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Understanding the effects of migrant remittances on agricultural production in West African countries

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Abstract

This research aims to explore the effects of migrants' remittances on agricultural production in West African countries. Particular attention is given to the interactive effect of these remittances and farm-related characteristics such as the area of farmland farmed, agricultural labor force and temperature variation. The study sample is composed of six countries of the West African Economic and Monetary Union (WAEMU) and covering the period 1993-2020. The panel corrected standard error (PCSE) and weighted least squares indicate that the effect of migrant remittances on agricultural production in WAEMU countries depends on the area of agricultural land exploited and the variation in temperature. The results suggest the interest for WAEMU countries to develop internal means of financing adapted to the needs of large farms and to support the diversification of non-agricultural rural activities.

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1. Introduction

Agriculture is for most people in West African Economic and Monetary Union (WAEMU) countries an essential source of income and food supply. Although important and employing 65 to 85% of the active population depending on the country, the WAEMU agricultural sector remains marked by a low level of financing of farms (Nyoro, 2019). According to data from the World Bank (2020), 80-90% of farmers experience significant financing constraints.

To cope with the financing constraints of the agricultural sector, several strategies are developed by households, including migration. For Stark (1978) and Stark and Levhari (1982), remittances from migration are a risk management strategy and can be used in productive investing in general. These authors belong to the current of the new migration economy, which conceives of migration as family or collective decision-making aimed at removing household liquidity constraints and/or diversifying risks in the absence of credit or insurance markets in rural areas (Stark, 1984; Stark and Bloom, 1985).

Several studies have focused on the use and impact of migrant remittances on the development pillars of the countries of origin. Thus, numerous studies have highlighted the beneficial effects of migrant remittances through the reduction of the prevalence of working children (Ebeke, 2010), greater access to drinking water and sanitation (Tsafack and Djeumankan, 2021), the smoothing of consumption and income (Combes and Ebeke, 2011) and the reduction of income inequalities (Kratou and Goaied, 2018). On the other hand, other studies show that migrants' remittances have damaging consequences. For example, migrants' remittances deteriorate the quality of recipient countries' institutions (Attila et al., 2018) and reduce the participation of beneficiaries in the labor market (Catrinescu et al., 2009).

Moreover, although the problem of agricultural development is not new, little work has been done on the relationship between migrant remittances and agricultural production. As part of the analysis of the new migration theory, the decision to migrate is made at the household level, and migrants transfer funds to their families of origin to cope with the various shocks that threaten their agricultural production (Generoso, 2012). The empirical literature on the effects of migrant remittances on agricultural production presents contradictory results. On the one hand, research shows that increased remittances from migrants in countries of origin promote increased agricultural production (Taylor et al., 2003; Zahonogo, 2011; Damette and Gittard, 2017). On the other hand, a second wave of empirical work finds a negative effect of remittances on agricultural production (Wang, 2010; Gonzalez-Velosa, 2011; Castelhano et al., 2016; Dedewanou and Tossou, 2021).

With particular reference to farm characteristics such as farm area, agricultural labor force and temperature variation, several studies show mixed results on the sensitivity of agricultural production to these determinants (Ogbuabor et Nwosu, 2017; Yakete-Wetonnoubena et Mbetid-Bessane, 2019; Djoumessi, 2021; Warsame et al., 2021). The current debates are on the level of complementarity or substitution between these determinants in determining agricultural production. While the differential effects of migrant remittances on agricultural production have attracted the attention of researchers, the formal links between agricultural area and migrant remittances are not clearly identified. This has important implications in our research by considering the interaction between migrant remittances and farm characteristics. This work contributes to the literature on the determinants of agricultural production by exploring the joint contribution of farm-related characteristics and migrant remittances.

The WAEMU area offers an interesting field of investigation to examine this relationship and test the influence of these characteristics on the relationship between migrant remittances and agricultural production. In this area, agricultural production contributed an average of 23% to the gross domestic product over the period 1993-2021 (World Bank, 2022). Remittances from migrants to WAEMU countries reached nearly $4,180 million in 2016 (World Bank, 2022). These remittances from migrants, a source of international income, play an essential role in the WAEMU countries. They can therefore promote an increase in agricultural production.

The level of agricultural production appears to be linked to the acquisition and valuation of factors of production and the financial availability allocated to the agricultural sector (Zakaria et al., 2019). Similarly, research (Quinn, 2009; Taylor et al., 2003; Damette and Gittard, 2017) on the possible complementarity or substitution of factors of production in determining the level of agricultural production suggests that remittances, as a source of agricultural finance, influence agricultural production in two ways: either directly through the acquisition of primary factors of production or indirectly through the valuation of these factors of production. The indirect effect is exerted through the positive influence of migrant remittances on agricultural production, provided that they are combined with primary production factors. The main objective of this research is to examine the influence of migrant remittances and general characteristics related to farms and their interactive effects on agricultural production in WAEMU countries. Specifically, it is a question of determining the direct individual effect of migrant remittances on agricultural production and the interaction effect of migrant remittances and farm-related characteristics on agricultural production in WAEMU countries. The hypotheses put forward in this research are: the primary factors of production, i.e., the area farmed, the agricultural labor used and the variation in temperature, have a positive effect on agricultural production; the effect of migrant remittances on agricultural production depends on the level of these factors of production.

The rest of this article is organized as follows. A selective review of the literature is provided in the section 2. Section 3 discusses the methodology used. Section 4 presents and discusses the results from econometric estimates.

2. A selective literature review

The empirical literature focusing on the effects of migrant remittances on agricultural production presents contradictory results. On the one hand, research shows a positive effect of migrant remittances on agricultural production. Indeed, Quinn (2009) shows that migrant remittances promote the use of high-quality seeds, thus reducing household risks and credit constraints. Similarly, Zahonogo (2011) shows that migrant remittances provide households with the opportunity to invest in agricultural technologies and thus compensate for the negative effect induced by migrants' departure. Similar results (Taylor et al., 2003) found in China show that remittances compensate for the loss of labor due to migration. Migrant remittances thus allow households to improve their agricultural production. Based on 39 developing countries, Damette and Gittard (2017) show that the higher the remittances, the lower the rate of urbanization because the households that migrate are agricultural households and the higher the agricultural value added. While their work identifies a relationship between remittances and agricultural production, it does not directly measure the effects of remittances on agricultural production. On the other hand, some work highlights the negative effect of migrant remittances on agricultural production. Indeed, Castelhano et al. (2016) find that migrant remittances have not promoted rural investment in agricultural production in Mexico. They also show that migrant remittances have not significantly increased investment in agro-pastoral production. Similarly, Dedewanou and Tossou (2021) find in the case of Burkina Faso that a 1% increase in migrant remittances leads to a 0.9% decrease in sorghum agricultural production. In the Philippines, the work of Gonzalez-Velosa (2011) suggests that migrant remittances do not encourage investments outside agriculture. For Wang (2010), rural households use migrant remittances for living expenses rather than for investment expenditures.

The economic literature also identifies other determinants of agricultural production. Djoumessi (2021) shows that an increase in the area of agricultural land under cultivation favors an increase in agricultural production in these sub-Saharan African countries. It is also found that an increase in the agricultural labor force favors an increase in agricultural production (Yakete-Wetonnoubena and Mbetid-Bessane, 2019). As for Warsame et al., (2021), they underline the major role of temperature variation. The strong variation in average temperature is supposed to modify the conditions of agricultural production. Similarly, public expenditure on agricultural research (Beintema et al., 2019; Magazzino et al., 2021), credit to the agricultural sector (Magazzino et al., 2021), human capital (Khadimallah and Akrout, 2017), agricultural machinery (Djoumessi, 2021) and fertilizer use in agricultural production (Huang and Li; 2019) appear to be determinants of agricultural production.

Methodologically, these different studies have carried out econometric estimations to examine the effects of migrant remittances and have considered sets of countries, albeit with heterogeneous socio-economic and demographic characteristics. This research does not sufficiently take into account the problem of heteroscedasticity in the estimation of their econometric models. Countries in sub-Saharan Africa or the WAEMU have different socio-economic characteristics, which may constitute heterogeneous groups. Heteroscedasticity often masks another problem of misspecification. This research also addresses this problem in the econometric estimates to avoid incorrect inferences.

3. Methodological approach

This section presents the data sources used in this research, the specification of the analysis model, and the variables of the model.

3.1 Nature and sources of data

The data for this research come from the World Bank's database (World Development, 2020), the FAO database (FAOSTAT) (FAO, 2020) and the Penn World Table database, version 9.0 (PWT 9). The panel database is composed of six countries, namely, all WAEMU member countries except for Guinea Bissau and Niger, for which some data are not available. The six countries that make up this base are Benin, Burkina Faso, Ivory Coast, Senegal, Mali and Togo. The variables are filled in during the period from 1993 to 2020. The choice of this period is justified by the availability of data for the 06 countries of the panel. The panel can be described as a cylinder whose data are quantitative and annual and cover the period chosen, i.e., a total of 168 observations**.**

3.2 Model specification

The Cobb–Douglas production function is used to analyze the effects of migrant remittances on agricultural production in WAEMU countries. Indeed, this production function is one of the most widespread tools in theoretical and empirical analysis to represent the relationship between an output and its inputs. This function is also used by Chisasa and Makina (2013) and Omon (2021). The general form of the Cobb–Douglas function is given by the expression:

$$Y_t = A_t K_t^{\alpha} L_t^{\beta} \quad \textbf{(1)}$$

Where Y is output, K is physical capital, L is labor, A is technological level, and α and β are constants determined by technology.

The framework of this research shows that the explanation of agricultural production goes beyond the traditional factors of physical capital, labor and level of technology. Thus, considering a country i that has physical capital (K) and labor (L) and has a diaspora that transfers funds (remittances) to relatives who remain in the country of departure, agricultural production (Y_t) in this country is determined by:

$$Y_t = A_t K_t^{\alpha} L_t^{\beta} Remittances X_t^{\varepsilon} \quad \textbf{(2)}$$

where Y_t means agricultural production in period t and $A_t, K_t, L_t, Remittances_t$ and X_t denote the multiplicative factor in period t, physical capital in period t, labor in period t, remittances in period t and the vector of control variables, respectively.

A linear transformation of this production function gives:

$$\ln Y = \ln A + \alpha \ln K + \beta \ln L + \gamma \ln Remittances + \ln X \quad \textbf{(3)}$$

The model specification incorporates the control variables of area of farmland used, public expenditure on agricultural research, fertilizer consumption, human capital, agricultural labor, agricultural credit, agricultural machines and temperature. The econometric model measuring the effects of migrants' remittances on agricultural production can be written as follows:

$$lnAPI = \beta_o + \beta_1 lnRemittances_{i,t} + \beta_2 lnLand_{i,t} + \beta_3 \ln\left(Remittances_{i,t} * FRC\right) + X'_{i,t}\beta_4 + \mu_i + \omega_t + \epsilon_{i,t} \quad \textbf{(4)}$$

Where API : agricultural production index; Remittances: remittances from migrants; Land: the area of agricultural land used; $Remitances * FRC$: Measures the interaction between migrant remittances and Farm-related characteristics; X : a vector of control variables that determines agricultural production; ε: the error term. Research (Quinn, 2009; Taylor et al., 2003; Damette and Gittard, 2017) on the possible complementarity or substitution of factors of production in determining the level of agricultural production suggests taking into account cross effects between migrant remittances and factors of production. The present research considers the production factors of farmed area, labor input and temperature variation.

The variable explained is the Agricultural Production Index (API): This FAO indicator shows agricultural production for each year compared to the base period from 2014 to 2016. It is collected directly from the FAO database and considers all primary products of agriculture and livestock (rice, potato, maize, etc.). The quantities used as seed and animal feed shall be deducted from production. This index was used in previous work by Nkamleu (2004), Sarkodie and Owusu (2017) and Osabohien et al. (2019). The explanatory variables used for the estimation of the econometric model are presented in table 1. The values of migrant remittances, credit to agriculture and public expenditure on agricultural research have been deflated by the consumer price index to account for price fluctuations.

Table 1. Model variables and expected signs

Dependent variables	Measure	Expected sign	Source
Remittances (Remittances)	Billions of dollars	+/-	WDI
Area of agricultural land used (Land)	Millions ha	+/-	FAOSTAT
Credit to agriculture (Credit)	Billions of dollars	+	FAOSTAT
Public expenditure on agricultural research (Public expenditure)	Billions of dollars	+	FAOSTAT
Agricultural labor force (Labor)	Millions	+	FAOSTAT
Fertilizer consumption (Fertilizer)	Kg per hectare of arable land	+	WDI
Agricultural machines	Number of machines per dozen	+	FAOSTAT
Temperature (Temperature)	Deviation from the mean	-	WDI
Human capital (Human capital)	Human capital index	+	PWT

4. Results and discussion

This section provides descriptive statistics for the econometric model variables and presents the results of the econometric estimates.

4.1 Statistical analysis of data

The descriptive statistics for the endogenous variable, as well as those for the variable of interest and other explanatory variables of the econometric model, are presented in Table 2. This table shows that the average value of agricultural production captured by the agricultural production index is approximately 76.06 over the research period, with a dispersion of 27.78. The minimum and maximum values are 33.63 and 156.83, respectively.

Table 2. Description of variables

Variables	Obs.	Mean	Std. Dev.	Min	Max
API	168	76.066	24.636	33.633	156.832
Remittances	168	0.235	1.444	-9.848	13
Land	168	14.483	12.568	2.321	41.655
Public Expenditure	168	0.011	0.088	-0.846	0.378
Credit	168	0.034	0.176	-0.835	1.386
Labor	168	7.635	3.007	2.826	14.505
Fertilizer	168	13.678	9.634	0.002	44.118
Machines	168	233.191	313.371	8.801	1158.101
Temperature	168	0.001	1.547	-19.260	1.209
Human capital	168	1.425	0.231	1.041	1.918

4.2 Estimation results

4.2.1 Preliminary tests

The LM test of Breusch and Pagan (1980), the bias-adjusted LM test by Pesaran, Ullah and Yamagata (2008) assume interindividual independence. The test of Levin, Lin and Chu (2002) suggests the existence of a long-term relationship between agricultural production and the other explanatory variables retained in the model. The result of the Hausman endogeneity test makes it possible to reject the endogenous nature of migrants' remittances. The p value (prob=0.0000) of Hausman specification test indicates that the fixed-effect model is more suitable than the random-effects model at the 1% threshold. The Breusch-Pagan (1979) and White (1980) heteroscedasticity tests reject the null hypothesis that the variance of the model errors is constant for all observations. Furthermore, the general Cumby-Huizinga (1990, 1992) test attests to the presence of autocorrelation of the series errors.

In order to detect more precisely the variables that cause the heteroscedasticity problem, the Breuch-Pagan (1979) test is used on the different independent variables. It is found that the area of agricultural land used, agricultural labor, fertilizer consumption and public expenditure on agricultural research are the variables that cause the heteroscedasticity problem. To deal with this problem, the weighted least squares method is used to estimate the econometric model. This method produces more efficient parameter estimates by assuming that the residual variance is an exponential function of a linear combination of the variables causing the heteroscedasticity. The panel-corrected standard error (PCSE) technique efficiently handles heteroscedasticity, autocorrelation, serial correlations and produces accurate estimates with no or minimal loss of efficiency. Table 4 presents the results obtained with the weighted least squares method.

4.2.2 The effects of migrant remittances on agricultural production

Table 3 presents the results obtained with the PCSE method. The first three columns present the results of the direct individual effect of migrant remittances on agricultural production. Column (4), column (5) and column (6) present the estimates taking into account respectively the cross effects between migrant remittances and agricultural labor, between migrant remittances and temperature, and between migrant remittances and area of agricultural land exploited. In the following, the dependent variables, and the variables such as fertilizer consumption, human capital and number of agricultural machines are expressed in logarithms.

The analysis of the results in Table 3 shows that agricultural labor, human capital and the interaction between migrant remittances and exploited agricultural land are the factors that improve agricultural production in the WAEMU countries. The area of agricultural land exploited only improves agricultural production above a certain threshold (25 million hectares).

Table 4 presents the results obtained with the weighted least squares method. Interpretations are based on the results in Table 4 which are more robust to heteroscedasticity. Importantly, the results in Table 4 show that the coefficient associated with migrants' remittances is statistically insignificant. This result suggests that the effect of migrant remittances on agricultural production in WAEMU countries is statistically negligible. On the other hand, the coefficient associated with the interaction between migrant remittances and the area of farmland exploited is positive and significant. This result highlights the sensitivity of agricultural production to the complementarity effects between these two quantities. It allows us to conclude that the effect of remittances on agricultural production depends on the area of farmland exploited. The effect of migrant remittances improves with an increase in the agricultural area farmed.

Such a result suggests that in WAEMU countries, migrant remittances are used in agriculture for the acquisition of additional technologies or inputs needed to increase agricultural production. For countries with large agricultural areas, these large areas are a significant transmission channel between remittances and agricultural production. Remittances exert positive externalities on agricultural production by enhancing the value of large agricultural areas. The estimation results confirm that land availability does not seem to be a constraint to agricultural production.

High temperature has a direct negative effect on agricultural production. On the other hand, the results show that the coefficient associated with the interaction between migrant remittances and temperature is positive. Such a result could be explained by the fact that the rainfed agricultural system of the WAEMU countries remains vulnerable to climatic hazards such as temperature increase, recurrent droughts, variability of rainfall and seasons. Migrant remittances could facilitate the adoption of climate change adaptation practices. They can therefore mitigate the negative effect of temperature variation on agricultural production.

The results also show that agricultural labor has a positive and significant effect at the 5% threshold. More specifically, an increase in the agricultural labor force of 10% leads to an increase in the relative level of the volume of agricultural production of 16.9%. These results are in line with the work of Yakete-Wetonnoubena and Mbetid-Bessane (2019). Such a result could be explained by the fact that the agricultural production system of the WAEMU countries is based on small peasant farms whose socioeconomic unit is the household. Agricultural work is essentially manual and is characterized by its capacity to absorb a large part of the working population. It follows, therefore, that the increase in the labor force favors the increase in agricultural production. Another result of the econometric estimates indicates that public spending on agricultural research has a positive and significant effect at the 1% threshold. These results are consistent with the work of Beintema et al. (2019). Such a result in the WAEMU countries could be justified by the fact that agricultural research contributes to the change of agricultural production systems. According to FAO (2020), WAEMU countries are increasing public spending on agricultural research and development to modernize innovative technologies. Technological innovations developed through agricultural research are helping to overcome the problems that threaten crops. The results also show that human capital has a positive and significant effect on agricultural production. These results are similar to the work of Khadimallah and Akrout (2017). In the context of WAEMU countries, this result could be explained by the ability of farmers to adopt agricultural technologies and innovations in the face of changes in their environment. In addition, the experience of farmers also contributes to the improvement of agricultural production. Another result of the estimates indicates that fertilizer use has a positive and significant effect at the 1% level on agricultural production. This result confirms that fertilizer consumption is a determinant of agricultural production.

Table 3. Estimates of migrant remittances on agricultural production

Panel corrected standard error method						
Dependent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Remittances*Land						0.0015***
						(0.0004)
Remittances*Temperature					-0.0083	
					(0.0306)	
Remittances*Labor				0.0004		
				(0.0010)		
Remittance	-0.0005	0.0005	-0.0052			
	(0.0055)	(0.009)	(0.0071)			
Public Expenditure		-0.0166			-0.0187	
		(0.1584)			(0.0872)	
Credit			0.0661	0.0221		0.0217
			(0.0611)	(0.0653)		(0.0511)
Temperature	0.0004	0.0003	0.0014	0.0009	0.0072	0.0021
	(0.0029)	(0.0031)	(0.0032)	(0.0031)	(0.0257)	(0.0036)
Land	-0.0565***	-0.0571***	-0.0553***	-0.0548***	-0.0578***	-0.0448**
	(0.0212)	(0.0213)	(0.0211)	(0.0510)	(0.0212)	(0.0192)
Land2	0.0011***	0.0011***	0.0011***	0.0011***	0.0011***	0.0009**
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0003)
Labor	0.0594***	0.0593***	0.0585***	0.0578***	0.0602***	0.0533***
	(0.0083)	(0.0082)	(0.0082)	(0.0081)	(0.0083)	(0.0079)
Machines	0.1317	0.1357	0.1235	0.1258	0.1342	0.0907
	(0.1124)	(0.1133)	(0.1131)	(0.1125)	(0.1126)	(0.1023)
Fertilizer	0.0048	0.0049	0.0048	0.0052	0.0036	0.0043
	(0.0113)	(0.0113)	(0.0114)	(0.0113)	(0.0118)	(0.0111)
Human capital	1.4440***	1.4357***	1.4052***	1.3972***	1.4420***	1.3375***
	(0.2002)	(0.2010)	(0.2047)	(0.2016)	(0.2192)	(0.1969)
Constant	1.3055***	1.3045***	1.3238***	1.3270***	1.3000***	1.3768***
	(0.0962)	(0.0971)	(0.0997)	(0.0976)	(0.1024)	(0.0883)
Observations	168	168	168	168	168	168
R^2	0.9451	0.9553	0.9437	0.9435	0.9282	0.9523

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

Table 4. Estimates of migrant remittances on agricultural production

			Weighted least squares method			
Dependent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Remittances*Land						0.0012***
						(0.0004)
Remittances*Temperature					0.0908**	
					(0.0350)	
Remittances*Labor				0.0004		
				(0.0010)		
Remittances	0.0001	0.0047	0.0019			
	(0.0054)	(0.0095)	(0.0079)			
Public Expenditure		-0.0865			16.1798***	
		(0.1486)			(1.9840)	
Credit			-0.0279	-0.0404		-0.0759
			(0.0892)	(0.0877)		(0.0663)
Temperature	-0.0006	-0.0004	-0.0004	-0.0005	-0.0537 **	0.0002
	(0.0083)	(0.0083)	(0.0084)	(0.0083)	(0.0209)	(0.0083)
Land	0.0174	0.0178	0.0179	0.0177	-0.0457***	0.0050
	(0.0124)	(0.0123)	(0.0124)	(0.0124)	(0.0117)	(0.1364)
Land2	0.0001	0.0002	0.0001	0.0002	0.0005***	0.0002
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Labor	0.1693**	0.1652**	0.1684**	0.1674**	0.1712***	0.1970***
	(0.0694)	(0.0692)	(0.0691)	(0.0690)	(0.0527)	(0.0171)
Machines	-0.0771	-0.0712	-0.0747	-0.0737	-0.0070	-0.074
	(0.0535)	(0.0542)	(0.0539)	(0.0539)	(0.0368)	(0.055)
Fertilizer	0.5124***	0.5134***	0.5116***	0.5128***	0.6182***	0.5228 ***
	(0.1802)	(0.1801)	(0.1802)	(0.1804)	(0.2061)	(0.1818)
Human capital	1.5211***	1.5258***	1.5308 ****	1.5316***	1.6804***	1.5610***
	(0.1365)	(0.1363)	(0.1397)	(0.1396)	(0.1314)	(0.1402)
Constant	-6.6019***	-6.5804***	-6.6037***	-6.5942***	-6.3225***	-6.6875***
	(0.4138)	(0.4131)	(0.4123)	(0.4122)	(0.3621)	(0.4175)
LR test of lnsigma2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

**** p<0.01, ** p<0.05, * p<0.1. the LR test indicates that the exponential variance model fits the data better than a model where the variance is constant.*

4-2-3 Robustness of results

An estimate of two types of crops is made to check whether the results are affected by the definition of the endogenous variable, which is the index of agricultural production. As such, a first estimate is made on a cash crop (cotton, measured in tons of production) and a second estimate on a cereal crop (Millet/Sorghum taken together), measured in tons of production). The choice of crops is justified by their importance in the agricultural production of WAEMU countries. In these countries, millet and sorghum account for around 64% of cereal acreage and cotton 60% of export earnings (BCEAO, 2020). According to the ranking of African countries by cotton production (FAO, 2020), three WAEMU countries (Burkina Faso, Benin, Ivory Coast) occupy the first three places. Mali, Togo and Senegal are ranked tenth, fourteenth and twentieth respectively. Table 5 and Table 6 present the results of the estimates by crop type.

The analysis of the results in Table 5 shows on the one hand that remittances have a negligible effect on millet/sorghum production. On the other hand, the results show that the coefficient associated with the interaction between migrant remittances and the area of farmland exploited improves the production of millet/sorghum. Migrant remittances allow the acquisition of additional inputs necessary to increase millet/sorghum production. Table 6 reveals, on the other hand, that the direct and indirect effects of migrants' remittances on cotton production in the WAEMU countries are negligible. Such a difference could be explained by the fact that cotton cultivation in the WAEMU space always benefits from financing or subsidies from the States. Consequently, the financing constraints for this crop are less salient compared to cereal crops. Indeed, in these countries there are cotton companies that play a role in the promotion of cotton cultivation through the supply of inputs, advice and production techniques.

Table 5. Estimates of migrant remittances on the culture of Millet and Sorghum

Weighted least squares method on the culture of Millet and Sorghum						
Dependent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Remittances*Land						0.0042*
						(0.0021)
Remittances*Temperature					0.2947***	
					(0.1010)	
Remittances*Labor				0.0131**		
				(0.0053)		
Remittances	0.0004	0.0588	0.0989			
	(0.0244)	(0.0381)	(0.0383)			
Public Expenditure		-0.9337			-3.0342	
		(3.2370)			(2.0343)	
Credit			-1.473***	-1.4107***		-0.8756***
			(0.4543)	(0.4455)		(0.3296)
Temperature	0.0033	-0.0183	-0.0207	-0.0155	-0.1920**	0.0023
	(0.0514)	(0.0478)	(0.0505)	(0.0502)	(0.0819)	(0.0503)
Land	0.0372**	0.0424**	0.0229	0.0379***	0.0297*	0.0373**
	(0.0160)	(0.0185)	(0.0076)	(0.0165)	(0.0180)	(0.0161)
Labor	0.2841***	0.3200**	0.2709**	0.2724***	0.3034**	0.2797***
	(0.0619)	(0.0640)	(0.0625)	(0.0626)	(0.0657)	(0.0623)
Machines	-0.0825	-0.0830	-0.0504	-0.0617	-0.0061	-0.0869
	(0.1726)	(0.1749)	(0.1672)	(0.1674)	(0.1762)	(0.1692)
Fertilizer	0.5122***	-0.0078	0.5880***	0.5854***	0.6265***	0.5544***
	(0.1598)	(0.0305)	(0.1590)	(0.1588)	(0.1658)	(0.1597)
Human capital	-0.5400	-0.5368	-0.3007	-0.3158	0.2315***	-0.2626
	(0.6751)	(0.6747)	(0.6431)	(0.6455)	(0.2360)	(0.6514)
Constant	-4.5863***	-4.4286***	-4.6325***	-4.6290***	-4.7458***	-4.6356***
	(0.413)	(0.3552)	(0.3855)	(0.3866)	(0.3702)	(0.3863)
Observations	168	168	168	168	168	168
LR test of Insigma2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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

Table 6. Estimates of migrant remittances on the culture of cotton

	Weighted least squares method on the culture of cotton					
Dependent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Remittances*Land						0.0008
						(0.0008)
Remittances*Temperature					-0.0727	
					(0.1130)	
Remittances*Labor				0.0021		
				(0.0031)		
Public Expenditure		0.679			1.0156	
		(2.005)			(2.1535)	
Credit			-0.1688	-0.2113		-0.2020
			(0.1858)	(0.1830)		(0.1545)
Remittances	-0.0086	0.0130	0.0102			
	(0.0261)	(0.0435)	(0.0327)			
Temperature	-0.0057	-0.0069	-0.0074	-0.0075	0.0516	-0.0072
	(0.0217)	(0.0230)	(0.0218)	(0.0217)	(0.0930)	(0.0216)
Land	-0.1243***	-0.1261***	-0.1281***	-0.1293***	-0.1249	-0.1307***
	(0.0104)	(0.0105)	(0.0111)	(0.0109)	(0.0105)	(0.0109)
Land2	0.0011	0.0010	0.0009	0.0008	0.0011	0.0006
	(0.0009)	(0.0008)	(0.0009)	(0.0009)	(0.0009)	(0.009)
Labor	0.0691*	0.0695*	0.0745**	0.0761**	0.0675*	0.0782**
	(0.0373)	(0.0373)	(0.0378)	(0.0378)	(0.0374)	(0.0379)
Machines	0.9255***	0.8945***	0.8480***	0.8274***	0.9080***	0.7803**
	(0.3078)	(0.3070)	(0.3102)	(0.3051)	(0.3106)	(0.3035)
Fertilizer	-0.3277*	-0.3231	-0.3185	-0.3159	-0.3160	-0.3181
	(0.1972)	(0.1972)	(0.1950)	(0.1943)	(0.1949)	(0.1948)
Human capital	-1.2119	-1.1663	-1.0163	-1.0044	-1.2986	-0.9780
	(1.0302)	(1.0371)	(1.0498)	(1.0468)	(1.0611)	(1.0458)
constant	0.6881**	0.6962***	0.6896**	0.6900**	0.6824**	0.6925**
	(0.2677)	(0.2682)	(0.2681)	(0.2681)	(0.2662)	(0.2684)
Observations	168	168	168	168	168	168
LR test of Insigma2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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

5. Conclusion

This research explores the effects of migrant remittances on agricultural production in WAEMU countries. Specifically, it examines the influence of migrant remittances and farm-related characteristics such as the area of farmland farmed, agricultural labor, climate and their interactive effects on agricultural production. The empirical analysis covers six WAEMU countries covering the period 1993-2020. Empirical verification the PCSE and weighted least squares method are used. This work contributes to the literature on the determinants of agricultural production by exploring the joint contribution of farm-related characteristics and migrant remittances.

The results indicate that the individual effect of migrants' remittances on agricultural production in WAEMU countries is not significant. On the other hand, it appears that the effect of migrants' remittances on agricultural production in WAEMU countries depends on the area of agricultural land exploited. The farmed area is a catalyst for the contribution of migrant remittances to increased agricultural production. Another major result of the estimates highlights the moderating role of migrants' remittances in the face of temperature variation that negatively affects agricultural production. In addition, the results reveal that agricultural labor, public expenditure allocated to agricultural research, Fertilizer consumption and human capital also contribute significantly to the improvement of agricultural production in WAEMU countries.

These results suggest the interest of WAEMU countries in adapting their rural financial markets to the needs of different categories of farms. While remittances from migrants make it possible to increase agricultural production by exploiting agricultural areas, these results also raise questions about the need to develop internal means of financing adapted to the needs of different categories of farmers. Furthermore, to reduce dependence on rain-fed agriculture that is sensitive to climatic shocks, it would be interesting to support the agricultural producers in the diversification of non-agricultural rural activities. For example, remittances sent by migrants can be channeled into craft and commercial activities that will help overcome fluctuations in agricultural income caused by climatic hazards. To do this, it is useful for these states to put in place easier, less costly means of channeling the flow of remittances to the areas of origin and to support migrants in their investment projects.

The specific colonial legacies of African states and territories still reverberate today, shaping countries' borders, administrative and legal structures, and economic systems (Lucas, 2015). France, the former colonial power, remains the leading country of destination in developed countries. Migration dynamics in WAEMU countries are also the result of recent changes due to fluctuating economic conditions and the gradual implementation of restrictive migration policies in France (Word Bank, 2015). Therefore, remittance issues can be linked to broader economic development issues.

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