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Price risk and farmers' decisions: A case study from Benin

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ABSTRACT

Farmers face many types of risks that affect their behavior and well-being. Among these risks, the one related to the price of products appears the most economically sensitive. They develop various strategies to cope with this, either by taking decisions at the level of their exploitation, by using instruments offered by the market, or by diversifying their sources of income. This article analyzes, using a system Generalized Method-Of-Moment (GMM), the decisions made at the farm level to show that farmers are increasing their production and the areas that they sow in response to price volatility. Thus, price volatility exerts an incentive to increase maize production in Benin. This paper suggests taking the influence of risk aversion into account when defining policies to stabilize agricultural prices particularly in developing countries.

Introduction

Farmers face two main types of risk: production risk and price risk. The risk of production, or risk of return, concerns events of chance origin, related to nature, to which the producers are exposed. These shocks are linked inter alia to either rainfall and climatic variations, invasions of insects, or the occurrence of diseases. Sadoulet and de Janvry [42] note that the yield risk is particularly important for the individual producer. However, yield risk may be reflected in the price risk. Price risk due to price volatility, refers to unexpected price fluctuations that are so large and rapid that it becomes impossible to make expectations [36].

In agriculture, prices are subject to strong fluctuations. The significance of this price risk is mainly due to the lag between the production decision and the timing of the harvest associated with the low price elasticity of demand [11]. Price instability in African countries has increased as a result of the liberalization reforms of the agricultural sector in the 1980s in a context also marked by imperfect markets [15,43]. While farmers in developed countries have access to market-based

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tools to hedge against price risk such as insurance or futures markets [22], these tools are generally unavailable or very weakly developed in developing countries [43].

However, in the absence of an insurance mechanism, the price risk induces prudent behavior on the part of the farmer. The farmer produces less and postpones the impact on the consumer. The consumer sees his burdens increased because a decrease in production translates into high prices due to the price elasticity of demand, which is particularly low in agriculture. Such a situation is not far from generating social problems, as evidenced by the "hunger riots" in several parts of the globe (Mali, Burkina Faso, Cameroon, Mexico, Thailand, etc.) during the surge in food prices toward the end of last decade [5,20].

Consumers are not the only people severely affected by the phenomenon of volatile prices. Poor producers are affected equally, at least they are when a new element, risk aversion is incorporated into the framework. An individual is assumed to be risk averse when he prefers low earnings but sure to uncertain high gains. Araujo Bonjean and Boussard [3] point out that the degree of risk aversion depends on the initial level of wealth of the farmer. A poor producer is empirically more averse to risk than is a rich producer and, therefore, apprehends a situation of unstable prices as a threat. From this point of view, a poor producer will seek to reduce the consequences of a price decline and will not be able to take advantage of the price increases. Voituriez [45] concludes that uncovered price risk is a source of inefficiency, since it causes an increase in prices that is harmful to consumers and detrimental to poor producers.

Consequences of the price risk may be harmful to producers, particularly in the Sub-Saharan Africa (SSA) countries where farmers are both producers and consumers of their products. Indeed, this can be a major problem in the SSA countries where agricultural production fails to keep pace with the needs of the growing population. Current production and productivity trajectories show that sub-Saharan African countries will not be able to close the growing gap between supply and demand because of the pressure of population growth and urbanization on demand agricultural products [34]. This inability of farmers to meet demand is, among other things, attributed to the weak supply response of smallholders who do not systematically respond to market signals ([30] and Di Marcantonio et al., 2014).

Poor farmers' ability to cope with this type of risk would lead to serious food problems. Serra [43] argues that this price fluctuation is one of many factors affecting food security in the region. This concern is still legitimized by the peculiarity of countries in Africa south of the Sahara (SSA), such as Benin, where more than half of the population lives in rural areas and where the income of most of these people depends on agriculture (MDAEP[1] and UNDP, 2015).

In the context of Benin with unstable and unpredictable prices for agricultural products, and where price signals can sometimes be misunderstood, considering a mechanism to regulate supply and demand to stabilize price changes remains a major concern. The National Office of Stabilization of Cereal Prices, a Beninese organization tasked with this issue, finds it difficult to find the right strategy. In addition, price stabilization for producers remains controversial when producers have little opportunity to hedge against price risk. Their means of action are all the more limited because the credit, futures, and insurance markets are imperfect, particularly in most developing countries.

Several studies have been conducted to better understand the decisions of farmers in price risk situations [4,25,33,42]. Most of these works remain theoretical, and few of the studies are specific to sub-Saharan Africa. The main contribution of this article is to analyze supply behavior of farmers in developing countries by taking into account price risk. A good knowledge of the interrelationships between price risk and farmers' attitudes is, nevertheless, necessary for a better formulation of agricultural policy objectives in developing countries. To do this, we fill this gap by highlighting the differentiated responses of producers under price risk.

The application to Beninese farmers is motivated by the fact that food prices in this country have not escaped the successive outbreaks of 2007–2008 and 2010–2011. The consequences of this were particularly disastrous, thereby leading the government to put in place a set of price stabilization measures (see Table A4 in annex) with more nuanced results [1]. Indeed, the government over the period of six months (December 2007-May 2008) has implemented a system of closer monitoring of the price evolution of the main imported products by reducing the mercurial value to be used as a basis for the calculation of the customs levies and in order to bring prices back to pre-rise levels. Similarly, the government has made available to ONASA[2] a subsidy for the creation of a buffer stock of food products (maize, sorghum, rice and soya). But the measures adopted did not have the desired effect on price fluctuations. Some measures have experienced difficulties in their implementation that have made them ineffective. For example, after the attempt to control the prices of the main imported food products in the first six months of the year, the Beninese State had given up the extension of the implementation of this measure because of the excessive fluctuation of international product prices [46].

Data suggest that price volatility is not an isolated phenomenon in the country as one might think (see Table A1). At the best of our knowledge, there are no studies on the supply of agricultural products in Benin that have taken into account the impact of price risk. This paper aims therefore to analyze the influence of price volatility on farmers' supply using the GMM method (Generalized Method of Moment). We show that the choice of production levels and areas planted by farmers are affected by price volatility. Farmers tend to increase their production as well as the acreage in response to this price volatility to ensure food self-sufficiency.

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[2] ONASA: National Office of Support to Food Security in Benin.

This paper is organized as follows: In the next section, impacts of price risk on farmers and their responses to mitigate the effects are reviewed. Section 3 deals with the methodology and data used. The empirical results are presented and discussed in section 4. Section 5 presents the conclusions.

Literature review

Several theoretical and/or empirical contributions have dealt with the behavior of farmers in the face of price risks [8,20,22,24,30,44,49]. In general, these different studies highlight the impact of agricultural price fluctuations on the well-being of farmers as well as the influence of price volatility on decisions making in terms of the allocation of factors of production and offer.

Effects of price risk on farmers

It is common for agricultural households in developing countries to face unstable food prices, which are closely correlated with food production. Price risk, often referred to as market risk, is linked to price fluctuations for finished products and inputs [14]. Several empirical studies highlight the negative consequences of price risk for farmers. El Benni and Finger [17] show that farmers using traditional less intensive techniques are highly affected by price risk. The double price and yield risk induce an average change of 98% in the net income of Swiss farmers for sugar beet.

Wossen et al. [49] studied the impact of price and climate change on the welfare of farmers in Ghana and Ethiopia. They show that price fluctuations in agriculture have negative effects on farmers. The effect is greater when the concerned individuals are poor. Poorer agents see price and climate variability exacerbate their level of poverty by deepening inequality with the poorest and increasing their food insecurity For Gilbert and Morgan [22], the impact of high and volatile grain prices is concentrated on the poorest countries rather than the developed economies. Authors note that at the individual level, the impact of price volatility on well-being is greater in a developed country than in a developing country.

Sudden increase in prices poses a threat to farmers in developing countries who base their planning and investment on anticipated prices. Farmers who depend mainly on agricultural products - as is the case in sub-Saharan African countries - see price instability results on large fluctuations in their income, at which they are disarmed [19]. These producers are in fact less equipped to take advantage of this price volatility.

Rezitis and Stavropoulos [39] underline that a very pronounced fluctuation in the price of agricultural products increases the uncertainty about the prices expected of the producers, particularly in the absence of mechanisms of coverage of the risk. High food prices could increase farmers' incomes, provided they are net sellers and that price increases are effective in local markets and do not result in higher production costs. On the other hand, uncertainty poses a serious threat to poor smallholders. For many producers, especially smallholders, some of the conditions described above were not met during the 2007–2008 food crisis. In developing countries, producers are mostly net purchasers of foodstuffs, which implies that they spend more than the income from the sale of the harvested produce alone. As a result, they face significant obstacles that prevent them, among other things, from increasing production for the market. Responses to price volatility therefore depend on the attitude of the producers and can vary from one producer to another.

Attitudes of agricultural producers to price risk

Episodes of price volatility usually induce a variety of responses to shocks. High prices induce reactions from producers, who have the options of either, increase the area sown or increase investments to improve returns [35]. But price risk is reflected in successive and unpredictable phases of high and low volatility [9]. Such unpredictability in price movements may have implications for the allocation of resources and investment decisions of producers.

Sadoulet and de Janvry [42] pointed out that price risk appears to be the most important element in the decision-making process of farmers. Indeed, prices play an "allocative" role. They function as a signal for farmers in choosing crops that can provide them with high incomes. However, the randomness of the price variable makes its parameters difficult to control. This complicates the role of information that price is assumed to play [10]. Thus, a transient increase in prices can result in positive changes in farmers' production plans and, ultimately, will lead to lower incomes. Smallholder farmers in developing countries face the problem of volatility in the prices of agricultural products, and the increase in production is not enough to mitigate the effects [34]. The price risk is likely to change the choices of farmers before the establishment of production.

Indeed, investment decisions take into account the price volatility of previous periods. Boussard [11] notes that it is impossible for smallholder farmers, in an environment of volatile prices, to choose correctly their production techniques or even to plan their investments calmly. Price volatility is likely to distort the allocation of inputs, inhibit agricultural investment, and reduce agricultural productivity growth, particularly in the absence of effective risk-sharing mechanisms, with long-term implications for poor consumers and farmers [12].

Farmers facing the negative consequences of price risk develop several strategies aimed at either reducing the risk to an acceptable level (*ex ante*) or mitigating the impact (*ex post*). The answers are analyzed as decisions or choices directly related to the farmers' production activities. Let us first note that the two types of risk that determine the decision-making of producers are the risks of production and prices. Production risks, also known as climatic risks, are more important for individual farmers. Sadoulet and de Janvry [42] suggest that they can reduce their exposure to this type of risk through geographical dispersal of their arable land and diversification of crops. Nevertheless, as Araujo Bonjean (1992) argues, the strong correlations between the prices of different crops show the difficulty of offsetting the risks at the level of the operator's overall income. However, in a recent study, Haile et al. [24] show that the negative correlation between producer price volatility and aggregate supply reflects the reallocation of cultivable acreage and investments to improve yields of crop which prices are less volatile. By simulating the impact of price dynamics since 2006, Haile et al. [24] find that price risk has led to a reduction in supply, particularly of wheat.

It seems that the risk associated with price volatility induces changes in farmers' behavior. Such behavioral responses can be analyzed in terms of producers' level of risk aversion and of market characteristics. Indeed, the forms of response vary according to whether the farmer is more or less risk averse, depending on whether the price and production are correlated, and according to the size of the market. Fafchamps [18] notes that, due to high transport costs and low agricultural productivity, rural food markets are narrow and isolated. Farmers are, therefore, confronted with volatile food prices that are strongly correlated with their own agricultural production. From this point of view, they are very categorical about protecting themselves from the price of foodstuffs, given that the staple foods constitute a large part of their total consumption.

Uncertainty in output prices generally leads farmers to reduce the use of inputs in the production process [6]. Under the hypothesis of unstable prices closely correlated with production, and in the context of narrow and isolated markets and general characteristics of food markets in developing countries, Araujo Bonjean and Boussard [3] show that the self-consumption of either part of or the entire harvest by the household is a form of self-insurance against price risk. Consequently, the household that consumes a wide amount of its own output produces more than does a household that sells all its harvest for the same risk aversion purpose, although its production is reduced compared to a non-risky situation [3,33]. Fafchamps [18] notes that food price volatility hurts poor household and encourages them to maintain a high level of food self-sufficiency. This attitude therefore leads to an increase in their production.

In the absence of formal markets for labor and inputs, and given the risk of survival caused by under-production in a price-risk environment, farmers do not systematically reduce production. Their responses may vary significantly, depending on their level of risk aversion. Therefore, risk aversion plays a crucial role in producer decisions (Belhaj Hassine and Thomas, 2001). For a producer averse to risk, and in a context where prices and production are negatively correlated, the price fluctuation is likely to lead to an increase in the quantity produced. On the other hand, when prices and production are uncorrelated, in particular with regard to local markets, the producer averse to risk decreases his production in the event of price instability.

As we can see, the effects of price instability on agricultural production are largely dependent on the assumptions made about the behavior of producers in the face of risk. In other words, risk aversion is likely to induce varied responses on their part. This reaction, supported by risk aversion, therefore requires taking into account risk in the analysis of the supply behavior of producers. Neoclassical theory that analyzes farmers' production behavior in a profit maximization framework has been criticized for failure to take risk into account [2],[16],[32]. That is why the methodology proposed here considers price risk in the analysis of the supply response of producers.

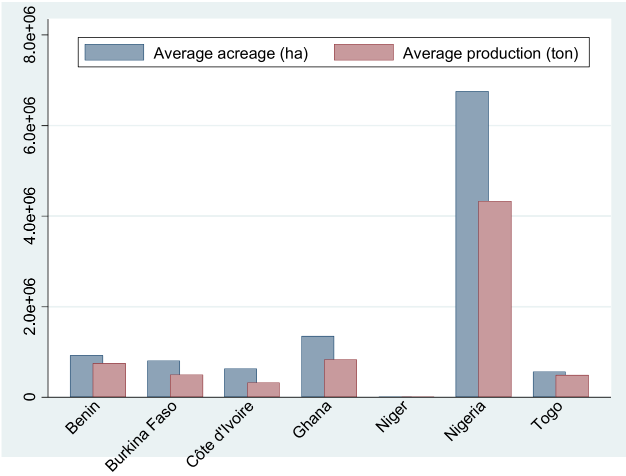
Background on the agricultural sector of Benin and some West African countries

The agricultural sector is one of the pillars of the Benin's economy contributing to over 35% of the GDP in average [29]. Therefore, this sector deserves a particular attention when it comes to policymaking. The agricultural production, like that of the other West African countries, is practiced mainly by small farmers. The average land area is estimated at 1.7 ha with about 34% of farms covering less than one (01) hectare. Smallholders, estimated at about 550,000, alone account for nearly 95% of the output of the agricultural sector (MDAEP and UNDP, 2015). The main food crops in Benin are maize, sorghum, yams, cassava, millet, rice and beans. Cotton and cashew are the main cash crops. Cereals occupy the largest area cultivated, representing on average 49.5% of the area planted during the 2003–2013 period.

Maize remains the most dominant crop among cereals representing, respectively, 77% and 76% of the total cereal production during the 2012–2013 and 2016–2017 crop years, according to data published by the "Ministère béninois de l'Agriculture de l'Elevage et de la Pêche" [29]. Benin is self-sufficient in maize and this cereal is a major contributor to food security in the country. Maize production is for self-consumption as well as for sale in urban and peri-urban markets. Part of the production is exported to neighboring countries such as Nigeria, Niger and Togo.

After the 2008 global food crisis, the country is now in surplus of maize as a result of government stimulus measures (see Annex Table A4). But these different policies have been limited in scope since maize yields are still low in Benin compared to other West African countries such as Burkina Faso, Ghana and Nigeria (see Fig. 1). The average yield of maize over the period 1995–2015 are 570.72 kg/ha, 1604.50 kg/ha, 1608.27 kg/ha and 1219.65 kg/ha, respectively, for Nigeria, Burkina-Faso, Ghana and Benin. These statistics show that maize yields in Benin are far from those of the West African countries. Nigeria, despite its high production, has a low yield compared to Ghana and Côte d'Ivoire. The lowest productivity among the bordering countries of Benin is observed in Niger.

These observed characteristics show the importance of questioning producers' responses to price instability by country and to analyze the common features that would imply a policy of coordinated actions in the West African subregion.



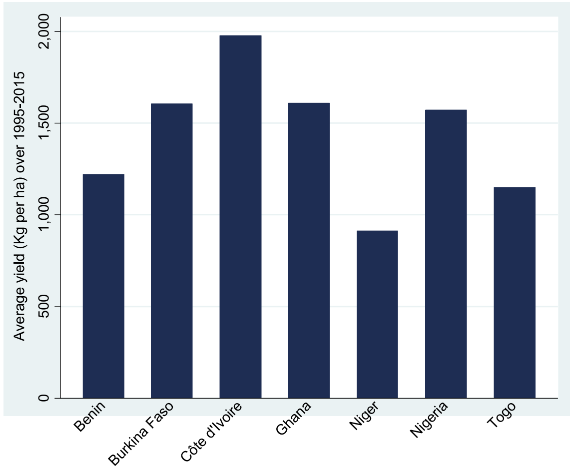


Fig. 1. Average area, production and yield of maize in Benin and selected West African countries over 1995–2015 period. *Notes:* Fig. 1 presents the evolution of relative risk premium by municipality during 1995–2015.

Methodology and data used

Two methodological approaches are used. The first, descriptive, is based on the analysis of the evolution of different variables, such as supply and areas sown in relation to price fluctuations, and the second considers an econometric model based on agricultural supply functions to discuss producers' responses.

The data used are mainly secondary and come largely from national statistical services.

Methodology

Several approaches are developed to analyze agents' decisions under price or output uncertainty. Haile et al. [24] refer to two other main approaches developed to analyze farmers' responses in terms of supply. The first is the Nerlovian model, which allows analysis of both to the speed and the level of adjustment from actual toward desired output. The second concerns supply equation, which is obtained from the profit-maximizing framework. This needs detailed input prices. This approach also requires a simultaneous estimation of output supply and input demand equations.

Because of missing or imperfect input markets in many countries, particularly in developing countries, and given that we focus on the output supply function, we use the partial adjustment framework, enhanced with dynamic response, and the introduction of price risk variables. The methodology used in this work is close to that of Haile et al. [24]. Based on their framework, supply response models for a crop can be formulated in terms of either production, acreage, or yield. Thus, the expected output of a certain crop in period t could be written as a function of the expected price and a set of other exogenous factors:

$$Y_t^* = \alpha_1 + \alpha_2 p_t^e + \alpha_3 X_t + \varepsilon_t \qquad (1)$$

where Y_t^* constitutes the expected output level in period t; p_t^e is the expected price of the product under consideration; and X_t denotes the aggregate of other exogenous variables that may affect the supply of the product—these include input prices, competing product prices, climatic variables, and changes in technology; and ε_t accounts for unobserved random factors that can influence production with zero expected mean.

Adjustments in the agricultural sector (increase in area, intensification of production) are not systematic but are delayed for one or two production cycles, particularly due to insufficient resources. To take account of this time lag in the response of agricultural supply, it is necessary to use a dynamic approach. The supply response is usually a two-step process. Given that harvest prices are not determined at planting, producers, as a first step, allocate area between different crops on the basis of expected prices.

Similarly to the production equation, the desired area to be cultivated for a given crop in period t, (Z_t^*), is determined by the price of the crop itself and that of the competitive crops and other non-price factors (Eq. (2)). However, it is difficult to identify a competitive culture for all communes. Indeed, the cultivated speculations vary according to the agroecological zones as well as the food habits are different among the main regions of the country (from North to Center and South). Thus, we use the real price, i.e., the producer price deflated by the Consumer Price Index (CPI), which allows to capture the prices movements of other goods. Farmers adjust their production decision looking at the price of their crop relative to those of other goods [30]. Thus, we have:

$$Z_t^* = \beta_1 + \beta_2 p_t^e + \beta_3 X_t + \varepsilon_t \qquad (2)$$

The yield equation can also be written in the same way as Eqs. (1) and (2).

We use the volatility specific to the crop considered to capture the price risk of the product. This volatility is determined from the standard deviation of the first difference of the logarithm of prices. The volatility measure is annualized by multiplying it by the square root of 12 because of the sigma which is calculated at monthly intervals. Volatility is then given by: $Volatility = \sigma * \sqrt{12}$ with $\sigma = \sqrt{\sum_{i=1}^{N}\sum_{t=1}^{T}(r_{it} - \bar{r})^2/NT - 1}$ and $r_{it} = \ln(P_{it}) - \ln(P_{it-1})$. This approach makes it possible to obtain price series without a trend.

The econometric model is specified as follows:

$$Q_{kt} = \gamma_0 Q_{k,t-1} + \gamma_1 p_{k,t-1} + \gamma_2 \nu_{kt_k} + \gamma_3 R^*_{kt_k} + \gamma_4 TC_t + \rho t_k + \varphi_k + \mu_{kt} \tag{3}$$

where Q_{kt} denotes the total production (or total area sown) of commune k in period t. p_{kt-1}, ν_{kt_k}, and $R^*_{kt_k}$, respectively, represent the expected price of the product, product price volatility, and the yield shock measured as a deviation from the yield trend of the product. The performance shock variable is included in the model under the assumption that deviations from yield trend may be due to various hazards, such as floods and insect invasions, which affect the yield expected by the producer. TC_t means the real exchange rate Naïra / FCFA. Benin has deep trade relationships with Nigeria through his borders for many products such as maize, cassava and so on. The exchange rate is used to capture the effect of demand from Nigeria on farmers' production and acreage decisions. We expect that a depreciation of Naira will lead to a weak purchasing power of Nigeria's traders or consumers. With regard to other neighboring countries, Benin already shares the same currency because it is part of the same monetary zone. The trend dummy t_k is integrated to take account of certain structural changes, φ_k denotes fixed effects per producing municipality to control the time-invariant heterogeneity between the communes, and γ_i are parameters to be estimated. μ_{kt} is a normally distributed error term with mean zero and variance σ^2.

The system GMM method is used to estimate the dynamic supply model (3). Why this choice? The application of ordinary least squares (OLS) to dynamic panel data could lead to regression biases due to the correlation between the delayed dependent variable and the individual fixed effects. By introducing delayed production in the right-hand model of Eq. (3) the estimators resulting from this regression by the OLS will be biased and not efficient. Indeed, delayed production depends on individual fixed effects. In addition, past and present price volatility may affect the production and location choices and could lead to endogeneity problem. To address the bias problems in dynamic panels and the endogeneity issues, authors mostly use the generalized method of moments (GMM) developed by Arellano and Bond (1991).

One choice is to use the difference GMM estimator, which first differentiates the data to eliminate the fixed effect, and then to instrument the first-difference equation with the lagged-level equation of the series. A more appropriate alternative in our framework is to estimate the GMM system as proposed by Blundell and Bond [7]. They refine the GMM difference by transforming the instruments themselves to make them exogenous to fixed effects [40]. In other words, they propose to estimate a system of equations in both differences and level, where the instruments for the level equation are the lagged first-differences of the series.

Several tests are available for the validation of the GMM system method adopted in this article. On the one hand, there is the Hansen test, whereby the validity of the instruments used is checked, and, on the other hand, the Arellano-Bond's autocorrelation test, which provides information on the lack of autocorrelation of errors of the equation in level. The standard deviations of the estimator are robust for the different specifications, and we use Windmeijer's [47] method to correct the finite sample covariance matrix and eliminate any bias due to the two-step estimation. Similarly, we limit the proliferation of instruments using the method proposed by Roodman [41].

Data used

Data used are provided by several national sources, which cover thirteen different communes from 1995 to 2015. Data on rainfall were collected from the National Institute of Statistics and Economic Analysis (INSAE). Data on crop production, acreage, and yields were obtained from the Directorate of Programming and Forecasting (DPP) and the Directorate of Agricultural Statistics of the Ministry of Agriculture of Benin. Price series come from ONASA, which produces statistics on food prices at several markets in the various municipalities of the country. These nominal prices were deflated by the Consumer Price Index (CPI) of food products proposed by INSAE to obtain real price series. This allows to take into account the relative prices of substitute goods. Corn is speculation retained because it is the most cultivated and consumed cereal in Benin. Annual corn production represents more than 80% of total cereal production and consumption, nearly 70% of the basic food package [31].

The model variables except for the volatility measure were log transformed. The choice of the 13 communes of Apahoué, Bohicon, Comé, Djougou, Dogbo, Glazoué, Kétou, Malanville, Nikki, Natitingou, Parakou, Pobè, and Tanguiéta is not insignificant, in that they make it possible to take into account the different agro-ecological zones of the country. They are also, for the most part, considered to be regions of high maize production but are subject to climatic vagaries, especially in the northern communes. In these communes, producers are numerous and price fluctuations are likely to lead to serious food crises that can spread throughout the country.

The next section presents and discusses the empirical results obtained with respect to the impact of price risk on the decisions made by producers in Benin.

Table 1
Descriptive statistics of production and acreage variables.

Variable	Mean	Std. Dev.	Min	Max	Observations
Production (tonnes)	17,191,94	18294.8	3004.244	68924.44	$N = 260$
Acreage (ha)	14326.62	15073.53	3066.126	57556.68	$N = 260$
Yield (Kg per ha)	1204.36	192.9917	869.0131	1475.097	$N = 260$
Price (FCFA* per Kg)	134.70	15.55418	115.0771	176.6723	$N = 260$

Source: Authors' calculations, based on data obtained from INSAE, DPP and ONASA.
* NB : 1€ = 655.957 FCFA.

Table 2
Results of GMM system estimation of producer responses.

	Production		Acreage	
	Coefficient	Corrected Std. Error	Coefficient	Corrected Std. Error
$Q_{k,t-1}$	0.784***	0. 098	0. 589***	0. 120
Price (t-1)	0.747**	0. 319	0. 769***	0. 216
Volatility	0.508***	0. 162	0. 427*	0. 203
Yield Shock	0.873***	0. 097	0.062	0. 048
Real exchange rate (Naïra/FCFA)	−0.007**	0.003	−0.005*	0.003
Time trend	−0.027***	0.007	−0.010*	0.006
F-test for joint significance	0.000		0.000	
Observations	256		256	
Hansen test (*p*-value)	0.576		0.531	
Diff-in-Hansen test (*p*-value)	0.928		0.652	
AR(1) test: *p*-value	0.004		0.008	
AR(2) test: *p*-value	0.192		0.264	

Source: Authors, based on data obtained from INSAE, DPP and ONASA.
Note: Coefficients are two-step GMM estimate with the lagged dependent variable and price variable treated as predetermined. Robust standard errors with the Windmeijer [47] correction are reported in the second column. All the instrument matrices are collapsed. ***, ** and * represent the 1%, 5% and 10% levels of significance, respectively.

Producers' response to price risk

This section is devoted to the descriptive analysis of the study data and to the presentation of the results of the estimates.

Descriptive analysis

Table 1 presents the descriptive statistics of the main variables used. The descriptive statistics for the different communes are presented in Table A3 (see annex). For the sample, the average production is approximately 17 191.94 tonnes from 1995 to 2015, with an average price of 134.70 FCFA/Kg. The commune of Kétou records the average maximum values of production and area: 68,924,44 tonnes and 57,556,68 ha, respectively. The average minimum production value (3004.24 tonnes) is obtained by the municipality of Bohicon while Natitingou has the minimum average area (3066.13 ha).

As for the average yield, the commune of Tanguiéta shows the highest level (1475.10 Kg/ha) while the lowest level (869.01 kg/ha) is in the municipality of Bohicon. In terms of the correlation of study variables, it appears that production is positively and significantly correlated with both price (0.80) and acreage (0.75). These variables seem to be strongly linked with output price (see Table A2).

Estimation results

The results of the GMM system estimation of supply and acreage responses of maize producers are reported in Table 2. The estimate uses the lagged variable of the price due to the time lag in the production cycle as a proxy of the expected price of the producer.

As expected, the results show that exchange rate has negative effect on farmers' production as well as acreage. This could be explained by the fact that negative shock on Nigeria currency (a devaluation for example) leads to a declining of consumers demand from Nigeria and negatively affect Beninese farmers supply. This result highlights the intensity of trade linkage between Nigeria and Benin as showed in previous studies [27,28].

The responses to market price changes in terms of product supply or area allocation of farmers for all the communes under study are positive and statistically significant. Producers are reacting to rising maize prices in the market by increasing their production. More concretely, a 10% increase in prices leads to an increase of approximately 7.47% in production. As suggested by economic theory, farmers are able to interpret the market signals and respond positively to an increase of the real price of staple food crops.

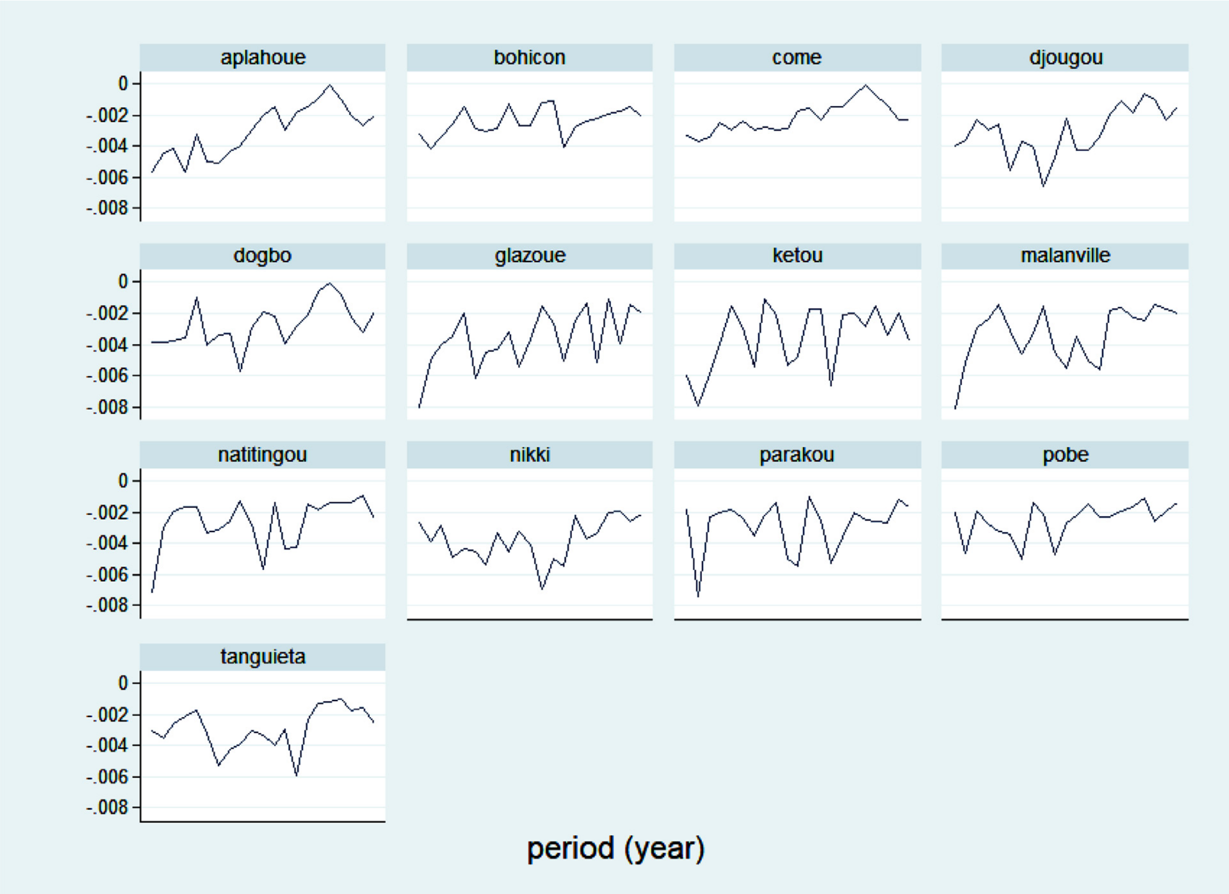


Fig. 2. Relative risk premium (RRP) by municipality (Source: Authors based on estimated results).

Similarly, some studies show high elasticities indicating a high sensitivity of farmers to price [21,30,38]. For instance, Magrini et al. [30] obtain price elasticities of production of approximately 0.60 for the retail price and 0.63 for the wholesale price. These elasticities are, however, small in terms of area response. Peterson [38] obtains elasticities on the order of 1.25 to 1.66. Following a comparison of the elasticities between developed countries (DCs) and less developing countries (LDCs), Peterson [38] concludes that it seems fairly to say that the estimated supply elasticity is certainly not lower in LDCs than in DCs. However, other studies result on lower elasticities showing a positive but moderate response of farmers to price [24,44].

Maize has two essential functions which certainly explain this strong price sensitivity in the Gulf of Guinea: this product is present in the food habits in Benin, Togo, Niger, Ghana and Burkina-Faso. It is also a product of speculation used by the producer to avoid the liquidity constraints.

As regards the impact of price risk, the coefficient associated with the variable volatility appears positive and significant. This result shows a positive effect of price instability on farmers in Benin. Indeed, an increase in volatility leads to an increase in production and an increase in the area sown. Although price volatility is expected to lead to a reduction in output, this positive reaction to volatility shows that, in the face of price instability, farmers choose to increase, rather than reduce, production to ensure a minimum of income deemed essential. These findings support analyzes, which show that producers having to work hard to increase supply in order to avoid extreme situations under uncertainty. These results oppose those from the works of Subervie [44] on a panel of developing countries in Africa and America, Chavas and Holt [13] and Guillaumont and Bonjean [23], which highlight a decrease in farmers' supply following an increase of price instability. Differences in results may be due to the level of data aggregation and the structure of the economy [37]. Indeed, these different studies with the exception of that of Subervie [44] focus on supply responses in developed countries. Replication of similar work in Burkina Faso, Togo and part of Nigeria could lead to policy coordination if results achieved here were strengthened.

The risk-taking trend is confirmed by the results of the relative risk premium (RRP), which is negative. The RRP is the negative of the ratio of the variance and price elasticities [26]. Inspired by Rezitis and Stavropoulos [39], we estimate this risk premium at each point of time (see Fig. 2). It is obtained from Eq. (3) by $RRP_t = -(\gamma_2/\gamma_1)x\frac{v_{kt_k}}{p_{kt_k}}$. It should be noted that the values of the relative risk premium, although negative, are absolutely low because they are close to zero. It averaged −0.30%, the lowest value being in Malanville (−0.81%) and the highest in the commune of Dogbo (−0.0005%). These negative values suggest that farmers do not develop risk aversion.

Statistics show that cereal production driven by maize grew at an average annual rate of 6.5% between the 2003–2004 and 2013–2014 crops [31]. Therefore, it is a system of hedging developed by producers against price volatility. The national human development report for 2015 indicates that it has since risen in line with improved yields due to farmers' access to the seeds and to the fertilizers NPK and urea.

Moreover, this strategy of Beninese producers is explained by the constitution of a precautionary stock for self-consumption, which limits their sensitivity to price changes. The fear of falling into food insecurity explains this precaution. This rate of food insecurity is higher in rural areas than in urban areas, 15% against 8% [48].

Conclusion

This article analyzes, using panel data on thirteen communes in Benin, the responses of producers to price volatility in terms of supply and areas sown. Price uncertainty represents a serious threat to farmers, particularly in developing countries. The threat is all the more serious as the proportion of poor households in these countries remains high and the share of the budget devoted to food is constantly increasing.

The results highlight the importance of price volatility in the upstream choices made by producers in the production process. Producers respond positively to price volatility by increasing their production and sown areas. Thus, high volatility in agricultural prices is likely to induce an increase in the corresponding supply of the product. This result revives the debate on the role of risk aversion in farmers' production decisions. It is expected that the risk-averse producers, faced with price volatility, will behave prudently by reducing production to limit potential losses. However, the results here show an inverse reaction, which requires taking into account the influence of risk aversion in the strategies and responses of particularly poor producers in developing countries.

In sum, price volatility signals an income threat to producers. To hedge, they respond by increasing the area sown to grow the supply of goods produced and ensure a buffer income. This behavior shows that farmers are not neutral in relation to price risk. Their reaction is likely to cause a fall in grain prices by an abundance of production. This result is relevant to policy makers, as it suggests a different approach for price risk management. A public or private price risk insurance system may be appropriate to manage policy. To maintain stable prices, the stabilization policy must aim at regulating market flows in the event of an abundant surplus. This implies a national policy of stock management and regulation of cereal flows intended for the market according to forecasts. A forecast of high price volatility would lead to a reduction of the existing stock and further a replenishment from the surplus of production generated in response to sharp price fluctuations. Such policies are also valid in sub-Saharan countries because of the similarities of economies.

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Appendix

Table A1, Table A2, Table A3 and Table A4.

Table A1
Volatility and price levels of maize in some Benin markets.

Periods	Price Volatility						Price Level					
	Bohi-con	Gla-zoué	Kétou	Malan-ville	Nati-tingou	Para-kou	Bohi-con	Gla-zoué	Kétou	Malan-ville	Nati-tingou	Para-kou
1990–1994	0,4580	0,7871	0,6696	0,4811	0,5136	0,5767	63	55	54	61	65	64
1995–1999	0,4602	0,5927	0,6551	0,5244	0,4708	0,4590	116	102	99	116	133	124
2000–2005	0,4462	0,6505	0,5156	0,5487	0,5195	0,5637	135	116	118	116	124	137
1990–2005	0,4543	0,6751	0,6073	0,5200	0,5024	0,5351	107	92	92	99	109	110
2006–2011	0,5012	0,5586	0,5305	0,6854	0,5131	0,6014	150	132	131	153	159	148
2012–2016	0,4910	0,4368	0,5213	0,4891	0,3763	0,4314	180	142	139	172	176	169

Source : authors' calculations.
Note: Price levels are in FCFA per Kg. 1€ = 655.957 F CFA.

Table A2
Correlation between variables.

	Production	Acreage	Yield	Price
Production	1			
Acreage	0,9012 (0.0000)	1		
Yield	0,5393 (0.0158)	0,2183 (0.2935)	1	
Price	0,7946 (0.0000)	0,7556 (0.0001)	0,4302 (0.0465)	1

Source : authors' calculations.

Table A3
Descriptive statistic by communes.

Variables	Communes	mean	std. Dev.	Min	Max	Communes	mean	std. Dev.	Min	Max
Production	aplahoue	17702.010	7828.196	6732	32463.070	malanville	8553.793	6908.755	2194	22450
Acreage		17568.640	6204.325	7072	31084.420		6759.790	4300.077	1933	15,000
Yield		1003.580	256.218	479.139	1744.572		1171.848	219.227	745.542	1674.857
Price		138.385	49.749	80	243		130.991	37.997	55	197
Production	bohicon	3004.244	1513.670	1241	6530	natitingou	4285.490	3309.548	1649	18036.84
Acreage		3571.333	1934.994	1280	7717		3066.126	1797.603	1666	10516.64
Yield		869.013	135.917	712.731	1363.281		1349.109	257.649	708.488	1715.077
Price		137.145	35.178	66	194		140.548	34.554	69	201
Production	come	6530.000	4674.598	1126	16189.220	nikki	26645.580	12428.160	11,559	60,591
Acreage		6250.836	3438.458	2415	14,197		20423.700	8537.026	8234	43,760
Yield		1088.332	323.213	466.253	1800.002		1291.220	226.055	952.822	1961.780
Price		176.672	52.975	102	269		115.077	32.846	65	177
Production	djougou	8394.849	5345.535	147	18559.130	parakou	8670.789	4719.457	3982	25,162
Acreage		5654.880	2620.319	2231	10,850		6722.190	3450.503	2618	17,142
Yield		1395.048	400.985	35.125	1884.702		1332.816	304.262	925.542	1973.434
Price		133.985	30.539	75	176		137.971	34.417	66	199
Production	dogbo	10594.530	7122.606	3945	26971.100	pobe	36629.100	15484.220	4062	67,382
Acreage		9644.490	5683.687	4158	22164.300		26973.030	7038.439	18,414	40,674
Yield		1063.539	170.720	691.256	1432.396		1422.899	596.822	101.504	2489.452
Price		143.548	41.361	92	238		127.364	30.512	75	195
Production	glazoue	17397.950	10345.820	3901	41099	tanguieta	5510.183	3067.725	1626	12624.3
Acreage		18389.570	10455.980	4520	38521		3664.825	1734.407	1316	6570
Yield		965.944	186.882	603.636	1350.809		1475.097	279.329	764.107	1921.507
Price		119.162	31.386	60	176		132.833	30.119	93	185
Production	ketou	68924.440	17167.710	32,172	95926.16					
Acreage		57556.680	16059.710	24,717	88,748					
Yield		1228.228	227.236	852.096	1675.790					
Price		117.359	29.992	60	180					

Source: authors' calculations.

Table A4
Price interventions in Benin to mitigate the effects of the food crisis.

Period	Types of measures	Products concerned	Areas concerned
December 2007-February 2008	Targeting of the products of first consumption and reduction of the import taxes for 3 months.	Standard milled rice, Milk powder, Wheat flour, Pasta, Tomato concentrate, Petroleum products	Whole country
2008	Establishment of price control and recruitment of more than 200 contract agents for control	Staple foods	Whole country
December 2007-January 2008	Establishment of the buffer stock through the ONASA of 2990 tons of food.	Staple foods	Whole country
March 2008-May 2008	Renewed pricing measures	Staple foods	Whole country
May 2008	Abolition of VAT on certain goods.	Staple foods	Whole country
May 2008	Rice subsidy 25% broken	Rice	Whole country
July 2008	Establishment of control shops by ONASA	Staple foods (Rice, maize, etc.)	Whole country

Source: authors from WFP [46].

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