RESEARCH ARTICLE

Adoption and technical efficiency of organic and fair-trade cashew production in Benin (West Africa)

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The global demand for raw cashew nuts has been growing steadily over the years and has led to a sharp rise in the use of chemical inputs, becoming the only alternative to improve production. As a result of many environmental and health problems related to the use of chemicals, but also due to their marginalization on the international market, some small producers in Africa; particularly in Benin (West Africa) have embarked on the fair-trade, organic production of cashew nuts to meet the ever-increasing global demand. This research identifies factors determining the adoption of fair-trade organic cashew and estimates producer's technical level efficiency in central Benin. Two-stage random sampling was used to select 160 cashew producers. The study used the student's "t" test, logistic regression and the method based on stochastic frontiers of type production Cobb-Douglas function to assess data collected from the research sample. Our investigations revealed that large field size, cotton production and producer's secondary activities have negative effects on organic cashew fair-trade adoption while the number of agricultural assets, experience in cashew production, land access and frequency of contacts with extension services positively affect organic cashew fair-trade adoption. Women are more likely than men to produce organic, fair-trade cashews. The average efficiency indices of organic fair-trade producers are 0.63, suggesting that farmers have room to improve their technical efficiency, using their existing resources.

Key Words: *Adoption; Market; Fair-trade organic cashew; Stochastic frontier; Benin*

INTRODUCTION

Cashew is one of West Africa's most important export products and the main cash crop along with cotton since the late 1990s [1]. It is an essential source of cash income to fight against poverty and food insecurity for many West African smallholders. Its spontaneous development occurred in parallel in more than ten countries of the sub-region. Three categories of farms are encountered among producers. These are 1) Cashew-based farms doing organic nut production, 2) Medium-sized farms combining other crops with cashew planting and/or doing cashew only and 3) Conventional cashew farming, the dominant type. However, conventional cashew is produced with the intensive use of synthetic chemicals for fertilization and to manage weeds and pests. The global demand for raw cashew nuts has been growing steadily over the years and has led to a sharp rise in the use of chemical inputs, becoming the only alternative to improve production. However, the excessive use of agrochemicals has negative effects not only for the effective disease management or pest control, but also for the environment and human health [2]. It creates negative externalities such as pollution, destruction of biodiversity, poisoning, etc., but also leads to lower yields, resistance of pests to pesticides as well as a considerable loss of producer income [3,4]. Awareness of the social, environmental and economic costs of this kind of agriculture, which consumes many agrochemical inputs, has resulted in new requirements regarding the origin and production methods of foodstuffs. Thus, in recent years, significant efforts have been made to promote environment preservation through a significant reduction in chemical inputs [5]. Thus, alternative cashew production systems that respect the environment and human health are promoted [6].

One of these sustainable systems is the production of fair-trade organic cashew. Organic production is considered to have beneficial impacts on the future sustainability of agriculture and it is deemed to be beneficial for the environment and producers. It provides healthy agricultural products but also fair remuneration for the work of producers, taking into account the overall costs of production (economic costs, social and environmental costs) [7-10]. Over the past ten years, the global demand for organic products has tripled and this trend continues to increase providing a dynamic economic opportunity [11]. Access to this market is a challenge for developing countries, but also an opportunity to export their agricultural products. Furthermore, the production of fair-trade organic cashews constitutes a path to sustainable development for the agriculture of these countries, since this agriculture is associated with the preservation of resources, financial stability and positive social impacts [12-14].

Despite these multiple advantages offered by the production of fair-trade organic cashew particularly in terms of improving soil fertility, preserving the health of producers, protecting the environment, the guaranteed minimum price, the fair-trade premium, etc., it has been adopted by a minority of producers, while its ability to respond to the agriculture of tomorrow is the subject of debate [15]. This situation can be explained by a number of factors, including those specific to farmers and their households, those linked to their farms, biophysical factors, institutional factors and economic factors [16]. Added to this is the low productivity of the Beninese cashew nut with low yields oscillating on average between 300 and 400 kg/ha [17]. This may result from poor management of existing resources and one wonders if producers of fair-trade organic cashew in Benin are technically efficient [18,19]. This study attempts to identify the determinants of adoption and the level of technical efficiency of fair-trade organic producers in central Benin. It will contribute to decision-making to support the future efforts of the various actors in the sector to improve the current level of production of organic and fair-trade cashew nuts.

MATERIALS AND METHODS

Study area

The study was conducted in the municipality of Ouesse (8°29′45.46 latitudes north and 2°25′24.03 longitudes east) in central Benin, with several village cooperatives from organic and fair-trade cashew producers. This municipality benefits from agro-ecological conditions that are very favorable to cashew production. Classified in the 5th agro-ecological zone of Benin and located in the humid tropical zone, Ouesse enjoys an intermediate tropical climate between the Guinean climate and the Sudanese climate with an annual rainfall varying between 1100 and 1200 mm. This is a highly favorable environment for cashew production and intensification of trade [20]. The

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population of Ouesse was estimated at 142,017 inhabitants, of which 70,423 are women.

Sampling and data collection methods

The data were collected in six villages of the municipality which had both groups of producers (conventional and organic fair-trade). Using a list obtained from the producers' support organizations, a sample of 160 producers including 80 fair-trade organic cashew producers and 80 conventional cashew producers was randomly selected from selected villages. Data were collected in two main phases. Firstly, an exploratory study by using focus group discussions to collect global information on the conventional and far-trade organic cashew production was conducted. After that, we collected data through a semi-structured interview using direct survey. These data focused on the socio-economic characteristics of the producers, the determinant factors of fair-trade organic cashew adoption and the inputs/outputs engaged and/or obtained. (Table 1)

TABLE 1
Sampling structure

	Number of respondents		
Villages	Conventional	Fair-trade organic	Total
Odougba	15	13	28
Dokoundoho	14	16	30
Gbeme	12	12	24
Idouya	12	12	24
Tchedjinnangnon	15	15	30
Attata	12	12	24
Total	80	80	160

Data analysis

Determinants of fair-trade organic cashew adoption: The logistic regression model was used to access factors explaining producer's decisions to adopt fair-trade organic cashew. Logit and Probit are two of the most commonly used logistic regression models [21]. The Logit model is based on the logistic law of probability distribution while the Probit model is based on the normal law. According to Greene [21], these two models often lead to the same conclusion despite their characteristic differences. Many researchers use the Logit regression model because it is mathematically simpler, which is one reason why we chose to use Logit. It has also been used in many previous adoption studies in agriculture [20,22,23].

Data were analyzed using the STATA 13 software. The theoretical model is as follow:

$$Y = f\left(X, e\right)$$

Where,

Y: Dependent variable; X: Matrix of variables likely to explain the variation of Y; e: Logistical error of distribution.

Let P_i be the probability that the Logit associates with the survey unit,

$$P_i = F\left(I_i\right) = \frac{1}{1+e^{-It}}$$

$$I = \alpha_0 + \alpha_1 X_{i1} + \alpha_2 X_{i2} + \alpha_3 X_{i3} + \ldots\ldots\ldots + \alpha_n X_{in} + e_j$$

Where,

I_i: Vector which represents the characteristics of the survey unit, its environment and the object of its choice; α_1: Coefficients of the explanatory variables; X_{in}: Explanatory variables.

The empirical model is written in the form:

$$X = \alpha_0 + \alpha_{1SEX} + \alpha_{2NBACT} + \alpha_{3TAILEXP} + \alpha_{4EXPANA} + \alpha_{5DISTEX} + \alpha_{6ACCRED}$$
$$+\alpha_{7ALPHA} + \alpha_{8EDUCS} + \alpha_{9EDUCP} + \alpha_{10COTON} + \alpha_{11MODEA} + \alpha_{12COMMER} + \alpha_{13FREVUL} + \in i$$

Where, SEX denotes producer's gender; NBACT is the number of agricultural workers in the household; TAILEXP is the size of the farm; EXPANA is experience in cashew production; DISTEX is the distance between the farm and the producer's home; ACCRED is access to credit; ALPHA is literacy; EDUCS is the level of secondary education; EDUCP is the level of primary education; ACTIS is producer secondary activity; EDUC is producer educational level; COTTON is the production of cotton; MODEA is the mode of access to land by purchase; COMMER is trade as a secondary activity and FREVUL is the frequency of extension services.

These explanatory variables introduced into our Logit model are as follows

Producer gender takes the value of one when the respondent is a man and zero for a woman. A negative effect is expected. In rural areas of Benin, women often face problems adopting new technologies due to lack of time or funds and poor control over productive resources. Women are often more interested in organic production because it frees them from dependence on their husband [16,23].

Number of agricultural workers in the producer's household is a quantitative variable which we expect to exert a positive effect, because organic production requires high labor requirements, particularly for transport, weeding and the application of organic inputs (pesticides, fertilizers, etc., which are often bulky). Moreover, the positive effect of this variable has been proven by the adoption studies of Dossa et al., [20] and Moumouni et al., [24].

Farm size is a quantitative variable expressed in hectares, representing the total (usable agricultural) area owned by producer. The literature on farm size is ambiguous. For example, by McBride et al., [25], describe "big" farmers as less inclined to convert to organic farming because of it high labor requirements. In addition, operators of small units find in this mode of production a solution to their problems of economies of scale. Small farms can also make greater use of family labor and they have a lower conversion opportunity cost [26]. Large farms easily adopt some soil fertility improvement practices (intercropping, crop rotation, agroforestry and fallowing). Indeed, most of these organic technologies require large amounts of land, which smallholders do not have. In view of the above, a positive or negative sign is expected.

Producer's experience in cashew production is a quantitative variable expressed in years. The knowledge a producer gains over time, even when farming in an environmentally harmful production, can influence how they evaluate the information, thus influencing their adoption decisions. Some producers who have also spent several years in conventional cashew production may get used to or create/integrate networks that force them to continue conventional farming. Because of this ambiguity, a positive or negative sign is expected.

Another quantitative variable used in the model is the distance between the farm and producer's home, as expressed in kilometers (km). Organic farming requires daily maintenance. Conversely, producers whose farm is nearby can visit it more often and will be more likely to adopt fair-trade organic production. However, the farms attached to the producer's houses are generally smaller, thus reducing the possibility of adopting certain practices strongly encouraged in organic farming such as crop rotation and intercropping. Producers with distant farms would be more likely to practice fair-trade organic cashew. A positive or negative sign is expected.

Access to credit is qualitative variable that takes the value 1 when the producer benefits from credit and 0 if not. Indeed, having access to financing allows producers to acquire the inputs necessary to implement the new technology and hire labor for maintenance activities. A positive effect is expected.

Literacy is a qualitative variable that takes the value 1 if the producer is literate and 0 if not. A positive sign is expected. Literate producers may be more willing to access new information and adopt organic production.

Level of secondary education is a qualitative variable that takes the value 1 if the producer has some secondary schooling and 0 if not. Educated producers are able to read manuals and other extension materials. They also have easy access to information, especially through the media and can communicate easily with extension services. Education can also improve farmer's ability to efficiently allocate input uses and gain more knowledge about the adverse effects of conventional farming. A positive effect is expected.

Level of primary education is a qualitative variable that takes the value 1 if the producer has some primary schooling and 0 if not. Educated producers are able to read manuals and other extension materials. They also have easy access to information, especially through the media and can communicate

easily with extension services. Education can also improve the ability of farmers to allocate inputs efficiently conventional agriculture. A positive effect is expected.

Production of conventional cotton is a qualitative variable which takes the value 1 if the cashew producer produces conventional cotton and 0 if not. The choice of this variable was justified by the fact that it could constitute an obstacle to the adoption of organic production because of these requirements in chemical inputs, something prohibited in organic farming. A negative sign is expected.

Mode of access to land by purchase is another qualitative variable that takes the value 1 if the producer purchases the land used for crop production and 0 if not. Cashew is a perennial crop requiring huge investments. Producers who own the land would be willing to undertake actions to preserve and maintain soil fertility in the medium and long term. A positive effect is expected.

Trade is a qualitative variable which takes the value 1 if the producer has trade as a secondary activity and 0 if not. The role of an off-farm activity in the decision to adopt organic farming is ambiguous. Working off-farm reduces the time available on-farm, which can be a barrier to conversion as organic production requires more attention, but it can also provide capital to invest in agriculture. The work of McBride et al., [25] and Kallas et al., [27] found the important role of secondary activity i.e., non-farm activity. A positive or negative sign is expected.

Frequency of extension services visit is the last quantitative variable used in the model. A positive sign is expected (Table 2).

TABLE 2

Summary of explanatory variables and expected sign of model

Variables	Label	Modality	Expected signs
NBACT	Agricultural workers	0	+
TAILEXP	Farm size	0	±
EXPANA	Experience in cashew production	0	±
DISTEX	Distance between the producer's home and his farm	0	±
ACCRED	Access to credit	1=Access; 0=No access	+
SEX	Producer sex	1=Man; 0=Women	-
ALPHA	Literacy	1=Literate; 0=No literate	+
EDUCP	Primary education level	1=Yes; 0=No	+
EDUCS	Secondary education level	1=Yes; 0=No	+
COTON	Cotton production	1=Yes; 0=No	-
ACHAT	Access of land by purchase	1=Yes; 0=No	±
COMMER	Secondary activity	1=Yes; 0=No	±
FREVUL	Frequency of extension services	0	+

Note: (-): Negative influence; (+): Positive influence expected; (±): Positive or negative influence expected.

Estimation of technical efficiency indices

The stochastic parametric method was used to estimate the level of technical efficiency of fair-trade organic cashew producers. Based on Fisher's F-statistics of the Likelihood Ratio (LR), the Cobb-Douglas type stochastic frontier production function is the model used with the Frontier 4.1 software. Several agricultural production efficiency studies have used it [27,28]. Its functional form is as follows:

$$Ln(PROD_i) = \alpha_0 + \alpha_1 Ln(PLANTS_i) + \alpha_2 Ln(SUPANA_i) + \alpha_3 Ln(MOF_i) + \alpha_4 Ln(AMORT_i) + (V_i - U_i)$$

Where,

i: Producer; α_0: Aa constant; α_1: Parameters to be estimated; PROD: Quantity total of cashew produced (kg); PLANTS: Number of plants used (plants/ha); SUPANA: Total area of cashew nuts cultivated (ha); MOF: Quantity total labor used expressed in man-days/ha; AMORT: Value of total depreciation of the equipment used (FCFA/ha); V_i: Random variables outside the control of the producers and are assumed to be independently and identically distributed according to a normal distribution with zero mathematical expectation and variance; U_i: Technical inefficiency random variables and are assumed to be independently and identically distributed as non-negative random variables, obtained by truncation to zero, of the type distribution.

RESULTS

Producers socio-economic and demographic characteristics

Surveyed producer's mean age is 51 years old (± 10.19) and is similar for both groups of producers. Conventional producers employ an average of three workers (± 1) against three workers (± 2) among fair-trade organic producers. The mean farm size among conventional producers is 11.4 ha (± 12.33) compared to 8.98 ha (± 9.20) among fair-trade organic producers. Conventional producers have on average 3.75 ha (± 3.33) of cashew, slightly more than the 3.19 ha (± 2.86) for fair-trade organic ones. The cashew orchards of conventional producers 9.65 km (± 5.54) from the farmstead, slightly further than the 7.99 km (± 5.60) for fair-trade organic producers. The average frequency of agricultural extension services is 2 for fair-trade organic producers, but almost non-existent among conventional producers. 26.26% of conventional producers surveyed are female, while 67.5% of fair-trade organic producers surveyed are women, thus showing that women dominate fair-trade organic production of cashew while the conventional cashew is male dominated. Respectively 21.26%; 46.26% and 32.5% of conventional producers and 33.76%; 56.26% and 10% of fair-trade organic producers are Nago, Mahi and Fon. Indeed, only 10% of all the producers surveyed have access to credit. 15% of fair-trade organic producers are beneficiaries compared to only 5% among conventional producers. 46% of the producers surveyed are literate, in both two groups. Many farmers have no formal education: 47.5% of the conventional and 53.76% of organic producers never attended school. Most farmers inherited their land: 98.75% among conventional producers and 92.5% among fair-trade organic ones. Only 1.25% of conventional and 7.5% fair-trade organic producers bought land. Conventional cotton is produced by 20% of the conventional producers surveyed and 7.5% of the organic fair-trade producers. Agriculture is the main activity of the producers surveyed. Furthermore, about 35% of conventional producers compared to 40% of fair-trade organic producers have trade as a secondary activity (Table 3).

Determinants of fair-trade organic cashew adoption

Logistic regression results presented in Table 4 show the global significance of the model at 1% level (p=0.0053) i.e., the estimated coefficients are statically valid. Explanatory variables included into the model explain 85.48% (pseudo R2=0.8548) of observed variations in fair-trade organic cashew adoption. Eight variables were identified to significatively affect fair-trade organic cashew adoption (Table 3). Farm size, direct land access mode by purchase and the frequency of contacts with extension services are significant at only 1%; the number of agricultural workers, conventional cotton production and having an off-farm secondary activity (trade) are significant at the 5% while experience in cashew production and gender affect depend on variable at the 10% level. Farmers who adopt fair-trade cashew production tend to have more access to labor, more experience in cashew production, to have purchased more land and to receive extension services more frequently than conventional producers. Organic producers tend to be women with smaller farms, who do not produce cotton and are less likely to have a secondary off-farm activity (trade).

Estimation of the technical efficiency of fair-trade organic cashew production

Table 5 reveals that the test relating to the significance of the effects of technical inefficiency is significant at the 1% level. The presence of inefficiency or not analyzed through the gamma parameter shows that there is the presence of technical inefficiency in the production of fair-trade organic cashew (0.934, statically different from 0 and significant at the 1% threshold). Consequently, 93.4% of the variation in fair-trade organic cashew production is due to the technical inefficiency of producers and the remaining 6.6% of production is due to random effects including measurement errors.

TABLE 3
Producers socio-economic and demographic characteristics

Quantitative variables		Conventional producer		Fair-trade organic producer		Together	
		Average	Standard deviation	Average	Standard deviation	Average	Standard deviation
Age (years)		51.57	9.5	51.88	10.92	51.73	10.19
Agricultural assets		3.23	1.4	3.75	2.45	3.49	1.99
Farm size (Ha)		11.4	12	8.98	9.2	10.19	10.91
Cashew area (Ha)		3.75	3.3	3.19	2.86	3.47	3.12
Distance between plantation and producer's home (Km)		9.65	5.5	7.99	5.6	8.82	5.61
Frequency of extension services		0.47	0 .87	2.68	0.46	1.58	1.31
Household size		7.53	2.9	7.47	3.01	7.5	2.94
Qualitative variables		**Conventional producer**		**Fair-trade organic producer**		**Together**	
		Effective	**Frequency**	**Effective**	**Frequency**	**Effective**	**Frequency**
Sex	Female	21	13	54	33.75	75	46.88
	Male	59	37	26	16.25	85	53.13
Ethnic group	Nago	17	11	27	16.88	44	27.5
	Mahi	37	23	45	28.13	82	51.25
	Fon	26	16	8	5	34	21.25
Access to credit		4	2.5	12	7.5	16	10
Literacy		36	23	38	23.75	74	46.25
Primary education level		38	24	27	16.88	65	40.63
Secondary education level		4	2.5	10	6.25	14	8.75
No education		38	24	43	26.88	81	50.63
Inheritance access to land		79	49	74	46.25	153	95.63
Purchase access to land		1	0.6	6	3.75	7	4.38
Conventional cotton production		16	10	6	3.75	22	13.75
Secondary activity (Trade)		28	18	32	20	60	37.5

TABLE 4
Result of the fair-trade organic cashew adoption model

Variables	Coefficients	Marginal effects
Agricultural workers	1,033** (0,513)	0,033** (0,013)
Farm size	-0,157*** (0,044)	-0,005*** (0.001)
Experience in cashew production	0,135* (0,072)	0,004* (0,002)
Distance between plantation and producer's home (Km)	-0,063 (0,091)	-0,002 (0,002)
Access to credits	-0,666 (1,061)	-0,021 (0,032)
Sex	-2,014* (1,198)	-0,064* (0,043)
Literacy	-0,959 (1,206)	-0,030 (0,034)
Secondary education level	0,375 (1,299)	0,012 (0,041)
Primary education level	-1,389 (1,114)	-0,044 (0,036)
Conventional cotton production	-4,738** (2,127)	-0,152** (0,054)
Access to land by inheritance	7,310*** (2,768)	0,234*** (0,071)
Secondary activity (Trade)	-3,002** (1,162)	-0,096** (0,031)
Frequency of extension services	7,254*** (2,048)	0,232*** (0,039)
Constant	-13,368*** (4,026)	-
Number of observations=160		
Log likelihood=-16.098		
R-square=0.8548		
Chi-square=29.66		
Probability=0.0053***		

Note: (***): Significant at the 1% level; (**): Significant at the 5% level; (*): Significant at the 10% level.

TABLE 5
Result of estimating the stochastic production function

Variables	Coefficient	Standard error	T-ratio
Constancy (α_0)	-6.13	1.148	5.331
Number of plants (lnPLANT)	0.071	0.221	-0.321
Cashew area (lnSUPANA)	-0.777**	0.229	3.358
Family labor (lnMOF)	0.015	0.047	-0.327
Equipment depreciation (lnAMORT)	-0.071*	0.037	1.933
σ^2 (Sigma-square)	2.934	0.815	3.584
γ (Gamma)	0.934	0.029	31.211
Log likelihood	-	-81.44	-
Likelihood ratio test	-	22.88***	-
Average technical efficiency	-	0.63	-

Note: (***): Significant at the 1% level; (**): Significant at the 5% level; (*): Significant at the 10% level.

Furthermore, of the four inputs (number of plants, area of organic cashew plantation, family labor and equipment depreciation) included in the FRONTIER model, only the variables area of cashew plantation and depreciation of equipment are respectively significant at the 5% and 10% threshold. The coefficients representing the elasticities of these two variables are negative (respectively 0.777 and 0.071). It therefore follows that the production of fair-trade organic cashew is negatively correlated with the area of the cashew plantation and the depreciation of equipment. This reflects an overuse of these factors by fair-trade organic cashew producers. Indeed, an increase in the quantity of these inputs by 1% leads to a reduction in the quantity of fair-trade organic cashew produced equal to the percentage of elasticities.

Distribution of technical efficiency indices of fair-trade organic cashew producers

The distribution of technical efficiency scores shows that the technical efficiency indices vary between 0.01 and 0.89 with an average of 0.63 (Figure 1). There is still a big gap between the minimum score and the maximum score. The modal class of the scores is (60-80). Most producers are far from the production frontier. 2.5% have a score between (0-0.20); 3.75% between (0.2-0.40); 25% between (0.40-0.60); 57.5% between (0.60-0.80) and finally 11.25% between (0.80-1).

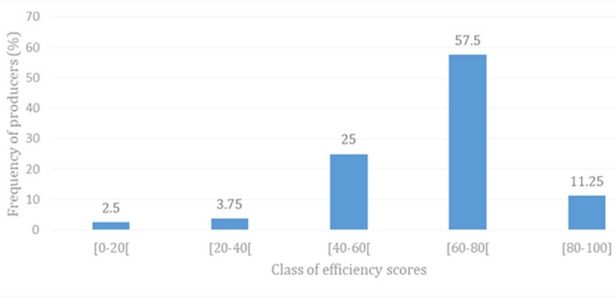

Figure 1) *Distribution of producer technical efficiency scores*

DISCUSSION

Determinants of fair-trade organic cashew adoption

Agricultural workers: The increase in the number of each additional agricultural worker in the household increases the probability of adopting fair-trade organic cashew by 3.3%, possibly because organic production requires labor in particular for research, transport, application of organic inputs and weeding. Most producers, being mostly poor, do not have sufficient financial means to hire this workforce, which has become increasingly rare and expensive. As a result, the number of agricultural assets held by the producer would be a response in terms of labor and would encourage him to better adopt the production of fair-trade organic cashew. This result is similar to those of Dossa et al., [20] who found that the growing number of agricultural workers makes it possible to meet the need for labor imposed on the producer. An increase in surface area results in a 0.5% decrease in the probability of adopting fair-trade organic cashew.

Farm size: Producers planting large areas are more inclined to adopt fair-trade organic cashew. Indeed, this result is justified by the strong demand for labor for the development of large areas. Organic farming is mainly based on the valorization of local resources (cow manure, neem seeds, papaya leaf etc.) for soil fertility and pest control and it is difficult to mobilize enough for a large-scale operation. An increase in area would require more field maintenance. Thus, the investment in paid labor increases with the increase in the size of the farm and therefore reduces the probability of adoption of organic cashew by producers. These results are in line with those of McBride et al., [25] who point out that "big" farmers are less inclined to convert to organic farming due to the high labor requirements of this mode of production. Furthermore, operators of small units find in this mode of production a solution to their problems of economies of scale. In addition, small farms have greater use of family labor and have a lower conversion opportunity cost [26-30].

Experience in cashew production: Each year of experience producing cashew increases the farmer's probability of adoption of fair-trade organic cashew by 0.4%. The more experienced farmers are more favorable to adoption, because they appreciate the advantages and disadvantages associated with this activity. Producers with more experience are looking for new strategies to make their operations more visible and more competitive in terms of profitability. These results confirm those of Yabi et al., [31] and Sall et al., [32] who found that the knowledge acquired over time by producers, by making production harmful to the environment can help to evaluate the information, thus influencing their adoption decisions. Kpadenou et al., [33] also concluded that the adoption of these practices was influenced by the experience of producers. Furthermore, these results contradict those of Yabi et al., [31] who, after finding the positive role of experience on the adoption of innovations, have on the other hand underlined that young, less experienced producers tend to take more risk than the older ones. Similarly, the results of Yovo [34] showed that older people are not willing to adopt new ideas or attempts. They are called "conservatives" and may be less able to use certain new adoptions efficiently and may be more reluctant to accept new ideas [35,36].

Gender: Male producers are 6.4% less likely to adopt fair-trade organic cashew. Women have a strong propensity to adopt fair-trade organic cashew. Women have played a great role in developing the fair-trade organic cashew sector. In fact, in rural areas of Benin, women often face problems in adopting new technologies due to lack of time or funds and poor control over productive resources. Their farms are smaller, facilitating the use of locally available inputs and good management makes them less dependent on their husbands [2]. The use of these locally available inputs influences women's decision to practice organic farming [37]. Also, women are particularly concerned about the harmful effects of chemical substances used in conventional production on the environment and on human health and are therefore more favorable to the fair-trade organic production of cashew [38]. This result corroborates

with that of Glin et al. [2], Sodjinou et al., [16] and Agalati et al., [23], who all showed that women are more favorable to organic production than men. This is in line with Kpadenou et al., [33] who found that men were more willing to adopt organic practices than women.

Conventional cotton production: The cultivation of conventional cotton by the cashew producer reduces his probability of adopting fair-trade organic cashew by 15.2%. The more they grow conventional cotton, the less they agree to convert to organic farming. Cotton farming requires a very high use of chemical inputs for pest control, weeding, soil fertility, etc. However, organic farming is mainly based on the use of natural resources. The land pressure also could explain the negative effect of conventional cotton production on the adoption of fair-trade organic cashew that producers face. Due to lack of available land, cotton is sometimes associated with young cashew plantations or sometimes planted near cashew orchards. Proximity to cotton fields, high consumers of chemical inputs, would represent a significant risk of contamination during the various chemical treatments (wind effect, slope, buffer zone, etc.). Cashew trees begin to produce from the third year, producers very often plant associated crops during the first two years to enhance their field. However, some of these crops, such as cotton, require the use of chemical inputs, which is prohibited in organic farming. It should be noted that for producers producing conventional cotton on land other than that hosting cashew orchards, a major problem of separation arises. The inputs and materials intended for conventional cotton production are stored in the same room intended to receive the organic cashew nuts. In addition, conventional cotton producers find the organic production system tedious and less profitable because of the low yields they would record due to the non-use of chemical fertilizers. This result confirms that of Houndekon [39] who showed the negative influence of conventional cotton production on the decision to do organic production.

Land access mode: The mode of direct access to land by purchase increases the probability of adoption of organic fair-trade cashew by producers by 23.4%. Those who bought the land where the cashew orchards stand are more favorable to fair-trade organic production than those who have acquired it by other means (indirect). Buying land grants the producer all the rights of ownership and use of the land. The decision to adopt fair-trade organic cashew is crucial because it requires conversion periods and investments, other modes of access to land do not secure the producer. Cashew producers who own the land would be willing to undertake actions to preserve and maintain soil fertility in the medium and long term. This result agrees with that of Kpadenou et al., [33] who found the positive influence of the land status of the market gardener, which is the direct mode of access to the land, on the adoption of agroforestry and on the conservation of soil and water. The formalization of property rights had a positive influence on the degree of investment of maize and cotton producers in the commune of Gogounou in sustainable land management. The same is true for Amichi et al., [40] who estimated that the unstable land status does not secure long-term investments in cropland. Indeed, our results invalidate those of Agalati et al., [23] who found that when moving from non-enjoyment of land ownership rights to direct access, the probability of adoption of organic production decreases.

Secondary activity of producer: The practice of a secondary activity such as trade reduces the probability of adopting fair-trade organic cashew by 9.6%. Working off farm reduces the time available on the farm, which can be a barrier to conversion. Organic production requires greater attention for the implementation of the various activities of maintenance, monitoring, preparation and application of organic inputs, etc. This result confirms those of McBride et al., [25] who showed that off-farm work for the farm manager has a negative effect on the probability of conversion, for a sample of soybean producers in the United States in 2006. Conversely, this result contradicts those of Kallas et al., [27] who found a positive effect of off-farm work on conversion for grape growers in Spain. For them, off-farm work can represent a form of insurance when the farmer decides to engage in "risky" production such as organic farming.

Extension services: The increase in extension services for producers increases by 23.2% the probability of adopting fair-trade organic cashew. Meetings with extension agents are a channel for producers to discuss the problems they encounter in their activities in order to have solutions in the form of advice or new technologies. The more the producer is in contact with extension agents, the more he receives closer supervision (information, training, new technologies, etc.). This result confirms those of Yabi et al. [31], Issoufou et al., [41] and Zoundji et al., [42] who showed the positive impact of extension or a Non-Governmental Organization (NGO) or a project on the adoption of agricultural technologies.

Level of technical efficiency of fair-trade organic cashew producers: Estimation of the stochastic Cobb-Douglas production function of fair-trade organic cashew producers shows decreasing returns to scale revealing that a simultaneous and identical increase in all inputs is likely to generate a decrease more than proportional to the quantity of cashew produced by the producers. Thus, production is highly dependent on the land (sown area) with an estimated coefficient of 0.77. This confirms that cashew production is extensive in the study area. This result is similar to that of Degla [28]. Indeed, an increase in the area of cashew sown by one ha leads to a decrease in the quantity of nuts produced by 0.77 kg. This result is not consistent with the results of Degla [28] who reported a positive coefficient of cultivated area. It could be justified by the lack of maintenance (weeding, pruning, etc.) of large areas of cashew by producers. In addition, an increase in the cost of equipment by 1CFA franc, leads to a decrease in the quantity produced by 0.071 Kg. This result may be justified by the fact that the equipment acquired by producers for the benefit of cashew production is diverted to other activities outside of cashew or is misused. The family labor coefficient is positive but not significant. This positive effect of work confirms the results of Audibert [43] and invalidates those of a negative coefficient attributed to the effect of the theft of collected nuts. In sum, the available resources are globally overexploited at the producer level. There are opportunities to use them further with a view to improving cashew production. This result confirms those of underlined the need for optimal use of factors such as capital and labor to increase agricultural production in agricultural systems. Farms where fertilizers and pesticides are generally not used. Indeed, the average efficiency scores of producers is 0.63 (min: 0.01; max: 0.89), i.e., these producers are at 0.37 of their productive capacities. These scores are well above those observed by other authors, namely 0.39 and 0.63 respectively for Degla [28] who recognize that inefficiency decreases over time. As a result, the producers are not technically efficient. There are still opportunities to increase production through better utilization of factors of production. They could improve the current level of their production without having to increase their volumes of inputs but by combining the available productive resources and those following the technical recommendations (technical route of production, good practices of maintenance and management of the plantations, good practices harvest and post-harvest, etc.). Majority of producers belong to the modal class (60-80) of the efficiency score distribution. Degla [28] found similar results in his study on the technical efficiency of cashew nut production in central and northern Benin.

CONCLUSION

This identified factors determining the adoption of fair-trade organic cashew and estimate producer's technical level efficiency in central Benin by using "t" test, logistic regression and the method based on stochastic frontiers of type production Cobb-Douglas function. The results show that several factors influence the adoption of fair-trade organic cashew nuts in the municipality of Ouesse. Among these factors, eight have a significant influence and explain the decision of producers to adopt fair-trade organic cashew nuts or not. The number of farm assets, experience in cashew production, mode of access to land by purchase and frequency of extension services positively influence the probability of adoption, while cotton production, secondary activity of the producer and farm size negatively influence it. Women are more likely to adopt organic production. In terms of measuring technical efficiency, results show that farmers are not technically inefficient. There is still considerable room for improvement and enormous scope for increasing fair-trade organic production based on the current level of used. It is therefore incumbent on the structures promoting organic and fair-trade agriculture to take into account the different factors listed above in order to contribute to a more sustainable dissemination of organic fair-trade cashew nut production. Policy actions must be engaged towards the reinforcement of the technical supervision device for an improvement of the productivity and a better competitiveness of the sector.

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