Spatial Interactions and Price Transmission in Yam Markets in Côte d'Ivoire

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Abstract

Spatial interactions are essential factors in the process of price transmission. However, very few studies have taken these factors into account in the analysis of price transmission.

This study attempts to analyze the price transmission in the yam markets in Côte d'Ivoire by emphasizing on spatial interactions. To do this, based on the two types of data, rainfall and the price series of four varieties of yams (kponan, krenglè, assawa and bêtè-bètè) and cassava, the dynamic Durbin spatial model has been used. The results show that prices are transmitted both between markets and yam varieties. Indeed, the prices of krenglè and assawa varieties influence the price of the kponan variety. The rainfall also increases the price of the kponan variety. Therefore, it would be important to take into account the different varieties of yam in price stability reforms and encourage producers to produce more of these varieties. Out-of-season production will prevent risks from climatic hazards.

Keywords: Price transmission, spatial econometrics, yam market, Côte d'Ivoire

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1. Introduction

The situation of prices on the markets of agricultural products and in particular of food products is a subject of interest and topicality for several economists. Indeed, prices play an essential role in the transmission of information, they indicate the relative scarcity of goods and allow the behaviour of producers and consumers to adapt (Gérard and al., 2008).

Many studies have been conducted on the determinants of commodity prices and price transmission in both developed and developing countries. Indeed, the prices of food products depend on various factors which are linked to the conditions of supply and demand. The movements of supply and/or demand generate a situation of fluctuation in the prices of agricultural products on the markets. The factors that affect supply and demand are of exogenous and endogenous types (Gérard and al., 2008; Nzie and al., 2010).Exogenous factors include climatic hazards (rainfall, phytosanitary pressures), technical progress (introduction of new crop varieties), agricultural policies, macroeconomic shocks linked to poor governance, marketing and transaction costs and the impact of international markets when there is substitution between imported products and local food crops, to name but a few factors. As for endogenous factors, they are relating to the very functioning of the market. These are the behaviors of the actors (producers and traders) who intervene in agricultural markets. These actors have price anticipation behaviors that affect the level of future production. Among the two types of factors, the majority of authors are unanimous that exogenous factors affect the supply of agricultural products more and lead to a variation in the prices of agricultural products on the markets (Collange and Guillaumat-Taillet, 1988; Gérard and al., 2008). In both cases, the influence of these factors on the prices of agricultural products leads to variations or fluctuations in these prices. This could have serious consequences on the food security of the most vulnerable populations. In particular, in the short term on consumers' access to food and in the long term on the incentive for producers to invest and increase their production (Galtier, 2009).

The most pronounced price variations are those that take place on international or world markets. These variations have effects on national or domestic or local markets. The magnitude of these shocks varies from one country to another, i.e. according to the degree of their dependence on international markets. Thus, the determining factors of price transmission in a country are multiple. These include trade flows, trade policies, transaction costs, institutional reforms, development of road and communication infrastructure etc. (Ihle and al, 2010; Etoundi, 2011; Zakari and al., 2014). Indeed, when the local markets of a country are dominated by international products, the transmission is more severe than in the case where the local markets are dominated by local products. Furthermore, there is also price transmission between national markets. This means that price transmission occurs between markets within the same country or region. Also at this level, a certain number of factors measure the degree of transmission of the prices of food products. In particular, transaction costs, distance, market power, the presence of associated organizations, the perishability of the product and many other factors (Fiamohe and De Frahan, 2012; Fiamohe and al., 2013). In addition, the transmission of prices is also perceived at the level of the agricultural sector, it means between the different actors who intervene in a market. This transmission is generally referred to as vertical transmission. Indeed, it is for example a question of showing how the prices to the producers are transmitted to the consumers. In this case, the determinants of transmission are, among other things, the nature of the product and the number of intermediaries involved along the supply chain (Sobia and Keho, 2013).

It must be said that the analysis of price transmission measures the degree of connection of the various spatially separated markets. This connection demonstrates the perfect integration of the markets. Similarly, if markets are perfectly integrated, this implies that price signals are transmitted from one market to another market. Several studies in the literature have analyzed price transmission mechanisms. These studies have focused on two types of price transmission, namely horizontal transmission and vertical transmission. Horizontal transmission relates to the transmission of prices in spatially separate markets for the same product. Whereas, vertical transmission indicates price transmission that takes place at different links in the supply chain.

Whatever the type of transmission, a great aspect of literature has focused on improving the evolution of methodology in the analysis of price transmission. The approaches started with the use of correlation coefficients. Some researches have used regression models with error correction models accompanied by cointegration techniques (Zakari and al., 2014; Blazkova, 2015; Chen and Saghaian, 2016). In addition, other works have focused on the nonlinear aspect in the analysis of transmission using threshold models (Brosig and al, 2011; Fiamohé and De Frahan, 2012; Abunyuwah, 2020). The common characteristic of these approaches is that they are mainly based on the analysis of time series. These studies do not take into account spatial interactions in the analysis of price transmission between spatially separated markets. Indeed, as the transmission of prices takes place between different markets or places, it is therefore necessary to take into account spatial interactions at two levels. First theoretically, the fact that the places of production and the places of consumption are not the same leads to transport costs and other costs that must be considered. At the modeling stage, not taking spatial interactions into account could then bias the results. Indeed, some authors have identified five reasons for including spatial characteristics (spatial autoregressive) in a regression model (LeSage and Pace, 2009): (i) time dependence, (ii) omitted variables, (iii) spatial heterogeneity, (iv) externality issues and (v) model uncertainty issues. Obviously, price dynamics in a given location are influenced by the prices of neighboring locations (Keller and Shiue, 2007). In other words, the price of a product on a market may depend on the price of the same product on nearby markets. Neighborhood characteristics influence the location of an observation. Thus, spatial characteristics are important because they influence the degree of market integration.

These spatial interaction problems are mainly modeled by spatial econometrics. However, this model has rarely been used for the analysis of price transmission in the literature. Nevertheless, it is capitalized on two studies that have used this methodological approach. The first study concerned price transmission in rice markets in China (Keller and Shuie, 2007). The second study took place in Niger on millet markets (Goundan and Tankari, 2016).

Like grain markets, yam markets are not exempt from important spatial features to consider. With this in mind, the main objective of this study is to highlight the spatial interactions in the analysis of price transmission in the yam market in Côte d'Ivoire.

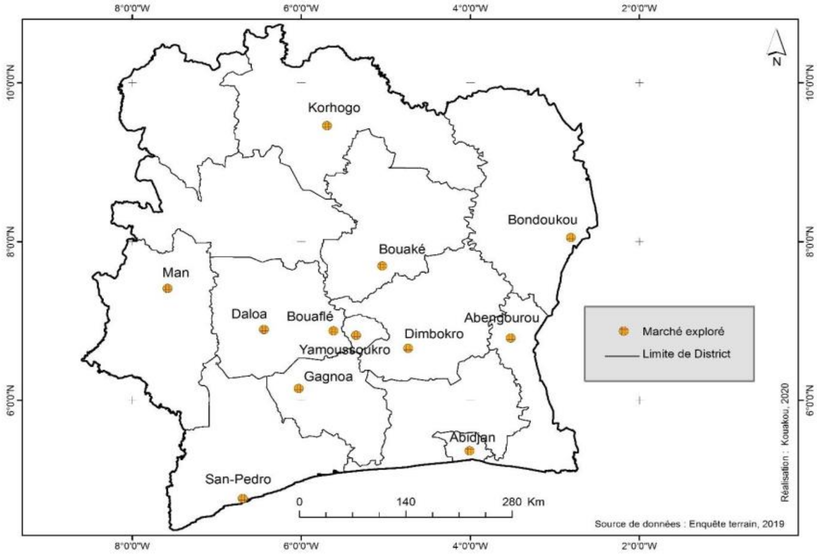
To do this, the work will be articulated around four main parts. First the methodology which will present the source and the technique of analysis of the data of the study. Then the results and interpretations will be discussed. Finally, the discussion of the results will be presented followed by the conclusion.

Research methodology

This section presents the framework, data collection and sources as well as the used model in this study. Indeed, the study covers the entire extent of Côte d'Ivoire and the used data come only from secondary data.

The study covers 12 markets in Côte d'Ivoire. These are the markets of Abengourou, Abidjan, Bondoukou, Bouaflé, Bouaké, Daloa, Dimbokro, Gagnoa, Korhogo, Man, San Pédro and Yamoussoukro. These markets are located in the different Departments of the country which are the regional capitals. Thus, out of 17 regions, 12 were exploited. The absence of the other five regions is due to the unavailability of data (see **Figure 1** : Location of exploited markets).

Figure 1. Location of exploited markets



Source : author's construction

It must be said that the study focuses on the yam market for three reasons. First, the yam is one of the five basic products with cassava, plantain, rice and maize. Then, in terms of local production, it ranks first among the basic products. Indeed, for this decade its annual production varied from 2.8 to 3 million tons (Anatole and al., 2017). Finally, the yam is consumed by the majority of Ivorians and has an economic and cultural value (Doumbia, 1990; Bricas and Attaie, 1998; Nindjin and al., 2007). In short, this culture plays an important role in the food security of Ivorians.

In the context of this article, two categories of data were collected. These are price series data and weather data.

Data on price series are monthly and relate to yams and cassava. They come from the Office for the Marketing of Food Products (OMFP). This structure was created in 1984. It is responsible for collecting and disseminating information concerning the prices and quantities of food products. The price series (in FCFA/KG) extend over the period from 2012 to 2018 for the 12 markets mentioned above. The series therefore has a duration of 7 years.

With regard to yam, it is important to specify that this speculation includes several varieties. Among these varieties four were retained in this study. These are the kponan, assawa, krenglè and bètè-bètè varieties which are grouped into two species. In particular the early ones (kponan and assawa) and the late ones (krenglè and bètè-bètè). The list of varieties is not exhaustive, but those mentioned are more common on Ivorian markets (Nindjin and al., 2007). Thus, for each variety of yam there is a series of prices available. Regarding cassava, two varieties are recognized, namely bitter cassava and sweet cassava. However, the study focused only on sweet cassava for two reasons. The first reason is due to the mode of consumption. Sweet cassava can be consumed either directly

(porridge, foutou, etc.) or after transformation into attiéké or placali. Unlike bitter cassava which is only consumed after processing (placali, attiéké, gari, etc.). The second reason for the choice is the unavailability of data on bitter cassava.
In addition, meteorological data, specifically rainfall, was collected from the *Société d'Exploitation et de Développement Aéroportuaire, Aéronautique et Météorologique* (SODEXAM). SODEXAM, as its name suggests, is responsible for the management, operation and development of airports, meteorology and aeronautical activities in Côte d'Ivoire in accordance with its creation decree No. 97-228 of April 16, 1997. It collects meteorological information from the various stations located in the regional capitals. Thus, the data on rainfall concern all the localities taken into account in the article over the same period of 7 years.

The appropriate methodological approach that takes into account spatial interactions in the analysis of price transmission is spatial econometrics. Indeed, spatial econometrics deals with the effects of spatial interactions between geographical units. These units can be postal codes, cities, municipalities, regions, countries, to name a few (Elhorst, 2014a). This econometrics is characterized by the presence of spatial autocorrelation. This therefore means that there is a functional relationship between what is happening at one point in space and what is happening elsewhere (Le Gallo, 2002). In other words, spatial dependence reflects a situation where the observed values at one place or region, let's say observation *i*, depend on the values of neighboring observations at nearby locations (LeSage, 2008). The appropriate tool to deal with spatial autocorrelation is the weighting or spatial weight matrix.

The weight matrix is the representation of the proximity relationships (geographical, cultural, social, economic) between units of analysis. This matrix is in the form of a square matrix having as many rows and columns as there are geographical areas. That is, N row and N column (N represents the region number). The matrix is denoted Wij and therefore represents how the i-region and the j-region are spatially connected. Thus, this matrix makes it possible to link together the neighboring regions according to their respective weight.

In this case, estimating spatial autocorrelation relates to defining how markets are connected to each other. Thus, based on standard spatial econometrics, the construction of the weight matrix is done through the geographic distance between markets. The intensity of the interaction between two markets i and j depends on the distance between the centroids of these markets. The indicator used in this study is the satellite positioning system (GPS). These data are characterized by the longitude and latitude of each city taken into account in the study sample. Indeed, longitude and latitude are used to measure or calculate the Euclidean distance between cities (Belotti et al., 2017). As a first step Therefore, the weight matrix w_{ij} is written as follows:

$$w_{ij} = \{\frac{\frac{1}{d_{ij}}}{\sum_j \frac{1}{d_{ij}}}, \quad for\ i \neq j\ 0, \qquad for\ \ i = j$$

where d_{ij} represents the Euclidean distance between cities i et j.

As part of this study with the specificity of the data available, spatial models in panel data will be used. This is in particular the Durbin Spatial Dynamic Model (SDMD) (Debarsy and al., 2012). On proposal, this model is also called the Spatial Dynamic Panel Data (SDPD) model (Lee and Yu, 2010). This model makes it possible to take into account three types of interaction in the transmission of prices. First, the consideration of time dependence. It means that the previous price can affect the price level of the next period in a specific location. This is particularly the case with time series modeling. Then the integration of endogenous interaction effects. The price level in a specific location is assumed to be influenced by the price level of adjacent locations. This is an interesting feature in the context of this study because the separate markets are linked by trade flows and price information. Finally, exogenous interaction effects are also integrated. It must be said that in the exogenous variables taken into account in the transmission model, those observed in adjacent locations are also considered. The model specific to this study is formulated as follows:

$$Pkpo_{it} = \delta Pkpo_{i,t-1} + \rho WPkpo_{jt} + \beta_1 \tau_{jt} + \beta_2 W\tau_{jt} + \theta_1 X_{it} + \theta_2 WX_{it} + \vartheta_i + \mu_t + \varepsilon_{it} \quad (1)$$

where $Pkpo_{it}$ is the price of yams of the kponan variety in market *i* at time *t*, $Pkpo_{i,t-1}$ is the price at time $t-1$; X_{it} denotes exogenous variables vectors or determinants of the price of kponan on the market *i* at time *t ;* W is the spatial weight matrix; $WPkpo_{jt}$ represents the price of the kponan variety in nearby markets j ; τ_{jt} is the price level of varieties (assawa, krenglè, bètè-bètè and cassava) from market *i* to time *t ;* $W\tau_{jt}$ is the price of varieties (assawa, krenglè, bètè-bètè and cassava) on nearby markets j ; ϑ_i represents fixed effects by market to control for country heterogeneity not observed over time t ; μ_t indicate temporal dummy variables controlling each year the common shocks affecting the Ivorian yam markets ; ε_{it} is the independent and identically distributed error term and ρ is a spatial autocorrelation coefficient.

On the other hand, the presence of the spatially lagged dependent variable and the temporally lagged dependent variable in the equation creates an endogeneity problem.

Equation (1) indicates this presence mainly by the simultaneity relationship between $WPkpo_{jt}$ and $Pkpo_{it}$ and by omitted variables that can be correlated with $Pkpo_{i,t-1}$. In order to have control over these biases, a quasi-maximum likelihood (QML) estimator for spatial dynamic panel models will be used (Yu and al., 2008; Lee and Yu, 2010; Elhorst, 2014b). The implementation of this method in the Stata software was done through the "xsmle" command (Belotti and al., 2017).

To do this, equation (3) must be transformed to the reduced version. The form of the transformed equation is as follows:

$$(I-\rho W)Pkpo_{it} = \delta Pkpo_{i,t-1} + \beta_1 \tau_{it} + \beta_2 W\tau_{jt} + \theta_1 X_{it} + \theta_2 WX_{it} + \vartheta_i + \mu_t + \varepsilon_{it} \quad (2)$$

$$Pkpo_{it} = (I-\rho W)^{-1}\left[\delta Pkpo_{i,t-1} + \beta_1 \tau_{it} + \beta_2 W\tau_{jt} + \theta_1 X_{it} + \theta_2 WX_{it} + \vartheta_i + \mu_t + \varepsilon_{it}\right] \quad (3)$$

With the reduced form, the model can be estimated using the bias-corrected quasi-maximum likelihood (QML) approach described by Yu and al. (2008). Indeed, estimation using the QML method produces consistent estimates in the presence of spatially lagged dependent variables (Lee, 2004). In addition, the reduced-form equation also makes it possible to simplify the likelihood function and its optimization.

It should be clarified that given the structure of the model, it would be ideal to address endogeneity when running as Simultaneous Regression and Generalized Method of Moments (IV/GMM). It is however difficult, if not impossible, to derive maximum likelihood (ML) or Bayesian estimators of models with spatial dependence and additional endogenous explanatory variables (Elhorst, 2014a). Additionally, using IV/GMM to estimate an SDM is less efficient than ordinary least squares unless the number of observations is greater than 500,000 (Pace and al., 2012). Since second-order spatially lagged explanatory variables in an SDM are weak instruments, they do not correctly identify the spatial autocorrelation coefficient.

In this study, price transmission in yam markets focuses on the kponan variety among the four varieties available. The attention paid to this variety is justified by the fact that it is the most consumed and prized variety in Côte d'Ivoire (Nindjin and al., 2007; Mahyao, 2008). Thus, in the model the price of the kponan variety is considered as the dependent variable in the model. The other varieties (assawa, bètè-bètè and krenglè) are considered as substitution varieties and therefore their prices represent the explanatory variables in the model. Similarly, the price of cassava was added to the explanatory variables since, belonging to the same family (tuber), it is considered a substitute product for yam. An important variable has been taken into account in the model. This is rainfall, which is an important factor in yam production that can influence market prices. Table 1 below summarizes the variables in the model presented above.

Table 1. Specifying variables in the DSDM model

Model	Variable to be explained	Explanatory variables
$Pkpo_{it}$ **Model**	Price of kponan	1. Rainfall 2.Assawa 3.Krenglè 4.Manioc 5.Bètè-Bètè

Source: author's construction, OCPV and SODEXAM (2019) data

Furthermore, the considered prices in this model are the average annual wholesale prices (FCFA/KG) of the different varieties of yam and cassava. This choice is justified on the one hand by the availability of data and on the other hand by taking into account the requirements of spatial econometric models. Indeed, these models apply to balanced panel data, i.e. individuals are observed over the entire period. In other words, panel data does not have missing values. Missing data can be problematic for spatial econometric models. Indeed, in a spatial context, the result of an observation depends on the results of the others, each observation thus representing a part of the spatial shift for the other observations. Moreover, missing data can complicate the convergence of the model. To overcome these problems (missing data), the monthly price series were grouped into average annual prices for each variety of yam and for cassava.

The specification tests make it possible to confirm the choice of the Durbin spatial dynamic model (DSDM) on the one hand and on the other hand to specify the type of model (fixed effects or random effects) within the framework of this study. Indeed, two tests are carried out, the validity test of the Durbin spatial dynamic model (DSDM) compared to the spatial autoregressive model (DSAR) and the spatial error correction model (SEM) and the Hausman test. The first test is to validate the DSDM model in the price transmission analysis against the DSAR and SEM model. The second test makes it possible to choose between the models with fixed effects and the models with random effects.

Regarding the DSDM validity test, we test the relevance of the DSAR model and the SEM model in the analysis of price transmission compared to the SDSM model. To do this, when we reduce equation (3) by canceling the coefficient β=0. In this case, the specification of DSDM is reduced to that of DSAR because it was considered that the coefficients of the spatially shifted explanatory variables are not significantly different from zero (LeSage and Pace, 2009).

Subsequently, to assess the appropriation of the DSDM model compared to the DSAR model, we test the joint nullity of the coefficients of the spatially shifted explanatory variables ($\theta_2 = \beta_2 = 0$) see equation (3). This test is significant at the 1% level ($\chi^2(11) = 230{,}02$; $Prob > \chi^2 = 0{,}0000$), leading to the rejection of the null hypothesis. It means the rejection of the DSAR model. Furthermore, the SEM model also derives from the DSDM model if in equation $\rho\beta_1 + \beta_2 = 0$ et $\rho\theta_1 + \theta_2 = 0$.

We reject the null hypothesis that $\beta_1 + \beta_2 = 0$ and $\rho\theta_1 + \theta_2 = 0$ ($\chi^2(4) = 193009{,}96$; $Prob > \chi^2 = 0{,}0000$) also at the 1% level. This implies that the DSDM model is preferred to the SEM model. The two verification tests of the DSDM model against the DSAR and SEM specifications confirm that the DSDM model is appropriate for this study.

Concerning the Hausman test, it is a question of making the choice between the DSDM model with fixed effects and that with random effects. The results of the Hausman test indicate ($\chi(11) = -140{,}50$; $Prob > \chi^2 = 0{,}000$) implying the rejection of the null hypothesis of independence between the unobserved individual effects and the explanatory variables. Therefore, the fixed-effect DSDM model is chosen in the present study. After the verification of these different tests, other statistical tests were made to bring out the averages, the standard deviations and the minimum and maximum price of the price variables.

Results

The results of this study show that the interactions are really present in the transmission of prices on the yam market in Côte d'Ivoire. But before presenting the results of the estimates in detail, it is important to describe the statistics at the level of the different variables used in the model. In the model, a total of 84 observations were estimated. This number of observations is the multiplication of the number of markets (12 markets) and by the duration of the data (7 years). From these observations, the statistics revealed the price averages, the minimum price and the maximum price of the different variables used in the spatial model.

Thus, we note that among the yam varieties, kponan has the highest average price at 317 FCFA/KG with a minimum price of 101 FCFA/KG and a maximum price of 675 FCFA/KG. Krenglè comes in second place for an average price of 267 FCFA/KG with a minimum price of 125 FCFA/KG and a maximum price of 610 FCFA/KG. The assawa finally followed by the bètè-bètè for respectively average prices of 238 FCFA/KG and 157 FCFA/KG. The assawa variety has a minimum price of 100 FCFA/KG and a maximum price of 625 FCFA/KG. As for bètè-bètè, the minimum price is 78 FCFA/KG and the maximum price is 263 FCFA/KG. Regarding cassava, it only has an average price of 75.5 FCFA/KG with a minimum price of 25 and a maximum price of 157 FCFA/KG. In addition, on the sample, there is an average rainfall of 1253 millimeters with a minimum precipitation of 605.1 millimeters and a maximum of 2171.5 millimeters. All this information is grouped together in Table 2 below.

Table 2. The statistics of the variables in the model

Variable	Average	Standard Deviation	Min	Max	N
Kponan	316,8452	93,4440	101	675	84
Rainfall	1252,7620	294,8342	605,1	2171,5	84
Assawa	238,0119	86,1488	100	625	84
Krenglè	267,1667	80,0090	125	610	84
Cassava	75,5238	31,4411	25	157	84
Bètè-Bètè	156,6310	30,7079	78	263	84

Source: author's construction, OCPV and SODEXAM data
$N = 12$ Markets, $T = 7$ ans et $N \times T = 84$

1. Nature of spatial interactions: Transmission of yam prices in Côte d'Ivoire

The main empirical results of this study are presented in Table 3. The presence of spatial interactions in the transmission of yam prices is confirmed by the significant value of ρ. Precisely **ρ=0.5014>0**, this means that there is indeed a transmission of prices between regions for the yam market. Indeed, a change in the price of substitute products in one region has an effect on the price of kponan in other regions. However, in column (1) of Table 3, the estimated coefficient of the price variable of kponan in year t-1 is not significant, suggesting that past prices are not as important in having an effect on future prices in markets. Table 3 summarizes the results of the estimations.

Table 3. Model estimation results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Estimations		Short-term marginal effects			Long-term marginal effects		
VARIABLES	Moy	WX	Direct	Indirect	Total	Direct	Indirect	Total
L.Kponan	0,0809 (0,0872)							
Pluviometrie	0,0401*** (0,0056)	0,0064 (0,0301)	0,0389** (0,0175)	-0,0099 (0,0217)	0,0299 (0,0253)	0,0435** (0,0191)	-0,0118 (0,0231)	-0,0316 (0,0268)
Assawa	0,3895*** (0,0557)	-0,5650** (0,2776)	0,4219*** (0,0559)	-0,5446* (0,2044)	-0,1227 (0,2395)	0,4620*** (0,0615)	-0,5936 (0,2174)	-0,1316 (0,2560)
Krenglè	0,1984*** (0,062)	0,9398*** (0,1680)	0,1673** (0,075)	0,5963*** (0,179)	0,7637*** (0,185)	0,1801** (0,083)	0,6288*** (0,196)	0,8089*** (0,203)

Manioc	0,4806** (0,250)	0,7741** (0,5356)	0,4583 (0,266)	0,3724 (0,345)	0,8307*** (0,232)	0,4983 (0,292)	0,3784 (0,371)	0,8768*** (0,241)
Bètè Bètè	-0,0910 (0,051)	-0,3254 (0,2588)	-0,0807 (0,060)	-0,1930 (0,186)	0,2738 (0,144)	-0,0872 (0,066)	-0,2017 (0,199)	-0,2889 (0,152)
Rho		0,5014** (0,2117)						
sigma2_e		2286,691*** (230,258)						
Observations	72	72	72	72	72	72	72	72
Number of group	12	12	12	12	12	12	12	12
Log-pseudolikelihood	-376,6812	-376,6812	-376,6812	-376,6812	-376,6812	-376,6812	-376,6812	-376,6812

Captions : ***, **, * p<0,01, p<0,05, p<0,1 represents statistical significance
Sigma2_e: the standard deviation of idiosyncratic errors
rho: the coefficient of the spatially lagged dependent variable.
Source: author's construction, OCPV and SODEXAM data

The reading of Table 3 presents eight (08) columns. Columns (1) and (2) report the estimation results of the first spatial difference of the model (3). Columns (3) to (8) present the results of the direct, indirect and total effects of the explanatory variables on the price of kponan yam.

By combining the results of columns (1) and (2), it is noted that out of five (05) estimated parameters, four are significant at the threshold of 1% and 5%. These are the parameters linked to the explanatory variables, namely rainfall, the varieties of yam assawa and krenglè and cassava. Rainfall has a positive impact on the price of kponan at a high of 0.0401 point or 4% while its delayed term is not significant. The price of assawa positively affects (0.4522) the price of kponan at 0.3895 (39%). On the other hand, its delayed value, i.e. its previous price, has a negative influence with 0.5650 points (i.e. 57%). In the same way the price of krenglè as well as its previous price positively affects the price of kponan with a respective level of 0.1983 (20%) and 0.9398 (94%). Finally, the price and its delayed value have an influence on the price of kponan with the respective points of 0.4806 (48%) and 0.7741 (77%). We see that it is only the price of the bètè-bètè variety that is not significant.

With regard to columns (3), (4) and (5), the results relate respectively to the direct, indirect and total short-term marginal effects of the explanatory variables on the dependent variable.

As a reminder, the explanatory variables in this study include the price of yam varieties (assawa, bètè-bètè and krenglè), the price of cassava and rainfall (meteorology). First, it is noted on reading the table in general, that a variation in cassava prices and the bètè-bètè variety has no direct or indirect impact on the price of kponan in the short term or in the long term. Then, focusing on columns (3), (4) and (5), the results show significant direct effects (at the 1% and 5% threshold) of rainfall, assawa and krenglè prices on the price of kponan with respective values of 0.0398, 0.4219 and 0.1673. This means that a variation in rainfall, assawa and krenglè prices is transmitted to the kponan price for about 4%, 42% and 17% respectively. Concerning the indirect effects, the results indicate the significance (at the 10% threshold) of the variation in the price of assawa and that (at the threshold of 1%) of the variation in the price of krenglè on the price of kponan in the other regions for the yam market. Thus, a change in the price of assawa negatively affects the price of kponan in other regions at around -0.5446 (54%). Same, a change in the price of krenglè positively affects the price of kponan in other regions at around 0.5963 (60%).

Also, the full effect of krenglè price significance persists but this time around the impact is around 0.1852 (18%). Moreover, we note that there is a significance of the price of cassava on the price of kponan when we add the direct and indirect effects (total effects). This significance is at the 1% threshold and the positive impact at a level of 0.8307 (83%). Finally, the last columns (6, 7 and 8) of Table 3 relate to the direct, indirect and total long-term marginal effects. Here the results are practically similar to those of the short-term marginal effects with a few differences. The same variables (rainfall, assawa and krenglè prices) remained significant (at the 1% and 5% threshold) and the impact is positive. This means that these variables have direct effects on the price of kponan Indeed, a variation in rainfall, assawa and krenglè prices is transmitted to the price of kponan. This impact is 0.0435 (4%) for rainfall, 0.4620 (46%) for the price of assawa and 0.1801 (18%) for krenglè. We note, however, that unlike the column results (3, 4 and 5), only the price of krenglè has an indirect effect on the price of kponan. A change in the price of krenglè affects the price of kponan in other regions at around 0.6288 (63%). However, at the level of the total effect, the observed results are identical. The variables (price of krenglè and cassava) are significant at the 1% level. The impact of the krenglè price variation on the kponan price is 0.8089 (81%) and that of the cassava price is 0.8768 (88%).

In this study, two types of variables were used in the transmission of yam prices, namely price variables and non-price variables. The results of the estimates show that the non-price variables, i.e. rainfall, have no effect on the price of kponan yam. With regard to the price variables, we note that the variation in the prices of assawa yam, krenglè and cassava has effects on the price of kponan yam. But among these variables, the krenglè price is considered as the control variable, i.e. a variable makes the results of the estimates relevant. Indeed, the results showed that in the short and long term, the price of krenglè has a direct and indirect effect on the price of kponan. This means that the price of krenglè affects the price of kponan regardless of whether these two varieties are present in the same market or in different markets. We can therefore perceive through this result that the formation of the price of kponan on the market takes into account the price of kenglè.

Disscusion

With regard to the results of the estimations in this study, two major results emerge. First, the consideration of spatial interactions in the analysis of price transmission in yam markets. This means that the spatial characteristics of each market have been considered in the model. Thus, among the explanatory variables taken into account in the model, variables such as rainfall, assawa and krenglè prices were tested to be significant. In other words, a change in rainfall and prices of assawa and krenglè varieties affect the price of the kponan variety. Secondly, the impact of these variables is specified through the effects (direct and indirect) in the short and long term. Indeed, the direct effects (short or long term) of the explanatory variables measure the impact of a variation of these explanatory variables on the dependent variable in a market *i*. The indirect effects relate to a variation of the explanatory variables on the dependent variable in the other markets. When we consider the individual effects of each variable, we notice the important role of each. Regarding rainfall, the results show that this factor has a direct effect both in the short and long term on the price of kponan. This means that rainfall affects the price of kponan in a considered market. However, this influence has a low rate (4%). In addition, the rainfall evolves in the same direction as the price of kponan. This result does not reflect reality because the rainfall should evolve in the opposite direction. This could be explained by the fact that other parameters should be taken into account, as some works by Keller and Shuie (2007) showed.

These authors considered both flooding and drought. They also considered the weather variable by categorizing it into three levels: (i) bad weather (exceptional drought and flooding), (ii) good weather (limited drought and flooding) and (iii) good weather (favorable conditions). Taking into account the appreciation of meteorology by level allowed them to better capture this variable in a model. Moreover, other studies have stipulated that weather variables can only affect supply and therefore price if they have extreme values. For example, the values of a flood or a drought must be stable and cover a large geographical area (Nzie and al., 2010). All these factors show the inconsistency of the result of the effect of rainfall on the price of *kponan* yam.

Regarding the price of assawa, in the short and long term the price of assawa acts on the price of kponan on the same market at substantially equal rates (42% and 48%). Similarly, a variation in the price of assawa affects the price of kponan by more than 50% on other markets or neighboring markets, but only in the short term. These results indicate that the assawa yam variety is a substitute variety for the kponan variety. Indeed, these two varieties belong to the same species *D. Cayenensis-rotundata (D.c.r to 2r)* commonly called early yams (Doumbia and al, 2006; Mahyao, 2008). They are produced and harvested in the same period and in the same areas. Among the early ones these two varieties are common in the markets. The kponan variety is the most appreciated by Ivorians, so it is placed in first position after the assawa variety (Nindjin, 2007). The latter is also exported to the sub-region such as Mali.

The price of krenglè on the other hand has a direct and indirect effect on the kponan price in the short as well as in the long term. In other words, a change in the price of krenglè influences both the price of kponan on the same market and on other markets or neighboring markets. This again demonstrates as assawa the question of substitution between the kponan and krenglè varieties. This means that the difference in terms of consumption between these varieties is not great. Like the assawa variety, all the different varieties are produced locally. At the level of this result, there is a relevant remark which is made, it is that the direct and indirect effects on the price of kponan take place in the short and long term as mentioned earlier. This leads us to consider this variable, i.e. the price of krenglè, as an important element in the variation of the price of kponan on the market. While the two varieties (kponan and krenglè) do not belong to the same species. Unlike the assawa variety, the krenglè variety is from the *D. Cayenensis-rotundata species (D.c.r to 1r)*, commonly called the late variety (Doumbia and al., 2006; Mahyao, 2008). Indeed, the krenglè yam is one of the species This yam appears on the market in the month of December until July-August when it begins to disappear (available in small quantities). This scarcity of krenglè in the markets leads to a high price. During this time, early yams appear, including the kponan variety. The price of kponan during the first periods of its appearance is on the rise. This price increase could be due to free competition between supply and demand. But it could also be defined by the continuity of the finishing price of the krenglè variety that sellers maintain for the kponan variety.In this situation, one could say that the future price of kponan yam is influenced by the previous price of krenglè yam in the markets. This makes the price of krenglè yam a determining factor in the formation of the price of kponan. From this explanation we notice in reality the krenglè variety is not really a substitute for the kponan variety since they are present on the markets consecutively. These varieties would be rather complementary. Furthermore, it must be pointed out that just as the kponan variety is appreciated by Ivorians, the krenglè variety is among the late varieties the second to be appreciated at a given time of the year in culinary terms (foutou) (Nindjin and al, 2007). These explanations could therefore justify the results of the estimates in relation to the price of krenglè. At the end of this justification, it can be noted that the formation of the price of the kponan yam also takes into account that of the krenglè yam. Overall, the interpretation of the results of this study revealed that the transmission of prices took place between the varieties of yam and the rainfall between the different markets.

Conclusion

This article has highlighted the presence of spatial interactions in the transmission of prices on yam markets in Côte d'Ivoire. This analysis concerned both the transmission of prices between different markets and between different products considered to be substitutable. To do this, the study was based on the use of the dynamic spatial Durbin model (DSDM). A model that is rarely used in the analysis of price transmission and therefore market integration. This model makes it possible to take into account the spatial characteristics (spatial interaction) in the transmission of prices. Unlike the studies that have used this model, this study considered as explanatory variables the products (varieties) of substitution as well as the meteorology (rainfall). The results reveal that both types of variables (price and non-price) have an influence on the price of kponan. Thus, a change in the price of assawa or the price of krenglè affects the price of kponan in the short and long term. In addition, through the degrees of price transmission of these results, we can say that there is a form of substitution between yam varieties even if in reality the krenglè variety presents a certain complementarity with respect to its appearance on the markets. These results call for the existence of an integration of yam markets in Côte d'Ivoire through early and late varieties. This would be due first to a good organization of the actors (traders). Then, the existence of a connection between markets through trade flows. Finally, the road infrastructure, especially for the major axes, would be passable as well as the development of telephone networks.

Several studies have in addition shown that kponan yam is the most consumed yam of all varieties but this study proves that price changes of kponan are also due to price changes of other varieties. Assawa, krenglè and kponan yams are all important for food security in Côte d’Ivoire. Thus, the focus should be on the production of these varieties encouraging producers. This would solve the problem of availability and at the same time accessibility. Similarly, conditions should be created to promote off-season production to avoid the risk of climatic hazards. It would be furthermore interesting for other investigations to measure the changeover time from one variety to another and from one market to another. This could provide insight into the nature of price transmission in yam markets.

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