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# Analysis of Local Rice Supply in Togo from Data in Cross Sections

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**ABSTRACT**

Togolese agriculture contributes about 40% to the Gross Domestic Product (GDP) and employs more than 60% of the active population and remains the mainstay of Togo's economic growth. Despite this important share of agriculture in the national economy, domestic production of rice is not consistent to meet the demand for this food by the population. This paper analyzes how Togolese farmers can respond to the rise of rice price and to the variation of other determinants. The study estimates local rice supply response in Togo using data from the *4ème Recensement National de l'Agriculture* (RNA) conducted within 2011-2014. Using the estimators obtained by the Ordinary Least Squares, we found that the price of rice to the producer has a significant positive impact on rice supply. The results of the econometric estimates then showed that the individual paddy rice supply is, on the one hand, elastic to the producer price and, on the other hand, inelastic to the cost of mineral fertilizers, to the amount of credits granted to farmers, to the price of corn - a complementary product of paddy rice on the farm. In terms of economic policies, our findings suggest Government supports the establishment of efficient systems of climate-resistant seeds and varieties of rice throughout the country, agricultural credit and above all for rice farmers, so that bridging yield gaps, improving quality management along the value chain, and investment in rice production and processing infrastructure.

**Keywords**: Local Rice, Supply, Data in cross sections, Togo.

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## 1. INTRODUCTION

Agriculture induces economic growth through the role of agricultural inputs in increasing agricultural yields and their effects on the supply capacity of producers (McArthur and McCord, 2017). Gillis, et al. (1998) underline the importance that the notion of food self-sufficiency could cover for an economy. They draw attention to the danger to the economic health of depending on food imports. Food tends more and more to become a strategic good, most of the same order as the armament. For example, a country dependent on others for food may be subject to different kinds of pressure from them. In 2014, agricultural sector accounted for one-third of the global Gross Domestic Product (GDP). Among agricultural products, rice occupies an important position in the world not only by its production but also and especially by its consumption. It is the second most important cereal crop in terms of acreage and third one regarding its production after wheat and maize and is the staple food for more than half of the world's population (Hirsch, 1999; Dupaigre, 2005). Although demanding in labor and water, rice production pays off. It produces more tons per hectare than the other major staple crops (Fuller and Qin, 2009). Its production and trade affect populations globally, with rice feeding half of the growing population, particularly in developing regions such as Africa (Fairhurst and Dobermann, 2002; Khush, 2005; Alexandratos and Bruinsma, 2012; Kuenzer and Knauer, 2013; United Nations, 2015). Nearly one billion people living in rural areas in developing countries are active in rice production systems and post-harvest operations (Baris et al, 2005). Rice is an integral part of agricultural production systems in Africa, where it has been cultivated for more than 3,000 years. Today, it is the fastest growing food source in Africa.

In Togo, agriculture contributes 40% to the GDP and employs more than 60% of the active population and remains the pillar of Togo's economic growth[1]. Indeed Agro-climatic conditions in Togo are generally favorable for agriculture. The agricultural sector has the greatest potential to directly increase the income of the poor. Despite this important part of agriculture in the national economy, Togo is unable to meet its food needs for cereals including rice due to weak extension services and limited agricultural research capacity, limiting generation, dissemination and adoption of new technologies, limited access to rural credit, which also prevents farmers from acquiring improved seeds and fertilizers (World Bank, 2017)... On-farm productivity is still very low (due to little use of inputs, and traditional production methods and farm equipment), and the irrigation potential remains largely untapped. Access to financing is limited outside the cotton sector. Agriculture in the country suffers then from low productivity, shortages of key inputs, and poor agricultural support services. Output growth has been mainly due to expansion of cultivated acreage rather than due to any noticeable improvement in productivity.

Rice is one of the country's main cereal food crops. It is a strategic crop for Togo and other African countries. It is the basis of food in the big cities and in the countryside.

[1] *http://www.worldbank.org/en/country/togo/overview, Accessed date: 5-Nov-2018*

The soils and climate of Togo offer enormous potential for its production. These potentials are not sufficiently valued for lack of appropriate technologies, among others. However, until 2007, barely 20% of the potential lands for rice paddy in Togo were only exploited (Manzamasso and Ram, 2015). Domestic production is not sufficient to cover food needs, hence the need for massive imports. Togo imports nearly half of its consumption of rice which is the third most consumed staple cereal in the country. As a common observation in most sub-Saharan countries, this reveals the inadequacy of domestic production despite many agricultural policies and several programs or projects previously undertaken for rice farming in Togo.

According to the National Strategy for Rice cultivation Development (SNDR) of the Ministry of Agriculture, Livestock and Fisheries, one of Togo's major challenges is to reduce the volume of rice imports that cost the country on average eight million US dollars (US$ 8,000,000) per year (MAEP,2010a). However, Togo has land that is potentially suitable for rice production: irrigable land (alluvial plains, lowlands) and open land. Togo's choice to increase rice production takes into account consumer preferences and indications of an ever-increasing demand in both rural and urban areas for this food, which is now part of the Togolese daily menu. The National Agricultural Investment and Food Security Program (PNIASA) identify rice as one of the growth-enhancing crops. The development of rice production in Togo appears as a challenge in terms of sovereignty and food security, the reduction of the volume of imports and economic and social growth.

Several studies on local rice in Togo focused on increasing consumption, profitability, competitiveness (Yovo, 2010), demand for imported rice and the price’s effects on the real purchasing power. However, the knowledge of the determinants of rice produced locally makes it possible to optimize crop yields in lowlands and thus the local supply of this foodstuff. For, as pointed out by Evenson and Golin (2003), the number of researchers compared to that of extension workers, which is much lower in Sub-Saharan Africa (SSA) than in Asia can be a fundamental constraint to improving farming efficiency in SSA. In this way, an understanding of the local rice supply responses with its determinants in Togo would improve overall economic performance. That is why this study is initiated to simulate the relations of the local production of the rice with the measures of policies in the matter in Togo. Our study focuses on the issue of local rice production and is a microeconomic analysis of the response of local rice supply of agricultural households to its determinants.

The main objective of this study is to analyze the supply of local rice in Togo since rice cultivation is becoming one of the most economically profitable among cereals. Specifically, the study aims to:

- Present the elasticity of supply of local rice in relation to the producer price;
- Determine the elasticity of local rice supply in Togo in relation to the cost of inputs (especially fertilizers). Thus, the present study concerns the rice sector through a wide investigation of the various factors that paddy rice production

in Togo depends on. To do this, the interest of the study lies in the verification of the following hypotheses:

H1: The supply of local rice (paddy) increases more than appreciably to an increase in its selling price;

H2: The supply of paddy rice increases less than significantly to a decrease in the cost of chemical fertilizers.

The present study aims to assess the likely impacts of rice price scenarios and the cost of inputs on the level of local production. Its ultimate goal is to present the reactions of local rice supply with their determinants. Also, the analysis of the sensitivities of the demand for inputs with their determinants in the supply of rice in Togo will make it possible to shed more light on the debates and the public authorities in their decision-making on economic policy in rice-growing sector.

### 1.1. Descriptive analysis of rice production in Togo.

In Togo, rice cultivation is practiced in all economic regions with variable importance and weight. Figure 1 below shows the evolution of production by region from 2000 to 2016. Through this figure, it appears that the Plateau, Central, and Savannah Regions are the areas of high rice production. From 2006 to 2008, paddy rice production in the central region exceeded that of other regions. But from 2009 until 2016, production in the Savannah region becomes the largest and it got the record in 2013 with about 82,000 tons of rice produced. Although rice production in the maritime region has never exceeded 20,000 tons, it is currently receiving more attention from the Administration and NGOs.

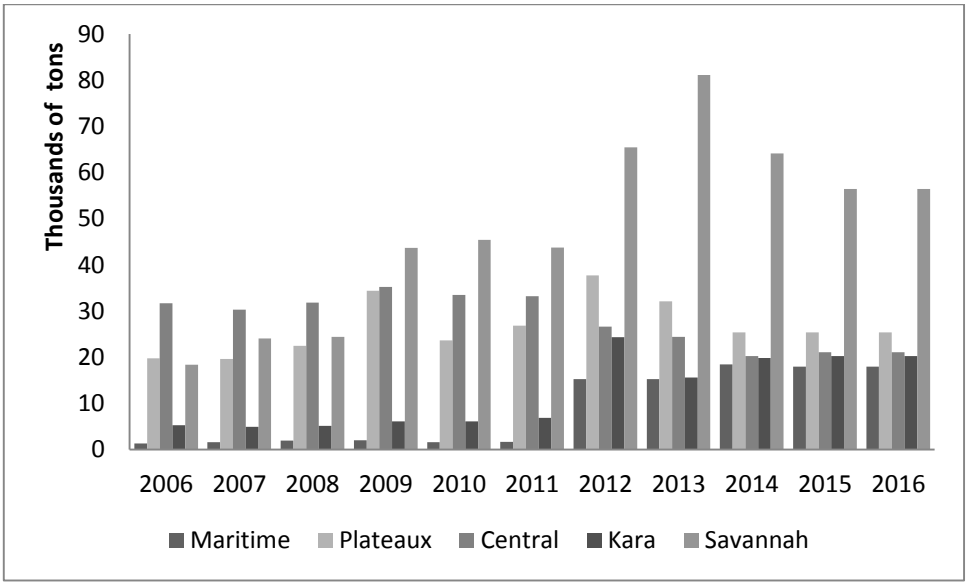


**Fig.1.** Evolution of rice production by region in Togo from 2006 to 2016. Source: author from DSID data (2016).Source: Realized by the authors from DSID database, 2015.

The evolution of the national production of rice compared to the domestic consumption shows that the demand is largely higher than the local production, over the entire period considered (fig.2). From 2000 to 2002, domestic rice production grew at about 8 percent before declining in 2003. Thanks to the government's food security policies, local production increased again in the following years. It reached a maximum volume of 170 000 tons in 2012 and .2013. These performances are the results of the PNIASA during the 2011/2012 and 2012/2013 crop years through PASA and PADAT[2] projects. From 2014, domestic production has declined, in contrast to the growing national demand. This creates a widening gap between local demand and local supply, thus strengthening the country's dependence on imported rice.

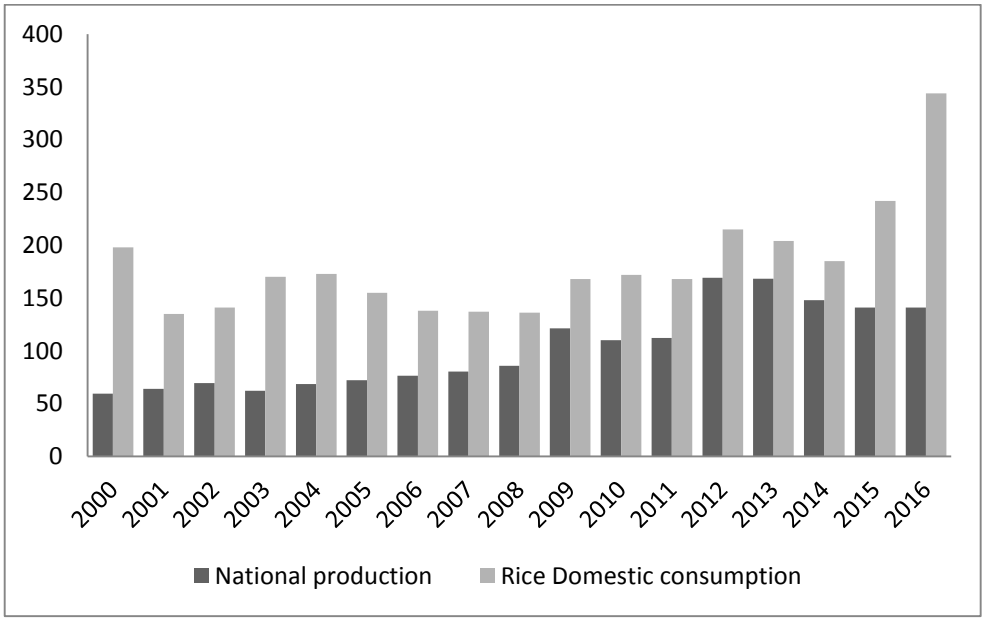


**Fig.2.** Evolution of rice production and domestic consumption (both in thousands of tons) during 2006-2016.Source: Authors' computation based on data collected from DSID, 2015 and FAO database 2018.

Part of the rice produced in Togo is mainly exported to other countries in the sub-region, including Ghana, Benin and to a certain extent Burkina Faso. These exports are very marginal in the sense that they are not taken into account by official statistics.

[2] *PASA : Projet d'appui au Secteur Agricole au Togo. Its goal is to increase the productivity and / or competitiveness of strategic food crops, export crops and animal / fish production, as well as to promote an enabling environment for agricultural development driven by private initiative.*
*PADAT: Projet d'Appui au Développement Agricole au Togo. It aims to contribute to the improvement of food security and the income of vulnerable small agricultural producers.*

## 2. MATERIAL AND METHODS

### 2.1. Literature review

Many theoretical and empirical works have been devoted to the rice sector in general. Provide a comprehensive description of rice sector in Togo would require an overview of what exists on the theoretical level as regards the rice production and its supply in Togo and to bring out the empirical results which confirm or possibly invalidate the theory.

Producers' theory is concerned with the behavior of firms in combining productive inputs to supply goods at appropriate prices (Nadiri, 1982). In reference to the neoclassical theory, the farmer's choice of production is based on the crop with the highest expected price, that is to say, the crop with a potentially higher profit. Several studies concerning the analysis of agricultural policy instruments and particularly those of reducing rice imports and achieving self-sufficiency in rice through the growth of local rice supply have been addressed.

In the analysis of efficiency and technical progress in traditional and modern rice production in China, Xu and Jeffrey (1998) found a positive relationship between efficiency and education for conventional rice production, thus, emphasizing the importance of considering peasants' abilities to receive and understand information relating to new agricultural technology. In other words, the peasants are more efficient in using inputs for conventional rice production than for hybrid rice production. According to Ngom et al., (2014) in " Estimating the technical efficiency of rice farmers in the Senegal River valley", efficiency determinants are mainly the place of residence, the gender, the household size, the level of education, the ethnicity, the walking distance between the house and the plot and the number of plots farmed. The sustainability of the farmers' high efficiency will depend on the continuous support they receive in the areas of input supply and education, among others (Donkoh, et al., 2013). Discussing on the role of rice in strengthening food security in northern Cameroon, Folefack (2014) suggested actions such as improving local rice productivity and competitiveness, strong institutional backstopping and further financing support for stakeholders in rice production sector need to be carried out in order to increase local rice production and its supply. Basavaraja et al. (2008) show in a comparative analysis of traditional and modern System of Rice Intensification (SRI) methods, the way to increase the productivity and obtain a significant reduction in production costs of paddy rice with the new SRI technology. Fertilizers were found to be the next important item of expenditure in both the methods of paddy cultivation. Although demanding and leading to a reticence of farmers to adopt it, this new method deserves to be encouraged and popularized because of its superiority in terms of yield and returns advantage. Boussard (1985) showed that the positive reaction of agricultural production to the price increase is not systematic and the elasticity of the supply of certain agricultural products in relation to the price is null or negative.

## 2.2. Method

Here in this section, it is a question of describing the methodology adopted to verify the hypotheses. We present here the study area, then the theoretical model and finally the data sources used for the present work.

### 2.2.1. Study area

This study was conducted on rice farmers in Togo (See Fig.3). Located between the 6th and 11$^{th}$ parallels north, Togo is a West African country, covering an area of 56 785 km². Its population is estimated at 7, 798, 000 inhabitants in 2017[3]. Togo is divided into two climatic zones: a sub-equatorial climate with two rainy seasons alternating with two dry seasons in the south; a Sudanese climate with one rainy season and one dry season in the north. The mean historical monthly rainfall for Togo during the time period 1901-2015 shows a minimum of 7.4 mm and 197.3 mm. As for the temperature, those figures are 25 and 29.5 ºC respectively for the minimum and maximum within the same period[4]. It means the temperatures are warm the whole year in the country. The Togolese landscape includes a range of hills running southwest to northeast, splitting the country into two regions of savannah plains. The maximum elevation of 986 meters above sea level is Pic Agou located in the Plateau region. Most soils in Togo derive from thoroughly weathered parent materials, are highly leached and moderately fertile. Land considered suitable for agriculture is estimated at 3.82 million hectares (ha), about 70 % of the total land surface area[5]. The area under cultivation in 1990 was estimated at 2.6 million ha, almost all rain fed (Bishop, 2002). Togo has land that is potentially suitable for rice production: irrigable land (alluvial plains, lowlands) and open land. The lowland potential is estimated at about 185 000 ha (MAEP, 2010b). The rice potential of the country in the lower Mono valley, in the Oti basin, in the Kpendjal, in the Zio and Kpele is a formidable asset whose implementation should lead to a competitive production of this commodity food. To meet, among other things, one of the objectives of PNIASA is: improve the coverage of the country's food needs and increase agricultural exports (MAEP, 2016).

[3] *data.un.org/en/iso/tg.html (Accessed 10-11-18)*

[4] *http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_historical_climate&ThisCCode=TGO (Accessed 11.11.18 )*

[5] *http://www.fao.org/countryprofiles/index/en/?iso3=TGO (Accessed 11.11.18)*


**Fig.3.** Map of Togo showing its five administrative regions.
*Source: Realized by the authors*

### 2.2.2. Model: Linear regression model

The multiple regression study involves the nature of the relationship between a dependent variable and two or more explanatory variables. The nature of the relationship can then be modeled using different functional forms. The techniques lead to estimates of the standard error of multiple regression and coefficients of multiple determinants. In implicit form, assuming that a particular variable of interest (Y) is associated with a set of other variables (X), the relation can be given as follows:

$$Y_i = f(X_1, X_2, \ldots . X_n) \quad (1).$$

With:

Yi is the dependent variable and $X_1, X_2, \ldots . X_n$, a set of key variables. The multiple determination coefficients quantify the relative magnitude of variation of the

dependent variable (Yi) explained by the regression relationship between Y and the explanatory variables (Xi).

Several functional forms make it possible to represent the production technology. The Leontief, Logarithmic, double-logarithmic and constant elasticity of substitution (CES) production functions are the best known. They differ mainly in the structural assumptions made about the elasticities of output relative to inputs, the returns to scale and the elasticities of substitution between inputs. These parameters make it possible to characterize all production technologies (Heyer et al., 2004). The double-log supply function is the most widely used in empirical studies because of the simplicity of the econometric estimation or calibration procedure. However, this production function is based on some restrictive assumptions. The logarithmic function from a linear regression model is used to estimate the local rice supply and the model chosen is written as follows:

$$LnQ_{RICE} = \beta_0 + \beta_1 \text{Ln}(P_{RICE}) + \beta_2 \text{Ln}(\text{FERT}) + \beta_3 \text{Ln}(\text{PHYTO}) + \beta_4 RAIN + \beta_5 RAIN^2 + \beta_6 \text{Ln}(Q_{ISEED}) + \beta_7 \text{Ln}(\text{CREDIT}) + \beta_8 TEMP + \beta_9 TEMP^2 + \beta_{10} \text{Ln}(P_{MAIZ}) + \boldsymbol{\varepsilon} \quad (2)$$

$Q_{RICE}$: Individual paddy rice output (in tons)

$P_{RICE}$: the selling price of paddy rice on the farm (in USD / kg)

FERT: the individual cost of fertilizers (in USD)

CREDIT: the value of the loans received in cash (in USD)

RAIN: the annual rainfall volume in the rainy season (in mm)

$Q_{ISEED}$: the volume of improved seeds received as a subsidy (kg)

PHYTO: the cost of phytosanitary products per capita (in USD/l)

TEMP: the temperature level (in ° C)

$P_{MAIZ}$: the price of corn on the farm (in USD / Kg)

Ln: the natural logarithm; $\beta_0$, $\beta_1$, $\beta_2$, $\beta_3$, $\beta_4$, $\beta_5$, $\beta_6$, $\beta_7$, $\beta_8$, $\beta_9$, and $\beta_{10}$ are the parameters to be estimated; ε the error term.

In line with the previous analysis, the production then the supply of local rice "$Q_{RICE}$" is a function of economic and demographic factors as explanatory variables: the prices of rice and inputs (fertilizers and phytosanitary products), the amount of credit received by the farm household, the amount of rainfall in the rainy season, the quantity of selected or improved seeds received in subsidy and the price of corn received by the farm household. The variables "RAIN" and "TEMP" make it possible to control a part of the variability due to the agro-climatic characteristics of the

environment on the production. The Expected sign of the coefficients of the explanatory variables of equation 2 appear in table 1 as follows:

**Table 1:** Summary expected signs of the estimators' coefficients

| **The explanatory variables** | **Expected sign of coefficients** | **Dependent Variable** |
|---|---|---|
| $P_{RICE}$ | Positive (+) | |
| FERT | Negative (−) | |
| CREDIT | Positive (+) | |
| RAIN | Positive/Negative (+) | $Q_{RICE}$ |
| $Q_{ISEED}$ | Positive (+) or Negative (−) | |
| PHYTO | Negative (−) | |
| TEMP | Positive (+) or Negative (−) | |
| $P_{MAIZ}$ | Negative (−) | |

Source : Authors' Specifications

As summarized in the previous table, the expected sign of some explanatory variables suggests an obvious sign. However, the influence of other explanatory variables on the endogenous variable is ambiguous. In fact, the increase in the selling prize "$P_{RICE}$" of paddy rice on the farm encourages agricultural households to produce more rice, which can be achieved through increased consumption of inputs. Indeed according to the supply theory, the supply of a good is a growing function of price. Thus, we expect for a positive sign of this variable on production "$Q_{RICE}$".

It is recognized that agro-climatic and meteorological conditions play a very important role in agricultural production as crop growth and development depend on it. One of the agro-climatic and meteorological factors of rice production is the level of rainfall before or during sowing or during harvesting. Rain usually plays an important role in rice production. However, when it becomes too abundant, the rainfall is unfavorable to crops from a certain threshold. Therefore, a positive or negative sign of the coefficient of the variable "PLUV" on the supply of rice is expected.

On the other hand, fertilizers can be considered as normal goods. An increase in the cost of fertilizers will lower the level of the corresponding demand of this factor. Therefore, a negative influence of the variable "FERT" on paddy rice production and thus on its supply by the producer is expected.

Plant protection products are agricultural inputs just like fertilizers. Increasing their price increases the producer's costs and consequently reduces their production and

supply capacity. Referring to the law of supply in microeconomic theory, an increase in production costs leads to a decrease in supply. Thus, the expected sign of the variable "PHYTO" is, therefore, the negative sign.

Temperature is one of the most important factors in rice production. This influences the duration of growth of the rice and delimits the area of culture. Indeed, among the ecological requirements of rice cultivation, agronomic research has established the temperature as one of the natural constraints favorable to obtaining optimal yield to its production. However, a torrid heat affects the production and therefore the supply of cereals including local rice. A positive or negative influence of the variable ‘’TEMP’’ on the supply of local paddy rice is then expected.

According to neoclassical theory, for two substitutable or substitutable goods, the cross-elasticity is negative. Also, the rice farmers in Togo are producers of other cereals, of which maize as the main crop, for the most part, they react by arbitration between the production of rice and that of other cereals in reference to the signals of the perceived prices. In the market, when the price of maize increases more than proportionally to that of rice, the producer is more inclined to increase corn supply more than rice and vice versa. We, therefore, hope for the negative influence of the variable "$P_{MAIZ}$" on the supply of local rice.

Some authors agree that, through education, the adoption of technological innovations in agriculture significantly influences agricultural productivity in general and especially that of rice (e.g. Weir and Knight 2000; Hossain et al., 2006; Asadullah and Rahman, 2009). The technical progress is embodied both in the quality and quantity of the improved seeds used. The higher the quality of the seeds, the better the chance of having good yields is. The more rice farmers have access to the improved seeds through subsidies, the more they use them. A positive influence of "$Q_{ISEED}$" is expected to be the amount of improved seed received as a subsidy by rice farmers on "$Q_{RICE}$" production.

Agricultural credit is a major stimulus contributing to the development of the agricultural sector. In fact, given the low income of the farming population, the majority of farmers do not manage to create savings that can enable them to make investments to develop their activities. Farmers without access to credit do not have the same efficiency as those with access to credit (Kinkingninhoun-Medagbe, et al., 2015). Agricultural credit allows, among other things, support for mechanization and the supply of inputs. Ceteris paribus, we can only expect a positive sign of the variable "CREDIT" on the paddy rice production.

As for those explanatory variables used in our regression model, table.2 presents summary statistics on production and inputs of paddy rice from the cross-sectional data of the 4th National Census of Agriculture 2001-2014.

**Table 2:** Summary statistics of local production and inputs of paddy rice

| Variables | Unit of measure | Mean | Standard deviation | Min | Max |
|---|---|---|---|---|---|
| **$Q_{PADDY}$** | Tons | 8507.67 | 5726.24 | 109.13 | 21591.68 |
| **$P_{RICE}$** | USD/KG | 0.35 | 0.07 | 0.25 | 0.65 |
| **RAIN** | Mm | 135.27 | 22.42 | 91.28 | 162.32 |
| **FERT** | USD/KG | 0.96 | 0.92 | 0.13 | 5.67 |
| **PHYTO** | USD/l | 0.43 | 0.44 | 0 | 5.60 |
| **CREDIT** | USD | 27.19 | 18.21 | 0 | 67.53 |
| **QISEED** | KG/ha | 1522.26 | 1653.67 | 6 | 9999 |
| **TEMP** | °C | 27.50 | 0.55 | 26.34 | 29.00 |
| **$P_{MAIZ}$** | USD/KG | 0.29 | 0.03 | 0.24 | 0.36 |

Source: Authors 'computation based on the data from the 4th National Census of Agriculture (RNA, 2011-2014).

We can notice a number of points from this table. The average amount of rice produced and offered by a producer is about 8,500 tons. During the period 2011-2014 when the survey was carried out, the kilogram of rice locally produced costs on average US$ 0.35. The cost of fertilizers and pesticides are respectively US$ 0.964 per kilo and US$0.43 per liter on average. The minimum zero value for plant protection products (pesticides) shows that some national rice growers do not use these products. The maximum amount of agricultural credit to which producers have access is about US$ 68, while the amount of improved seed each producer receives as a subsidy averages 1500 KG. The price of corn meanwhile, is between US$ 0.29 and

US$ 0.364 per kilo. The daily rainfall can even reach 162 mm depending on the localities while the average temperature is about 26 °C.

The Ordinary Least Squares (OLS) regression is used to estimate the parameters of our linear model of the local rice supply function. The estimation by the econometric software Stata 13 provides in one step the elasticities of the local rice production function and its supply in Togo and the coefficients of the different determinants. To estimate the parameters, we chose the functional form of the logarithmic type as explained above. The interest of this functional form is that it is practical and moreover the parameters of this function are the elasticities of the production vis-à-vis the various factors.

### 2.2.3. Data description

Data used for the present study were drawn from the ‘’4ème Recensement National de l’Agriculture 2011-2014’’ (MAEP, 2013). It is 4$^{th}$ National Census of Agriculture (RNA, 2011-2014) conducted by the Togolese Ministry of Agriculture, Livestock and Fisheries. This census was conducted according to the modular approach of FAO's global agricultural census program 2010 (basic and community modules by comprehensive enumeration and complementary/thematic sampling modules), which allows the articulation of the agricultural census in an integrated census and agricultural survey system with a community component. A total of 531,068 rural households were counted including 508,599 farm households. Farm households are assimilated to farms in which the sample of the RNA was drawn. The paddy rice database comprises 4256 rice producers.

The second reference dataset was collected from the Directorate of Statistics Information and Documentation (DSID) in Togo and from the Food and Agriculture Organization of United Nations (FAO) database.

## 3. RESULTS AND DISCUSSION

### 3.1. Results of rice supply estimation

Table 3 below presents the results of OLS estimates obtained by the robust heteroscedasticity method. In the second column of the table, we report the results obtained for the first estimation. In the third and fourth columns, results are reported using the " gender " to capture the difference in the responses of the various determinants of local rice production and its supply by the gender.

**Table 3:** Results of estimates

| | **First Estimation** | **Estimation according to the gender** | |
|---|---|---|---|
| | **For the whole sample** | **Male** | **Female** |
| **Constant** | -208.919* | -93.182 | -308.218* |
| | (0.022) | (0.639) | (0.049) |
| **PRIZ** | 1.342*** | 1.636*** | 0.955* |
| | (0.000) | (0.000) | (0.011) |
| **RAIN** | 0.089* | 0.070 | 0.122* |
| | (0.019) | (0.146) | (0.016) |
| **RAINsq** | -0.0003* | -0.0003 | -0.0005 |
| | (0.022) | (0.152) | (0.020) |
| **FERT** | -0.357*** | -0.414*** | -0.271*** |
| | (0.000) | (0.000) | (0.007) |
| **PHYTO** | -0.006 | -0.003 | -0.041 |
| | (0.922) | (0.971) | (0.568) |
| **CREDIT** | 0.671*** | 0.631*** | 0.721*** |
| | (0.000) | (0.000) | (0.000) |
| $\mathbf{Q_{ISEED}}$ | 0.101 | 0.055 | 0.186* |
| | (0.082) | (0.370) | (0.010) |
| **TEMP** | 16.337* | 8.105 | 23.366* |
| | (0.011) | (0.569) | (0.037) |
| **TEMPsq** | -0.294* | -0.145 | -0.419 |
| | (0.012) | (0.573) | (0.038) |
| $\mathbf{P_{MAIZ}}$ | -5.393*** | -5.535*** | -5.498*** |
| | (0.000) | (0.000) | (0.000) |
| **F-statistic** | 79.55*** | 13.22*** | 15.91*** |
| | (0.000) | (0.000) | (0.000) |
| $\mathbf{R^2}$ | 0.7270 | 0.7216 | 0.7682 |
| **Adjusted** $\mathbf{R^2}$ | 0.7027 | 0.6670 | 0.7199 |

NOTE: Values in parentheses refer to p-values. *** and * denote the significance respectively at 1% and 5%. The dependent variable is the production of paddy rice.

The results indicate that the producer price for rice has a positive and significant impact on supply. This fully justifies the relevance of the model chosen in this paper to analyze the determinants of local rice supply in Togo. The response of agricultural household supply to the selling price is positive as we have expected. This response of farmers' rice supply to the increase in the selling price of rice on the farm being elastic (elasticity = 1.342). This indicates that an increase in the farm gate price of 1% will increase the supply level by 1.34%. Rice supply relative to the producer price is more sensitive for men than for women (1.63 versus 0.96). On the other hand, our findings reveal that the price of fertilizers negatively and significantly affects the level of rice supply. A 1% downward improvement in the price of fertilizer will increase the level of production by 0.36%. As for the impact of the volume of agricultural credits, the analysis shows that a 1% increase in loans granted to rice growers will lead to a significant increase in rice supply of 0.67% overall.

The effect of the amount of subsidy of improved seed is not obvious. Indeed, the coefficient of subsidy quantity of improved seeds has a positive impact (0.101) but not significant overall with our first estimate. However, the second estimate involving gender indicates that the seed subsidy has a statistically positive and significant impact on female rice farmers at the 5% threshold (0.186 versus 0.055 for men). The effect of rainfall, whose influence should be statistically positive on the supply of local rice, is not surprising. The estimator obtained (0.089) by the robust heteroscedasticity method shows the existence of a positive and statistically significant impact of rainfall on the local rice supply. The coefficient 16.337 obtained for the temperature variable assumes that a variation of the temperature of 1% causes a variation of 16.34% of the rice supply in the same direction. Rainfall and temperature variables are significant at the 5% level. Since these variables are nonlinear in our model, our estimates indicate the threshold effects of 148.33 mm and 27.78 ° C, respectively, above which these two variables have a negative impact on local rice supply.

As for the price of corn, the results reveal a statistically significant relationship of corn price the supply of paddy rice locally. Indeed, when we cross the price of corn on the farm with rice production, we find a negative and significant coefficient reflecting the idea that the rise in the price of maize by 1% will lead to a decrease in the supply of local rice by 5.39%. Here too the supply is slightly sensitive for men (-5.54 versus -5.49 for women). Our estimates show that a 1% decrease in the cost of phytosanitary products will lead to an increase in rice supply of 0.006% for the entire sample. This sensitivity is 0.003% and 0.041% respectively for men and women.

In the final analysis, it should be noted that the values of the simple and adjusted coefficients of determination ($R^2$ and $R^2$ Adjusted) and Fisher statistic show that the estimates are generally acceptable. The specification explains about 73% of the variations of local rice supply in Togo. Finally, to confirm the robustness of our estimators, we applied the multicollinearity test and that of heteroscedasticity of Breusch-Pagan.

### 3.2. Discussion

The positive impact of the producer price is by no means counterintuitive since it could be expected that an increase in the price would encourage the producer to be more productive and thus increase the supply on the market. The positive effect of the producer price on rice production can also be explained by the existence of a positive relationship between price and quantity offered, as has often been acknowledged in the literature. This result is not surprising and is therefore consistent with the theory of supply. But it is contrary to those of the works of (Achy, 2016) who found that the supply of rice is negatively correlated with the price to the producer. He showed that Ivorian producers increased their production despite lower prices to ensure a minimum income. As for the sensitivity of local rice supply to credit, our results show that the variable ''CREDIT'' has a statistically significant impact on paddy rice supply. This confirms the findings from previous studies by Fontan (2008) in estimating the production and technical efficiency of rice farmers in Guinea. Also, Nuama (2010) concluded that a rice farmer who has obtained a credit has enough incentives to be technically efficient to honor his commitments. Obtaining credit reduces certain constraints of production, mainly the acquisition of inputs and the use of hired labor for certain cultural activities. The paddy rice farmer, who has received credit, whatever its nature, has an interest in applying much more to profit from the rice production activity. If funds obtained by farmers through informal or formal lending structures are used to purchase modern inputs, credit positively influences farmers' efficiency (e.g. Nuama, 2006; Mounirou, 2017). However, credit may not have an impact on agricultural performance if it is used for other purposes (e.g. Helfand et al., 2004; Coulibali et al., 2017).

Although not significant overall, the positive sign of the amount of improved seed subsidy shows the generally accepted trend. Mounirou (2017) in his work found that the volume of improved seeds used by the rice farmers determines the technical efficiency of the production of the rice in the municipality of Savé in Benin. While the high cost of improved seeds is very often a hindrance to their use, it is nevertheless obvious that they are necessary for the intensification of rice growing.

Regarding the effect of rainfall, the estimator obtained by the robust heteroscedasticity method obviously postulates the existence of a statistically significant impact of rainfall on the supply of local rice. This result is contrary to those of Kabore (2016) who, in his work, found that the variability of rice yields in Burkina-Faso is not significantly related to soil type or rainfall. However, the threshold effect of our estimates indicates that above 148.33 mm, rainfall has a negative impact on production and, in turn, the supply of paddy rice in the country.

Our results show for the temperature, a positive sign; which is in line with our expectations and the generally accepted correlation between temperature and rice production. Moreover, our results show that above 27.79 ° C, the temperature has a negative effect on local rice supply. The existence of a statistically significant and negative relationship between the price of corn and the supply of local rice reflects the idea that the increase in the price of corn will lead to a decline in the supply of local rice at home. The multi-activity of farmers affects their behavior as agricultural

producers: choosing certain crops that can be reconciled with other crops or even with part-time activity, a source of income that can be invested in the farm. The cost of phytosanitary products seems to have no significant effect on local rice supply in the country. For, the coefficient of this variable is not significant. However, our estimates show that a 1% decrease in the cost of phytosanitary products will lead to an increase in rice supply of 0.006% for the entire sample. This sensitivity is 0.003% and 0.041% respectively for men and women rice producers.

Ultimately, the results of our estimates indicate that at 1% or 5% thresholds, the coefficients of the explanatory variables in our model are all statistically significant, except the cost of phytosanitary products. This shows that levers that must be taken to effectively increase the supply of local rice in Togo exist.

## 4. CONCLUSION

Togolese agriculture accounts for 40% of GDP and employs more than 60% of the active population and remains the mainstay of Togo's economic growth. Despite this important share of agriculture in the national economy, domestic production of rice is not consistent to meet the demand for this food by the population. Rice is one of the main food crops in Togo. Its consumption is growing faster than production, thus increasing the deficit of the food balance of rice. Under these conditions, to meet the domestic needs of rice, Togo imports a very large quantity on a commercial basis. These imports reduce the incomes of local producers and cause the national economy to lose currency. Faced with such a situation and with regard to population growth, the development of rice production in Togo appears to be a challenge in terms of sovereignty and food security, the reduction in the volume of imports and in terms of the economic and social growth.

Paddy rice supply is thus mainly influenced by factors such as the level of production and the cost of factors as well as the elements of economic policy. It appears that the explanatory factors of rice supply in Togo are complex; it is, therefore, a combination of mutually reinforcing factors. This is why the present study focused on the question of local rice production and wanted a microeconomic analysis on the determinants of the local rice supply of agricultural households in Togo. Therefore, the question of the main determinants of rice supply in Togo and the effects of policies on its production becomes of paramount importance. This is exactly what this paper has aimed to. To do this, we adopted the theoretical. To do this, we used a logarithmic function from a linear regression model to estimate the local the supply of paddy rice from cross-sections data of the 4th National Census of Agriculture in Togo. Using the estimators obtained by the Ordinary Least Squares, we found that the price of rice to the producer has a significant positive impact on production and that the rainfall remains insufficient for the promotion of rice cultivation. The statistically positive effect of the volume of credit to rice producers is even reinforced by the improvement in the amount of selected improved seeds received by the rice farmers as subsidies. In addition, the results reveal that the cost of fertilizers and the price of corn - a complementary crop to rice for the producer - are factors that hinder the supply of local rice in TOGO. On the other hand, the cost of phytosanitary products seems to

have no statistically significant effect on the local supply of paddy rice in the country. Moreover, have these results of the econometric estimates shown that the individual supply of paddy rice is, on the one hand, elastic to the producer price and, on the other hand, inelastic to the price of mineral fertilizers, to the number of credits granted to farmers, to the price of corn - a complementary product of paddy rice on the farm. In terms of economic policies, there is a need to further support the establishment of efficient systems of climate-resistant seeds and varieties of rice throughout the country, agricultural credit and above all for rice farmers, so that bridging yield gaps, improving quality management along the value chain, and investment in rice production and processing infrastructure. The Togolese rice sector could become a driver of economic growth in the country, which would contribute to the elimination of extreme poverty and food insecurity. Good quality rice that can compete with imported rice requires a decent value chain approach through multi-stakeholder programs. Togo needs to start turning segments of the rice sector into commercial enterprises. This requires drastic reform by adopting market-friendly policies, committing more resources and bank lending to the agricultural sector. Finally, to truly boost the supply capacity of local rice farmers, the Government must invest much more in implementing new agricultural reforms that take into account the living and working conditions of farming households. It is then necessary to provide technical assistance that enables rice producers to improve their access to productive resources (credit, fertilizers, phytosanitary products, materials and equipment, hydro-agricultural infrastructures) and to strengthen their individual and organizational capacities through the organization of training to them.

## 5. LIMITATIONS

The empirical estimate of farm household production requires data that normally require regular recording of production, sales, own inputs or purchased over a period of at least one year (Upton, 2004). However, the data used here come from household surveys, conducted by single-pass, using the respondents' memory. Thus, the data is likely to be hit by a failure error of the respondents. In fact, the national structures in charge of agricultural statistics compile and disseminate a certain number of statistical data covering, in particular, the production, the yields, and the areas planted and other. But some key information for this study, such as labor costs, animal traction and motorized traction of the rice production system, are not systematically or annually disseminated. This would have made it possible to have the panel data better indicated for this study and thus capture the temporal dynamics of the levers of local rice supply in the country.

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