97.1%	762 670	27%
Dairy products	83.4%	154 459	5%
Other foods	99.1%	420 981	15%

Source: Authors' computations based on data from the PAPA survey, Senegal (2017-2018).

Table A2. Food groups descriptive statistics (rural households)

Food group	% of household consuming the product	Per capita annual expenditures (FCFA)	Share in household food expenditure
Local rice	35.7%	119,378	5%
Imported rice	73.3%	274,042	12%
Other cereals	94.5%	406,473	18%
Legumes	94.3%	258,568	11%
Fruits and Vegetables	99.6%	418,068	18%
Meat/Fish/Poultry	96.1%	404,619	17%
Dairy products	71.9%	75,871	3%
Other foods	99.2%	355,105	15%

Source: Authors' computations based on data from the PAPA survey, Senegal (2017-2018).

Table A3. Model's fit (urban)

Equation	Obs	Parms	RMSE	R-sq	F(25,1988)	Prob > F
Local rice	2,014	25	0.0795741	0.3657	47.79	0.0000
Imported rice	2,014	25	0.0770022	0.1806	18.27	0.0000
Cereals	2,014	25	0.0574076	0.6585	159.78	0.0000
Legumes	2,014	25	0.0331238	0.5149	87.98	0.0000
Fruits and Vegetables	2,014	25	0.0607494	0.5945	121.51	0.0000
Meat/Fish/Poultry	2,014	25	0.081318	0.5665	108.30	0.0000
Dairy	2,014	25	0.0399096	0.2768	31.72	0.0000
Other foods	2,014	25	0.0402774	0.7297	223.72	0.0000

Source: Authors' computations based on data from the PAPA survey, Senegal (2017-2018)

Table A4: Model's fit (rural)

Equation	Obs	Parms	RMSE	R-sq	F(22,4291	Prob > F
Local rice	4,314	23	0.0837022	0.2114	52.28	0.0000
Imported rice	4,314	23	0.0908067	0.4547	162.63	0.0000
Cereals	4,314	23	0.0706167	0.6836	421.43	0.0000
Legumes	4,314	23	0.0519327	0.6654	387.80	0.0000
Fruits and Vegetables	4,314	23	0.0575553	0.6278	329.02	0.0000
Meat/Fish/Poultry	4,314	23	0.0817439	0.3831	121.13	0.0000
Dairy	4,314	23	0.0338382	0.3568	108.19	0.0000
other foods	4,314	23	0.046244	0.7244	512.61	0.0000

Source: Authors' computations based on data from the PAPA survey, Senegal (2017-2018)

Table A5: Demand estimation results (urban)

Variables	Local rice	Imported rice	Cereals	Legumes	Fruits_Veg	Meat Fish Poultry	Dairy	Other_foods
log(Price1)	0.0600058***	- 0.0096891***	-0.005001*	-0.0034691**	- 0.0280189***	0.000363	0.0000185	- 0.0142092***
	(0.0034)	(0.0029)	(0.0022)	(0.0013)	(0.0023)	0.0035	(0.0016)	(0.0017)
log(Price2)	- 0.0096891***	0.0561345***	-0.0061734**	- 0.0054888***	-0.0124169**	-0.0061706	- 0.0063491***	- 0.0098467***
	(0.0030)	(0.0028)	(0.0022)	(0.0012)	(0.0022)	(0.0033)	(0.0015)	(0.0017)
log(Price3)	-0.005001**	- 0.0061734***	0.0631174***	- 0.0028667***	- 0.0184101***	- 0.0142614***	-0.0006385	- 0.0157662***
	(0.0018)	(0.0016)	(0.0013)	(0.0007)	(0.0013)	(0.0020)	(0.0009)	(0.0010)
log(Price4)	-0.0034691	-0.0054888**	-0.0028667	0.039193***	- 0.0083981***	-0.0065259**	- 0.0035338***	- 0.0089107***
	(0.0022)	(0.0021)	(0.0016)	(0.0009)	(0.0016)	(0.0023)	(0.0011)	(0.0012)
log(Price5)	- 0.0280189***	- 0.0124169***	- 0.0184101***	- 0.0083981***	0.1220484***	- 0.0204145***	-0.001074	- 0.0333159***
	(0.0032)	(0.0030)	(0.0023)	(0.0013)	(0.0024)	(0.0033)	(0.0016)	(0.0017)
log(Price6)	0.000363	-0.0061706*	- 0.0142614***	- 0.0065259***	- 0.0204145***	0.0649829***	-0.008734***	- 0.0092395***
	(0.0027)	(0.0024)	(0.0019)	(0.0010)	(0.0020)	(0.0033)	(0.0013)	(0.0015)
log(Price7)	0.0000185	-0.0063491**	-0.0006385	- 0.0035338***	-0.001074	-0.008734***	0.0215539***	-0.001243
	(0.0022)	(0.0021)	(0.0016)	(0.0009)	(0.0016)	(0.0023)	(0.0011)	(0.0012)
log(Price8)	- 0.0142092***	- 0.0098467***	- 0.0157662***	- 0.0089107***	- 0.0333159***	-0.0092395**	-0.001243	0.0925311***
	(0.0028)	(0.0026)	(0.0020)	(0.0011)	(0.0021)	(0.0029)	(0.0014)	(0.0015)

Variables	Local rice	Imported rice	Cereals	Legumes	Fruits_Veg	Meat Fish Poultry	Dairy	Other_foods
	-				-			-
beta_lnx	0.0272281***	0.0014877	-0.0070867**	0.0014968	0.0179609***	0.0579124***	0.0159488***	0.0245701***
	(0.0033)	(0.0031)	(0.0024)	(0.0014)	(0.0025)	(0.0033)	(0.0016)	(0.0017)
Head_male	-0.0056226	0.0019549	0.0016712	-0.0042435	-0.0059942	0.0092329	0.0008462	0.002155
	(0.0063)	(0.0060)	(0.0046)	(0.0026)	(0.0046)	(0.0065)	(0.0031)	(0.0033)
Age	0.000084	0.000089	-0.0000982	0.0000868	-0.000098	0.0000263	-0.0000958	50.93e-06
	(0.0001)	(0.0001)	(0.0001)	0(.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
							-	
Size	0.002648**	0.0001064	0.0002792	0.0003284	-0.0000119	-0.0028593**	0.0018238***	0.001333**
	(0.0009)	(0.0009)	(0.0007)	(0.0004)	(0.0007)	(0.0009)	(0.0004)	(0.0005)
Married	0.0148512*	-0.0045209	0.0040463	0.0010131	0.0077618	-0.0155037*	-0.0056586	-0.0019893
	(0.0067)	(0.0063)	(0.0049)	(0.0027)	(0.0049)	(0.0069)	(0.0032)	(0.0035)
Elementary	0.0023759	-0.0023756	-0.0075032*	-0.0030953	-0.0028869	0.0086466	0.0061687**	-0.0013301
	(0.0049)	(0.0046)	(0.0035)	(0.0020)	(0.0035)	(0.0049)	(0.0024)	(0.0025)
High_school	0.0044114	0.0057108	-0.013952***	0.0000345	-0.0047245	0.0044507	0.0069844**	-0.0029154
	(0.0049)	(0.0046)	(0.0036)	(0.0020)	(0.0036)	(0.0050)	(0.0024)	(0.0025)
University	-0.0168827*	0.0092971	-0.0032638	-0.0015019	-0.0089585	0.0174656*	0.0107975**	-0.0069532
	(0.0071)	(0.0067)	(0.0052)	(0.0029)	(0.0052)	(0.0074)	(0.0035)	(0.0038)
Other_school _level	-0.020325	0.000174	0.022618*	-0.0114831	0.0202996	0.0013149	-0.0088901	-0.0037084
	(0.0157)	(0.0148)	(0.0114)	(0.0064)	(0.0114)	(0.0160)	(0.0076)	(0.0082)
Women	0.0001356	-0.0013504	0.0012626	-0.0007498	-0.0005119	0.0016335	0.0002572	-0.0006769
	(0.0013)	(0.0012)	(0.0010)	(0.0005)	(0.0010)	(0.0013)	(0.0006)	(0.0007)
Children	-0.0026537*	0.0014852	-0.00005	0.0000842	0.0002498	-0.0003082	0.0018876***	-0.000695
	(0.0011)	(0.0010)	(0.0008)	(0.0005)	(0.0008)	(0.0011)	(0.0005)	(0.0006)
Refrigerator	-0.0017555	0.0017521	0.0029337	-0.0011345	-0.0022142	-0.0036896	0.0014264	0.0026815
	(0.0032)	(0.0031)	(0.0024)	(0.0013)	(0.0024)	(0.0033)	(0.0016)	(0.0017)
Car	0.0067329	-0.0080469	0.0017507	-0.0000527	0.0009647	0.0025238	-0.0025478	-0.0013247

Variables	Local rice	Imported rice	Cereals	Legumes	Fruits_Veg	Meat Fish Poultry	Dairy	Other_foods
	(0.0049)	(0.0046)	(0.0035)	(0.0020)	(0.0036)	(0.0051)	(0.0023)	(0.0026)
TV	0.0023567	-0.0019096	-0.0021672	-0.000822	0.0040329**	-0.0031491	-0.000506	0.0021642*
	(0.0018)	(0.0017)	(0.0013)	(0.0007)	(0.0013)	(0.0018)	(0.0009)	(0.0009)
Greater_Dakar	-0.0405765***	0.0172955*	0.0078395	0.0014745	0.0019195	0.0074299	0.0038783	0.0007394
	(0.0072)	(0.0069)	(0.0053)	(0.0030)	(0.0053)	(0.0075)	(0.0035)	(0.0038)
Secondary_Towns	-0.0336028***	-0.0012719	0.0070226	-0.0020393	0.0116427	0.0071918	0.0039588	0.007098
	(0.0083)	(0.0079)	(0.0061)	(0.0034)	(0.0061)	(0.0086)	(0.0040)	(0.0044)
Other_Towns	-0.0423139***	0.0212981**	0.0144582**	0.0021252	0.0070692	-0.0131375	-0.0006266	0.0111273**
	(0.0072)	(0.0069)	(0.0053)	(0.0030)	(0.0053)	(0.0074)	(0.0035)	(0.0038)
Constant	0.2722948***	0.0324716	0.1743511***	0.0811035***	0.2912253***	-0.1091516***	-0.0117695	0.2694747***
	(0.0223)	(0.0210)	(0.0161)	(0.0091)	(0.0164)	(0.0224)	(0.0109)	(0.0116)

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05

Table A6. Demand estimation results (rural)

Variables	Local rice	Imported_rice	Cereals	Legumes	Fruits_Veg	Meat_Fish Poultry	Dairy	Other_foods
log(Price1)	0.0608193***	-0.019884***	-0.0087892***	-0.0054918***	-0.0112285***	-0.0016288	-0.002061**	-0.0117359***
	(0.0019)	(0.0021)	(0.0017)	(0.0012)	(0.0013)	(0.0020)	(0.0008)	(0.0012)
log(Price2)	-0.019884***	0.1095006***	-0.0214377***	-0.0091298***	-0.0182045***	-0.008574***	-0.0073973***	-0.0248733***
	(0.0018)	(0.0020)	(0.0015)	(0.0011)	(0.0012)	(0.0019)	(0.0007)	(0.0011)
log(Price3)	-0.0087892***	-0.0214377***	0.1029522***	-0.0124012***	-0.0190528***	-0.0146255***	-0.0051219***	-0.0215239***
	(0.0014)	(0.0015)	(0.0012)	(0.0009)	(0.0010)	(0.0015)	(0.0006)	(0.0008)
log(Price4)	-0.0054918***	-0.0091298***	-0.0124012***	0.0701939***	-0.0116568***	-0.0131125***	-0.0042841***	-0.0141178***
	(0.0013)	(0.0014)	(0.0011)	(0.0008)	(0.0009)	(0.0013)	(0.0005)	(0.0008)
log(Price5)	-0.0112285***	-0.0182045***	-0.0190528***	-0.0116568***	0.0930638***	-0.0049027**	-0.0027111***	-0.0253074***
	(0.0017)	(0.0018)	(0.0014)	(0.0011)	(0.0011)	(0.0017)	(0.0007)	(0.0010)
log(Price6)	-0.0016288	-0.008574***	-0.0146255***	-0.0131125***	-0.0049027***	0.0523031***	-0.0020232**	-0.0074363***
	(0.0017)	(0.0019)	(0.0015)	(0.0011)	(0.0012)	(0.0019)	(0.0007)	(0.0011)
log(Price7)	-0.002061	-0.0073973***	-0.0051219***	-0.0042841***	-0.0027111**	-0.0020232	0.027526***	-0.0039275***
	(0.0015)	(0.0016)	(0.0013)	(0.0009)	(0.0010)	(0.0015)	(0.0006)	(0.0009)
log(Price8)	-0.0117359***	-0.0248733***	-0.0215239***	-0.0141178***	-0.0253074***	-0.0074363***	-0.0039275***	0.1089222***
	(0.0021)	(0.0023)	(0.0018)	(0.0013)	(0.0014)	(0.0021)	(0.0009)	(0.0013)
beta_lnx	-0.0000718	-0.0079195***	-0.0125886***	0.0014822	-0.0052051***	0.0466632***	0.0026598**	-0.0250202***
	(0.0021)	(0.0023)	(0.0018)	(0.0013)	(0.0014)	(0.0020)	(0.0008)	(0.0012)
Head_male	-0.0082003	0.0038668	0.0142742**	0.0023161	0.0046828	-0.0143512*	-0.0026182	0.0000298
	(0.0061)	(0.0066)	(0.0052)	(0.0038)	(0.0041)	(0.0059)	(0.0025)	(0.0035)
Age	0.0002774**	0.0000926	-0.0001893	-0.0000935	-0.0001699*	0.0000211	80.62e-06	0.000053
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0000)	(0.0001)
Size	0.0001431	0.0004617	-0.0002166	-0.0007102	-0.0001402	0.0008567	-0.0006208*	0.0002264
	(0.0006)	(0.0007)	(0.0005)	(0.0004)	(0.0004)	(0.0006)	(0.0003)	(0.0004)
Married	-0.005672	0.00088	0.0029037	0.0034879	-0.0054764	-0.0066578	0.0023503	0.0081843*
	(0.0059)	(0.0064)	(0.0050)	(0.0037)	(0.0040)	(0.0057)	(0.0024)	(0.0034)
No_school	-0.0079212	0.0061375	0.00169	-0.0028484	0.0019248	0.0010308	-0.0001803	0.0001668

Variables	Local rice	Imported_rice	Cereals	Legumes	Fruits_Veg	Meat_Fish Poultry	Dairy	Other_foods
	(0.0040)	(0.0043)	(0.0034)	(0.0025)	(0.0027)	(0.0038)	(0.0016)	(0.0023)
High_school	0.0084618	-0.0021496	-0.0030224	-0.0067514	-0.0066036	0.0199731***	-0.0044346*	-0.0054733
	(0.0050)	(0.0054)	(0.0042)	(0.0031)	(0.0034)	(0.0048)	(0.0020)	(0.0029)
University	0.0002613	0.0079945	-0.0104825*	-0.0120697***	-0.0006498	0.0190465***	-0.0021219	-0.0019783
	(0.0054)	(0.0058)	(0.0046)	(0.0034)	(0.0036)	(0.0052)	(0.0022)	(0.0031)
Other_school_level	-0.0007525	-0.0252403	0.0095713	-0.0294197*	-0.0283177	0.0392206	-0.0001617	0.0351001**
	(0.0221)	(0.0238)	(0.0186)	(0.0138)	(0.0149)	(0.0210)	(0.0089)	(0.0126)
Women	-0.001128	-0.0008022	0.0004131	0.0006043	0.0001473	-0.0001515	0.0005907	0.0003263
	(0.0009)	(0.0009)	(0.0007)	(0.0005)	(0.0006)	(0.0008)	(0.0004)	(0.0005)
Children	0.0001026	0.0003075	0.0012393	0.0002865	0.0000763	-0.0018044	0.000237	-0.000445
	(0.0008)	(0.0008)	(0.0006)	(0.0005)	(0.0005)	(0.0007)	(0.0003)	(0.0004)
Area	-0.0004143**	-0.0001461	0.0001431	0.0001544	0.0003175**	-0.0003209*	0.0000274	0.0002389**
	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0001)
Farmer_Organization	0.0074863	-0.0158358***	0.0035552	0.0036873	-0.0013156	-0.0053613	0.0051755**	0.0026083
	(0.0046)	(0.0050)	(0.0039)	(0.0029)	(0.0031)	(0.0044)	(0.0018)	(0.0026)
Intermediate	-0.0107109***	0.0035932	-0.0000655	0.0003731	0.0039849	-0.002699	-0.0021908	0.0077151***
	(0.0032)	(0.0034)	(0.0027)	(0.0020)	(0.0021)	(0.0030)	(0.0013)	(0.0018)
Hinterland	-0.0080833*	-0.004518	0.00671*	0.0039028	0.0071301**	-0.0120349***	0.0007924	0.0061008***
	(0.0032)	(0.0035)	(0.0027)	(0.0020)	(0.0022)	(0.0031)	(0.0013)	(0.0018)
Constant	0.0688803***	0.1341337***	0.2073594	0.1257861***	0.2142104***	-0.0759021***	0.0572103***	0.2683218***
	(0.0149)	(0.0161)	(0.0126)	(0.0093)	(0.0101)	(0.0145)	(0.0060)	(0.0086)

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05

Table A7. Uncompensated price elasticities (urban)

Food groups	Local rice	Imported rice	Cereals	Legumes	Fruits and Vegetables	Meat/Fish/Poultry	Dairy	Other_foods
Local rice	0.124**	-0.367***	-0.162***	-0.101***	-0.208***	-0.029	-0.039	-0.216***
	(0.046)	(0.034)	(0.026)	(0.025)	(0.033)	(0.031)	(0.027)	(0.039)
Imported rice	-0.148***	-0.151***	-0.149***	-0.064***	-0.127***	-0.072***	-0.056***	-0.171***
	(0.016)	(0.018)	(0.012)	(0.011)	(0.015)	(0.014)	(0.012)	(0.018)
Cereals	-0.045***	-0.107***	-0.412***	-0.061***	-0.091***	-0.090***	-0.027***	-0.098***
	(0.009)	(0.008)	(0.008)	(0.006)	(0.008)	(0.008)	(0.007)	(0.010)
Legumes	-0.051***	-0.088***	-0.117***	-0.354***	-0.110***	-0.120***	-0.039***	-0.135***
	(0.011)	(0.010)	(0.008)	(0.010)	(0.010)	(0.010)	(0.009)	(0.012)
Fruits and Vegetables	-0.064***	-0.100***	-0.103***	-0.065***	-0.455***	-0.032***	-0.015**	-0.137***
	(0.008)	(0.007)	(0.006)	(0.005)	(0.008)	(0.007)	(0.006)	(0.008)
Meat/Fish/Poultry	-0.025*	-0.101***	-0.160***	-0.107***	-0.086***	-0.653***	-0.017	-0.131***
	(0.012)	(0.011)	(0.009)	(0.008)	(0.011)	(0.010)	(0.009)	(0.013)
Dairy	-0.070**	-0.249***	-0.179***	-0.140***	-0.102***	-0.054*	-0.142***	-0.149***
	(0.024)	(0.023)	(0.018)	(0.017)	(0.022)	(0.021)	(0.024)	(0.027)
Other_foods	-0.067***	-0.132***	-0.098***	-0.076***	-0.131***	-0.067***	-0.023***	-0.244***
	(0.007)	(0.007)	(0.005)	(0.005)	(0.007)	(0.006)	(0.006)	(0.009)

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05

Table A8. Uncompensated price elasticities (rural)

Food groups	Local rice	Imported rice	Cereals	Legumes	Fruits and Vegetables	Meat/Fish/Poultry	Dairy	Other_foods
Local rice	0.127**	-0.366***	-0.166***	-0.102***	-0.209***	-0.028	-0.037	-0.216***
	(0.046)	(0.034)	(0.027)	(0.025)	(0.033)	(0.031)	(0.028)	(0.039)
Imported rice	-0.148***	-0.153***	-0.148***	-0.064***	-0.127***	-0.074***	-0.055***	-0.170***
	(0.016)	(0.018)	(0.012)	(0.011)	(0.015)	(0.014)	(0.012)	(0.018)
Cereals	-0.046***	-0.106***	-0.412***	-0.062***	-0.091***	-0.088***	-0.027***	-0.098***
	(0.009)	(0.008)	(0.008)	(0.006)	(0.008)	(0.008)	(0.007)	(0.010)
Legumes	-0.052***	-0.086***	-0.118***	-0.354***	-0.109***	-0.119***	-0.040***	-0.135***
	(0.011)	(0.010)	(0.008)	(0.010)	(0.010)	(0.010)	(0.009)	(0.012)
Fruits and Vegetables	-0.064***	-0.100***	-0.102***	-0.064***	-0.454***	-0.033***	-0.015**	-0.137***
	(0.008)	(0.007)	(0.006)	(0.005)	(0.008)	(0.007)	(0.006)	(0.008)
Meat/Fish/Poultry	-0.024*	-0.103***	-0.159***	-0.107***	-0.088***	-0.654***	-0.016	-0.131***
	(0.012)	(0.011)	(0.009)	(0.008)	(0.011)	(0.010)	(0.009)	(0.013)
Dairy	-0.067**	-0.245***	-0.182**	-0.142***	-0.102***	-0.049*	-0.144**	-0.152***

Food groups	Local rice	Imported rice	Cereals	Legumes	Fruits and Vegetables	Meat/Fish/Poultry	Dairy	Other_foods
			*				*	
	(0.024)	(0.023)	(0.018)	(0.017)	(0.022)	(0.021)	(0.024)	(0.027)
Other_foods	-0.067***	-0.131***	-0.098***	-0.076***	-0.130***	-0.067***	-0.024***	-0.245***
	(0.007)	(0.007)	(0.006)	(0.005)	(0.007)	(0.006)	(0.006)	(0.009)

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05