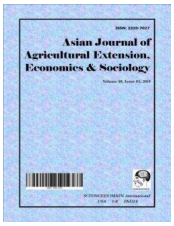

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Impact of Migration on Agricultural Productivity in Rural Mali

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The paper employed a national survey data of agricultural production in rural Mali. The study aimed at estimating the effect of migration on the technical efficiency of agricultural households. Therefore, a theoretical model was developed to investigate the fact, which showed that the more the migrants deliver insurance, the less incentive their behind families have to work. A production function-using cross sectional data with household-specific fixed effects was ran to test this assumption. Probability of being financially supported by migrants is found to significantly contribute to technical inefficiency. This result should help decision makers especially agricultural policy makers formulate more efficient development strategies in agricultural production sector.

Keywords: Migration; agricultural productivity; theoretical model; rural Mali.

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1. INTRODUCTION

Migration's impact on agricultural productivity has been a subject that catches researchers' attention in the entire world particularly in the developing countries. The decision of migration of any individual implicates several push factors that force migrant out of rural areas and pull factors that attract migrants to urban centres.

The earlier studies conducted by [1] and [2] describing rural-urban migration proved that anticipated wage differential is as or has been the main cause of migration from rural to urban. It implies that people will continue migrating from rural to urban centres until the wage in the rural area become equal to the wage in urban area. Therefore, the labour migration from rural area to urban area will involve the decreasing of agricultural workers, which can probably affect the production in the agricultural sector. Which goes with the result of [3], who argued that as economy continues to develop, the percentage of agricultural workers declines.

Agricultural sector is fragile from the viewpoint of rainfall dependent and price instability. Producers will be consequently affected if there is deterioration in the price of their production. Moreover, the farming industry offers seasonal employment, so it does not provide suitable revenue to sustain the household over an entire year. Therefore, there is a need for the family household to look for an extra revenue to support the household.

2. METHODOLOGY

2.1 Sources of Data

In the survey of the data, agricultural exploitation was defined as an economic entity of agricultural production including all the animals in it and all the land that belong, which is wholly in employment or in part and that, directed by the head of household. It is exploited by a household or a group of households independently associated regardless of title of possession, legal status, size and location of the exploitation.

EACI obtained its sample through stratified sampling of two stage with a sample of 2,515 exploitations sharing between 503 enumerations sections. Each section involved 750 persons in rural area and 1100 persons in urban area. At the first stage, exploitations are drawn with the same probability to the level of each stratum, which corresponds to the cercle or department. Cercle/department contains one to three sub-strata based on natural regions. At the second stage, two to five exploitations were drawn within the sample enumeration sections after counting all the exploitations. The survey covered the whole country and it was conducted in all regions apart from Kidal region and Bamako the capital. The survey covered both rural and urban areas. The objectives of this survey included collecting data on the rural sector, the establishment of significant information on the economics characteristics of farms, research of agricultural population statistics and various factors of production (CPS/SDR, 2014/2015). Based on these objectives the data collected included the following:

The characteristics of farm members (sex, age, education level, economic activities, marital status etc.), the characteristics of plots and factors of production (area of land, mode of cultivation, seed, fertilizer and pesticide type, labour use), stocks status and off-farm income generating activities. EACI has incorporated, since the general census of agriculture in 2004, a new module on vulnerability, which contains several sections including one related to farm migration. An emigrant was defined by the survey as an individual who has been living outside his/her origin department for at least six months. This module was usually surveyed before the beginning of the crop season or the rainy season while the production was measured at the end of the season. The effect of agricultural production in current year on the decision to migrate was then controlled.

This section provided information on the destination of the migrants, the reason of migration, and the remittances during the last twelve months (description, amount if it is money, level, and their share of food consumption). For 2014/2015, crop year had a complete data and hence was used in this research. After cleaning data, the exploitations with all the information available for the modules were gathered. The survey contains 2 331 exploitations over 474 enumerations sections.

With a very neglect rate of non-reply during the survey, the Malian agricultural population in 2016 was about 14 408 458 individuals. From the Fig. 1 the distribution of agricultural population by region except Kidal due to the insecurity, showed that more than one-fifth of the agricultural workers are living in the region of Sikasso (20.02%). This was followed by the region of

Ségou with 17.98% of the agricultural population. The region of Gao reported the lowest rate of agricultural population in Mali.

Some descriptive statistics on the agricultural sector and migration: The 2014/2015 crop year recorded an estimated of 8,849,551 tons of cereals production (rain season and dry season crop). In this quantity produced are including 2,811,385 tons of maize, 2,780,905 tons of rice, 1,806,559 tons of millet, 1,393,826 tons of sorghum, 40,137 tons of wheat and 16,740 tons of fonio. The quantity of cereals produced varies largely from region to another region in Mali. Sikasso first comes and follow by Segou. In terms of cereals production the regions of Gao and Kayes produce less cereals compare to other regions.

Table 1. The distribution of the sample by region

Region	Number of ES		Number of exploitations		Rate of reply
	Number	%			
Kayes	90	19.0	444	19.0	98.7
Koulikoro	72	15.2	359	15.4	99.7
Sikasso	81	17.1	400	17.2	98.8
Segou	80	16.9	394	16.9	98.5
Mopti	99	20.9	487	20.9	98.4
Tombouctou	32	6.8	151	6.5	94.4
Gao	20	4.2	96	4.1	96.0
Total	474	100.0	2331	100.0	98.4

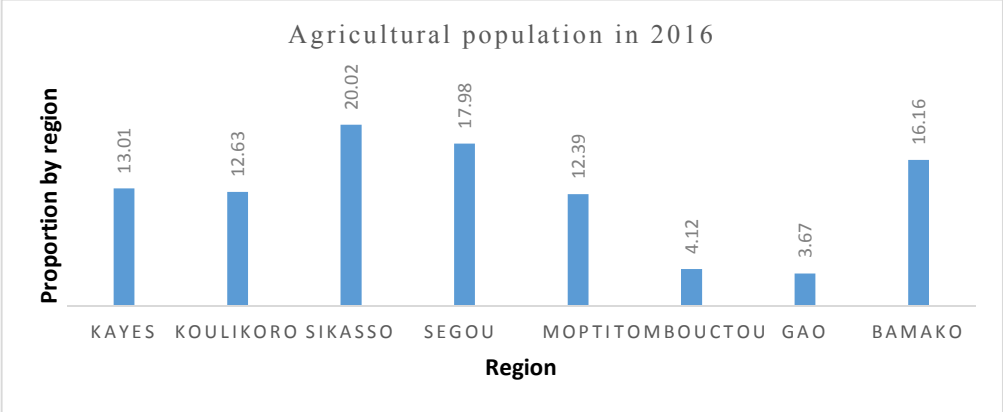

Fig. 1. Agricultural population by region except Kidal
Source: Author's field research

Table 2. Repartition of the agricultural population by status of residence and by region

Region	Present residents		Absent residents		Total number
	Number	%	Number	%	
Kayes	1 808 656	96.5	65 969	3.5	1 874 625
Koulikoro	1 812 764	99.6	7 950	0.4	1 820 714
Sikasso	2 840 592	98.4	45 092	1.6	2 885 683
Segou	2 559 074	98.8	31 555	1.2	2 590 629
Mopti	1 676 638	93.9	108 726	6.1	1 785 364
Tombouctou	570 214	96.0	23 709	4.0	593 923
Gao	526 919	99.6	2 024	0.4	528 942
Kidal	-	-	-	-	-
Bamako	2 255 866	96.9	73 222	3.1	2 329 088
Total	474	100.0	2331	100.0	98.4

Source: Author's field research

Table 3. Agricultural population by bracket age and by status of residence

Bracket age	Present residents		Absent residents		Total
	Number	%	Number	%	
0 to 14 years	6 449 928	97.8	145 076	2.2	6 595 004
15 to 29 years	3 653 106	97.0	113 771	3.0	3 766 877
30 to 59 years	3 256 352	97.3	88 900	2.7	3 345 252
60 years and more	690 824	98.5	10 500	1.5	701 325
Total	14 050 201	97.5	358 247	2.5	14 408 458

Source: Author's field research

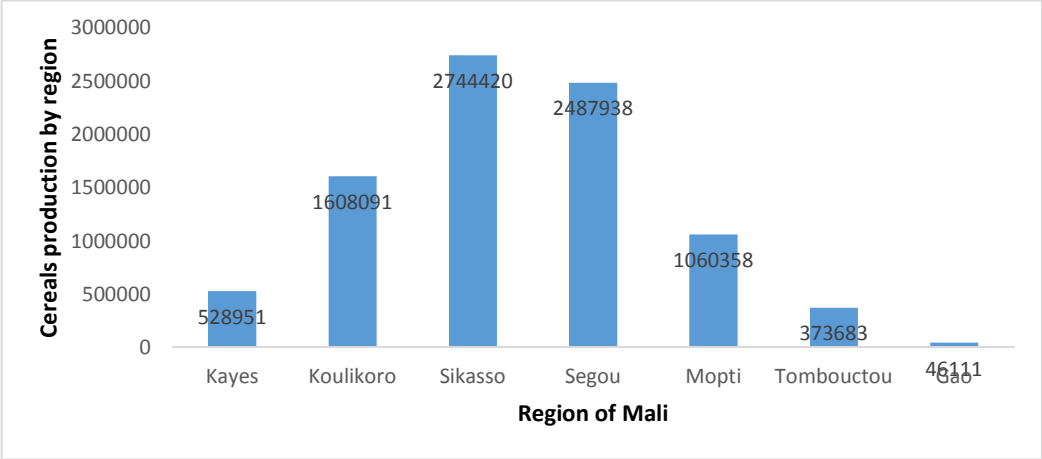

Fig. 2. Cereals production per region (2014/2015 rainy season)
Source: Author's field research

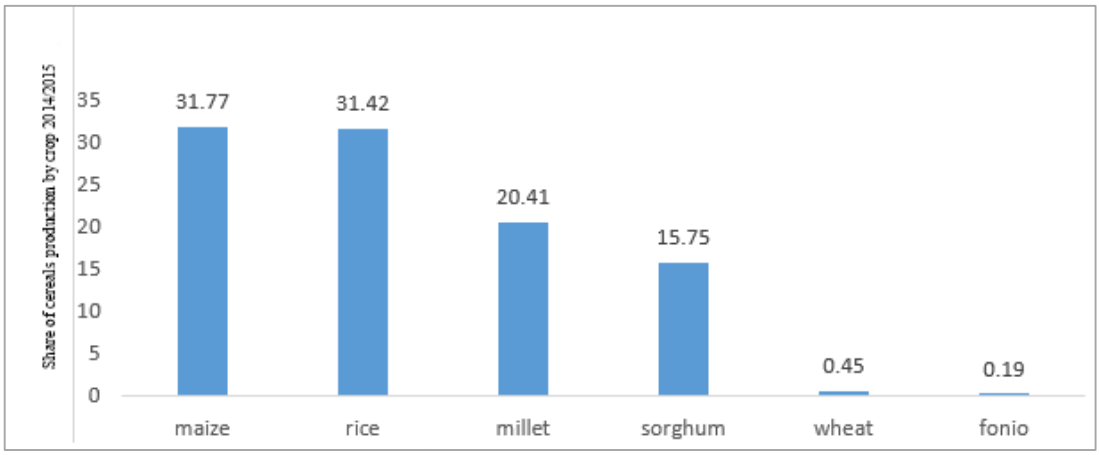

Fig. 3. Share of cereals production by crop 2014/2015
Source: Author's field research

Malian's agriculture remains dominated by the traditional subsistence sector. In fact, farms are generally small in terms of size. The average area cultivated is about hectare (ha) per farm. Three over ten farms (28.3%) have less than two hectares of cultivated area while only three over twenty (14.6%) cultivate more than 10 hectares. Agricultural mechanisation in Mali is quite widespread. The expansion of mechanisation is more linked to the possession of equipment such as plough availability from seven over ten farms. Animals like donkeys, camels, horses, sheep and goats are used as milking animals in some places in the country.

An agricultural worker is a member of the farm who is six years old or older, involving in the agricultural activities i.e. participating in at least one of the following activities: soil preparation, seeding or transplanting, weeding, spreading, crop treatment, harvesting and transportation. Across the whole country, farms have nine people as average of member of the household. This number is significant higher in exploitation lead by man than to the one head by woman. On gender basis, the data showed that females were engaged in farming as the males. This showed that women's involvement in agricultural activities is high in the county.

In addition to these farm assets, exploitations may use the service of others to help perform with certain stages of farming activity for cash or in kind compensation. This is what is chosen by the agricultural labour as defined by the EACI. It can be temporary or permanent. In 2016, four of every then farms used temporary labour while only one over ten used permanent labour.

Migration in the EACI survey, this phenomenon was measured by asking farmers if they have one or more family members living and working outside their community of origin. From their responses, the list of emigrants was then established and information was provided on each respondent.

2.2 Technique of Production and Migration

Table 4 displays a correlation analysis between the participation in migration and the ownership of certain agricultural equipment. The proportion of exploitation (household) with a hoe, a plough, and a cart is higher in the exploitations involved in migration than farming households without migrant. Thus, it is about 5.6% concerning household with internal migrant, 8.3% in household with international migrant and 4.3% in household without migrant. It is the same for the proportion of household owing a hoe plus cart and oxen this is also relatively higher in household involved in migration than those without migrant (23.2% for household with internal migrant, 27.9% for household with international migrant and 19.5% for household without migrant). . In addition, farmers owing only a hoe, an ox of tillage and a plough are higher than exploitation not involved in migration. In fact, the proportion of household with multiple equipment is higher among those participating in the migration than those who do not participate. However, looking well at the situation, the observed difference is not generally significant, specifically with respect to the possession of complete a hoe plus plough and seeder. Less than 5% of exploitations of the whole country owing the complete combination of equipment. These results show that except a relative mechanization of exploitation production, the equipment is still incomplete for most of the majority of the exploitation according to their participation in migration (their migratory status).

Average expenditures of hired labour were almost twice high in exploitation with member(s) participating in international migration than other group of farmers. From Table 4, farmers with international migrant had an average hired labour expenditure of 52,343 Francs CFA 29,316 Francs CFA for household involved in internal migration and 23,626 Francs CFA for household who do not participating in migration. Therefore, the observed differences are considerably high. However, in terms of exploitation usage of fertilizer those involved in international migration spend less on fertilizer. Among the inputs, is the expenditure on fertilizer was higher than the other inputs regardless of the migratory status of the exploitation.

The average cultivated areas and the number of plots are larger for the household participating in migration. In addition to this, improved seeds usage was more prevalent within the exploitations groups with internal migrant while it is roughly equal among those with no-migrant households and those participating in international migration.

In the country as a whole, average production varies between 1,900 tons for maize and 3,259 tons for rice. However, the major staple crops in the country are rice, millet, sorghum and maize while cotton is the only cash crop. Except for cotton, the average production of the staple crops was higher for farming households participating in migration. On the other hand, yields per hectare are lower for farmers with a member involved in migration, especially international migration. These results suggested that production is higher because farmers exploits larger areas, which is in line with the Malian family farming based on agricultural extension. The availability of equipment and the use of new farming practices do not favour an increase in agricultural yields. [4] showed that several factors may explain this situation. In fact, the soils of the plots exploited by migrant families

may be of a lower quality than those of non-migrants, which could be the cause of the departure to the migration of certain members of the household. In addition, the activities and types of crops chosen may be different depending on the migratory status. Moreover, the misuse of newly acquired equipment by exploitation participating in migration may result in lower yields. Finally, the imperfections of the labour and capital markets can lead to a difference in the opportunity costs of the factors of production according to the migratory status. [5] has also made similar arguments on the relationship between migration and yield. The explanation is that, the existence of a behaviour of collection of rent (rent - seeking behaviours) made possible by migrant remittances that make it less imperative to balance production and food needs. The technical inefficiency of household participating in the migration, i.e. their inability to reach the highest possible level of production with a certain amount of factor, can be explained by this "opportunistic behaviour [6].

Table 4. Cross tabulation of agricultural equipment by migration status

Characteristics	Household with internal migrant	Household with international migrant	Household without migrant
% of exploitation using equipment			
Cart	22.6	38.8	24.9
Ox of tillage	68.7	69.0	59.7
Plough	74.2	81.4	66.9
Seeder	20.3	24.8	25.6
Hoes	17.9	28.5	16.7
Combined equipment			
Hoe + plough + cart	5.6	8.3	4.3
Hoe + plough + seeder	8.2	11.4	10.9
Hoe + plough + ox	23.2	27.9	19.5
Area			
Average cultivated area	6.7	6.9	5.1
Average number of plot by exploitation	6.7	6.8	4.2
Plot with improved seed	21.9	15.0	16.1
Plot with fertilizers	26.0	19.3	24.8
Average expenditures			
Hired labour	29,316	52,343	23,626
Fertilizers	80 607	128 668	86 691

Source: Author's field research

Table 5. Production and average yield of the crops by migration status

Characteristics	Household with internal migrant	Household with international migrant	Household without migrant
Average yield (kg/hectare)			
Rice	2 398,6	1 908,4	2 051,5
Millet	814,8	715,0	804,2
Maize	1 678,3	1 423,5	1 615,6
Sorghum	934,0	890,6	956,6
Cotton	1 061,6	1 077,9	1 052,4
Average yield (kg)			
Rice	3 108.9	6 833.1	3 028.3
Millet	2 962.1	2 734.9	2 598.8
Maize	1 605.9	1 993.4	1 975.4
Sorghum	2 430.2	2 220.2	2 167.1
Cotton	2 126.8	3 159.0	3 189.8

Source: Author's field research

3. DATA ANALYSIS

3.1 Theoretical Model

According to [5], migration of a family member and its financial after-effects meet two essential purposes: firstly, the migration might contribute to ease the constraint of credit and risk constraints faced by rural household and facilitate technological change through remittances [5,6]. Finally, migration can be seen as part of a diversification strategy, aimed at protecting households from production failure or income risk in agricultural sector [7]. Therefore, migration as a strategy means that remittances from migrant labours respond to shocks affecting the recipient families in origin countries [8]. In some cases, moral hazard is probable to appear as shocks like climatic issue, which are not directly observable by the migrants in his own place. This situation can be analysed in a consistent theoretical framework used by [5].

Assume that, given the production technology and the state of nature, the agricultural household can produce either Y_h with probability $p(le)$ of Y_l with probability $1-p(le)$.

Where, l designs the amount of labour input and e is the average level of effort applied to these units of labour (le is labour in efficiency units). Therefore, $p'>0 \quad and \quad p''<0.$

The probable production level is then given as

$$E(Y)=p(le)Y_h+\left[1-p(le)\right]Y_l \tag{1}$$

In such net income of the farm production is given by:

$$\Pi = Y - x \tag{2}$$

In this second equation x represents the amount of material other than labour. Output and input prices have been normalised to one, since we are going to use only cross-sectional data in the empirical application.

Considering that $v(le)$ is the non-use of labour for the household, with $v(0)=0,\ v'>0 \quad and \quad v''>0.$

Under the assumption of risk neutrality, expected utility when the household works le in efficiency units follows as:

$$EU = E(C) - v(le) \tag{3}$$

C, is the agricultural household's level of consumption.

The expected utility of the household is maximised subject to the following cash-revenue and time constraints:

$$C=\Pi+R+\overline{Y} \tag{4}$$

$$1-l=loisir \tag{5}$$

where, R is the remittances from internal and international migrants, $\overline{Y}$ is exogenous income like pension, rental income, and l is the total (normalised) time endowment. However, assume that the levels of output are as follow:

$$\begin{cases} Y_h > Y_l \\ \Pi_h + \overline{Y} \geq \overline{C} \\ \Pi_l + \overline{Y} < \overline{C} \end{cases}$$

where $\Pi_h\,(\Pi_l)$ denotes net income from farm production when output level is $Y_h\,(Y_l)$, and $\overline{C}$ can be interpreted as the level of consumption such as the basic needs are satisfied.

Assume that, remittances be part of an implicit contract between migrants and their recipient origin families (exploitations), it is an informal arrangement, which rest on a sense of distributive justice. Concerning the justice involves that the migrants have the duty to satisfy the basic needs of their families whenever they are not able to do it themselves (i.e whenever C fails below $\overline{C}$).

In particular, a clause in the contract binds the migrants to send funds (or consumer goods) each time their families cannot establish entitlement over an adequate amount of food through purchase or through food production. Such a transfer of general purchasing power from the migrants to their families may be viewed as an informal tax aimed at re-allocating incomes between the modern capitalist sector, located either in Mali or abroad, and the subsistence farming sector. This family solidarity serves as a

substitute for the welfare state of industrialised societies and, by guaranteeing subsistence, provides what may be called a poverty insurance. The implementation of distributive justice as described above is not Pareto efficient, however, if we assume that the household's effort level is unobservable by the migrant. Imperfect monitoring of effort implies that the migrant cannot ascertain whether low yields in his family's fields are due to his relatives' idleness or to unfavourable weather conditions (or any other unfavourable state of nature). It may thus induce the household to shirk and to rely on the migrant for her subsistence.

Following [9], an effective way to prevent the occurrence of moral hazard is to use punishment strategies. The migrant may in fact, threaten his family to break the contractual arrangement by suspending remittances. Since the loss of the migrant's financial support is very costly in intertemporal utility terms, the family has a strong incentive not to shirk. This implies, however, that the migrant is able to check his family's work performance. A comparison of family output with that of others can serve as an indicator of effort. Such a scheme is often referred to as "yardstick competition" in industrial or labour economics [10,11]). Though compensation schemes based on relative performance may provide an efficient mechanism for monitoring productivity, collusive manipulation by participating firms or workers is often an important limitation of yardstick competition [10]. In the particular case of the Kayes area, some scope for collusion is undeniably present. Agricultural households may for example collude in order to send false signals to the migrants. Acts of collusion, such as the announcement of fictitious natural disasters, were actually observed in the area. Moreover, peer pressure could make family output an unreliable signal, for "zealous" families (i.e. those that do not take advantage of their informational rent) could well be constrained by others to reduce their labour effort. Ex- ante financial support is, according to [9], another way to prevent opportunistic behaviour. In the case of the Kayes area, survey data suggest that even if the bulk of remittances occurred after the harvest has been realised, the migrants supply some liquid assets prior to the crop season so that their families may have access to key factors of production.

So far, our theoretical discussion has not taken into account the presence of another informational asymmetry, which would this time be beneficial to the migrant. Indeed, the migrant freely decides whether he sends funds or not. If he decides not to, his family cannot ascertain whether this decision is due to temporary money troubles or to his intentional derogation of the contract. Various elements, among which directly moral motivations or migrants' concern about other persons' opinions of them, induce us to believe that the migrants do not take advantage of this informational asymmetry and that the implicit agreement to assist others is enforced by social pressure. Yet, the possible occurrence of money troubles is introduced in the model since it alters the reliability of the poverty insurance mechanism. Let Ψ the probability that the migrant financially supports the family be:

$$\Psi = h\left(\frac{N_m}{N}\right) \tag{6}$$

Ψ is assumed to be positively correlated with the number of family emigrants N_m divided by the number of family members residing in the country of origin N. The higher the ratio, the smaller the number of individuals being financially supported by each emigrant and the more the insurance mechanism.

Insurance mechanism reliability and level of effort: The presence of a relationship contractual between emigrants and their families of origin imply that when families suffering a shortfall in income receive an amount of remittances R in such a way that $R \geq \bar{C} - \Pi - \bar{Y}$ with probability Ψ and $R < \bar{C} - \Pi - \bar{Y}$ with $(1 - \Psi)$. For simplifying the model, we can assume that the migrants send either an amount strictly equals to the deficit of consumption $(R = \bar{C} - \Pi - \bar{Y})$ with probability Ψ or no remittances at all $(R = 0)$ with probability $(1 - \Psi)$, whenever, $Y = Y_l$

Under these assumptions, the expected value of remittances is written as follow:

$$E(R) = \Psi\left[1 - p(le)\right](\bar{C} - \Pi_l - \bar{Y}) \tag{7}$$

The optimisation facing each household is to choose a level of labour effort that maximises expected utility, where expected utility is given by:

$$EU = E(\Pi) + E(R) + \overline{Y} - v(le) \quad (8)$$
$$\Leftrightarrow EU = (1-\Psi)(\Pi_l + \overline{Y}) + \Psi\overline{C} + p(le)$$
$$\left[(\Pi_h - \Pi_l) + \Psi(\Pi_l + \overline{Y} - \overline{C})\right] - v(le)$$

This first-order condition is

$$\frac{v'(le)}{p'(le)} = (\Pi_h - \Pi_l) + \Psi(\Pi_l + \overline{Y} - \overline{C} \quad (9)$$

Starting from equation (9), the effect of increasing Ψ on optimal le can be derived from differentiating the first-order condition. The resulting expression is as follow:

$$\left[\frac{v''(le)\,p'(le) - v'(le)\,p''(le)}{[p'(le)]^2}\right] dle = d\Delta\Pi \quad (10)$$
$$+ (\Pi_l + \overline{Y} - \overline{C})d\Psi + \Psi d\Pi_l + \Psi d\overline{Y} - \Psi d\overline{C}$$
$$(+) \quad (-) \quad (+) \quad (+) \quad (-)$$

Where $\Delta\Pi = \Pi_h - \Pi_l$

Summary of the result of the comparative experiments on the level of effort derived from the model is:

$$le^* = le^*(\Delta\Pi, -\Psi, +\Pi_l, +\overline{Y}, -\overline{C}) \quad (11)$$

The model predicts a negative relationship between the Ψ, which is an indicator of the reliability of the insurance mechanism, and the labour in efficiency units in a context of informational asymmetry. This prediction cannot be directly tested due to lack of data. Formally it is possible to show the presence of a negative relationship between the degree of reliability of insurance mechanism and technical efficiency of the exploitation in the case where the hypothesis moral hazard is pertinent.

From the literature, technical efficiency is defined as follows:

$$TE = \frac{realised\ output}{Maximum\ ouput}$$

The maximum output in the model above Y_h corresponds to a level of effort $\overline{le}$, such that $p(\overline{le}) = 1$. Technical efficiency may then be written as:

$$TE = \frac{E(Y)}{Y_h} = \frac{p(le)(Y_h - Y_l) + Y_l}{Y_h} \quad (12)$$

It follows that:

$$TE'(le) = \frac{p'(le)(Y_h - Y_l)}{Y_h} > 0 \quad (13)$$

The key prediction of the model thus becomes the more reliable the income-smoothing mechanism, the higher the incentive to shirk, the lower the technical efficiency.

Extension of the model: aversion of the risk hypothesis

The hypothesis of the neutrality towards the risk can be modified by the speciation of the expected utility of the exploitation as follow:

$$EU = \log(C) - v(le) \quad (3bis)$$

So it becomes possible to show that:

$$EU = p(le).\left\{\log(\Pi_h + \overline{Y}) - \log(\Pi_l + \overline{Y}) + \Psi\left[\log(\Pi_l + \overline{Y}) - \log\overline{C}\right]\right\} + \Psi\log\overline{C}$$
$$+ (1-\Psi)\log(\Pi_l + \overline{Y}) - v(le)$$
(8bis)

Which gives the first order condition

$$\frac{v'(le)}{p'(le)} = \log(\Pi_h + \overline{Y}) + \Psi\left[\log(\Pi_l + \overline{Y}) - \log\overline{C}\right] \quad (9bis)$$

This last equation shows that the prediction of the model does not change nothing if we introduce the aversion hypothesis towards risk. Nous found a negative relationship between $le\ and\ \Psi$ in estimating the total difference of the expression (9bis). I search, in the following, to size the opportunist behaviour of the exploitations by analysing the technical efficiency. I propose frontier estimation of the production function using the fixed effects method to show that the offered guarantee linking the migrants to their origin exploitations are a determinant factor of the inefficiency.

3.2 The Econometric Model

Here is the function of the production technology on each plot

$$g(X_{ih}, W_i, G_{ih}, \mu_h, \theta_{ih}), \quad (14.a)$$

Where i is the index plots of land and h is the index of the household $(i = l,..... .p, \quad h = 1..... ....., H)$; X_{ih} represents a vector of physical inputs on plot i, W_i represents a vector of observable plot characteristics, G_{ih} stands for a vector of characteristics of the individual who controls the plot; μ_h represents a disturbance term that recapitulates the effects of unobserved plot quality variables and plot-specific production shocks.

Considering that

$$g(X_{ih}, W_i, G_{ih}, \mu_h, \theta_{ih}) = g(X_{ih}, W_i, G_{ih})\exp(\mu_h + \theta_{ih})$$

In fact, the logarithms are taken on both sides, the production function is specified as:

$$\ln Y_{ih} = \ln g(X_{ih}, W_i, G_{ih}) + \mu_h + \theta_{ih} \quad (14.b)$$

According to Greene (2012), the term μ_h can be considered as a fixed effect where it represents a specific constant to each exploitation. It is the estimator *within*, the statistics properties have been clarified by a relative study on panel data [12]. On the other hand, a random effect where, it is included in the residual where the distribution is not explicit specified. The generalised least squares GLS, which brings unbiased estimators and convergent can be used to estimate the model.

While it is possible to argue for one or the other model, unobserved heterogeneity and embodied in the error component μ_h are the key problem with the random effects approach, therefore, may be correlated with observed inputs. The traditional technique to deal with this problem is to exploit a fixed effects procedure, i.e. to remove the household-specific effect μ_h by transforming the data into deviations from household means [13]. In that case, sufficient conditions for the OLS estimates from the transformed variables to be unbiased and consistent is that the elements X and W are uncorrelated with the classical disturbance term θ .

[14] proposed a test for orthogonality of the random effects and the repressors. It is based on the thought that under the hypothesis of no correlation. The random effects and the fixed effects estimates should not differ systematically. The basic idea of the test is that, under the hypothesis of independence, the estimators within and Generalized Least Squares are not significantly different.

Two main limits are observed for this method. First, the regressors' specific to every exploitation and invariants according to the plots of land, are excluded by the within transformation, which consists in expressing variables according to their gap to the individual mean. Finally, the efficiency and the convergence of the within estimators are bound to the acceptance of the hypothesis of exogeneity of the independent variables with the term of classic error.

The use of the method of fixed effects is legal because the specification of the model does not contain invariant regressors according to the plots of land. However, without instruments, it was not possible to correct the estimated coefficients of biases introduced by a possible correlation between the explanatory and θ variables. After the estimation of equation $14b$, we test the hypothesis of a negative relationship between the reliability of the insurance mechanism (ψ in the theoretical model) and the technical efficiency (not observed) of the holdings, measured by μ_h. It will be a matter of simply regressing μ_h on a set of variables representing the characteristics of the exploitation with a proxy of ψ .

3.3 Specification of the Model

Before estimating the model, we have to choose the specific functional form $g(X_{ih}, W_i G_{ih})$. For that, we assume that the process of the production on a plot i from an exploitation h determined by Cobb-Douglas production function. In this case, we estimate:

$$\ln y_{ih} = \alpha + \beta_x \ln X_{ih} + \beta_k W_i + \beta_N G_{ih} + \mu_h \quad (15)$$

where,

y_{ih}, represents the yield on plot i from an exploitation h ;

X_{ih}, denotes the vector of traditional factors of agricultural production (area, labour, and capital);

W_i, is the vector of the plot characteristics (include the characteristics of the responsible of the plot himself "sex, age, education);

G_{ih}, is the representing certain variables exogenous uncontrollable by the farmers (like precipitation and regions' fixe effects);

The specification has an advantage to be simple and provide the estimators without bias. The estimation of this function gives a measure of technical efficiency that is regressed using certain characteristics of the exploitation and the locality of residence.

$$\hat{\mu}_h = \beta_{\grave{a}} + \beta_k Z_h + \varepsilon$$

Where, Z_h is a vector of the characteristics of the exploitation like participation in migration, le sex, education level, and ethnic of the head of exploitation, the proportion of plot with improved seed and the variables of localisation as region of residence.

3.4 Dependent Variables

The dependent variable for the first model is logarithm of the yield on each plot. The agricultural survey of economic conditions makes it possible to obtain the yield of all the crops on all the plots of the sample from the survey on the yield squares (carré de rendement) on 1/3 of the plot and the farmer declarations on the others. The regression on the production of the different plots of the holding provides a measure of technical efficiency, which is the dependent variables for the second model.

3.5 Explanatory Variables

The explanatory variables used in the regression are:

Area: The Malian's agriculture remains extensive. The increase of agricultural output remains linked to the expansion of the cultivated areas. All the plots of land of the exploitations samples are measured during the first move of the survey. When several speculations are cultivated on the same plot of land, is made an evaluation of the proportion occupied by each of them;

The variables of input: the work is measured by the number of the agricultural assets (active persons) having worked on the plot. When family cannot handle all the work, the exploitations can turn to hired labour in certain periods of the cultural calendar, the use of this outside work is taken into account through the cost made for this service. Fertilizers and improved seeds are taken into account through the introduction of dummy variables, take value 1 if the input is used on the plot and 0 otherwise;

The characteristics of the plot: the quality of the soil is measured by dummy variables that reflect it use or not during the previous season and it weeding for the current season;

Farming techniques such as the use of complete equipment, the practice of monoculture or the type of cereals grown are introduced in the regression. The method of exploitation of the plot (collective or individual) is also integrated into the model;

The individual characteristics of the person responsible for the plot are taken into account through sex and schooling.

For the technical efficiency regression, the explanatory variables are:

The reliability of the insurance mechanism is measured by the ration of migration, calculated by the number of migrants over the number of members of the exploitation. This ration is calculated separately for each type of migration to distinguish their effects. To show the existence of moral hazard, the coefficient associated with each ration must have negative sign.

Characteristics of the household head: the household head is the main decision maker at the production unit level. Its ability to make good decisions and ensure better execution is important for the proper running of the exploitation. Despite the theoretical and even empirical controversy surrounding the role of education on agricultural productivity, we expect that it will have a positive impact in the sense that it is important to us to strengthen its capacity to absorb new farming practices. In a society, still marked by cultural heaviness, it thought that men are better equipped to master a unit of production and consumption. Therefore, a negative sign of the sex variable of the farm

manager is expected, which takes the value of one if woman and zero if not. The manager's ethnicity is also integrated into the model;
Other variables such as the proportion of plots grown with improved seeds and locality characteristics across the region of residence introduced in the model.

4. RESULTS AND DISCUSSION

This section presents the results on the impact of migration influence on agricultural productivity in fact, on the productivity of growing crops in Mali. Primarily, the study supposed to estimate the impact of each type of migration (internal and external), unfortunately the secondary data used from national survey was cross sectional data so the international migrants were not enough to make our regression.

4.1 Descriptive Statistics of the Variables Used in the Model

Table 1 reveals the descriptive statistics of the variables used in the present study. The data employed in the estimation includes 37175 individuals sharing between 2331 farm households (13.82 individuals' in average per household with a standard deviation of 9.06) through the nine regions of Mali except Kidal because of the insecurity of this region. This data is a representative survey of 2331 households statistically distributed in the country. Children represented 33.99% aged less or equal to 14 years old of the sampled individuals and the work-force age going from 15 to 65 years old accounted for 60.28%, while the retired or the elders above 65 years represented 5.80%. Males represent 53.0% of the sampled individuals of the whole sample and the remaining 47.0% were females. The educational level from the sample showed that 72.38% had no formal educational, 17.47% had primary while only 9.46% had education up to secondary or professional educational level. For the university level, the percentage is very low in the agricultural production sector.

The Malian farming remains dominated by the traditional practice (see the Table 1), it is up to now family production scale with small cultivated area. In the survey, they used GPS to measure the cultivated area and the yield square to measure the output of the crop production. More than 51% of the farmers do not use the manure or fertilizer and the mode of cropping by the majority (91.45%) was mostly pure cultivation (one plot one crop), a system known as mono-cropping. On average, the production in kg is 113.59 for the entire staple crop together '(millet, sorghum, rice and maize) with a standard deviation of 206.81. It can say that there is a high variability of the cultivated area of crop in the agricultural production in Mali. The average cultivated area averages 6.85 hectare with standard deviation of 20.61, which simply show that there is a big difference between the sizes cultivated.

The proportion of young population in the population in Mali is very considerable, and this is evident in the sampled population. The average age is about 29.32 years old with 21.64 as standard deviation. This situation is associated with our variable of interest, migration, which is very widespread in the Sahel especially in Mali our study area. Indeed, the phenomena of migration in Mali is the consequence of unemployment and the difficult economics conditions of the country, which push the population to emigrate. Regarding to our sampled population, there is an average emigrant of 0.40 by household.

4.2 Estimates of Production Function

The econometric results is presented in Table 6. A multiple regression was estimated for the main staple crops in the country (millet, sorghum, rice, maize and bean) jointly and separately. It gives the elasticities of production in relation to the different factors used such as input (fertilizer and manure). The Adjusted R square shows that 62.5% of the variability of the plot production is explained by the explanatory variables used in the model. Seed is an important factor that influences the yield in terms of quantity and in terms of the quality of the seed used for the production. From the results, it was observed that the quantity of seed is positively significant in explaining the output of farmers. The use of improved seed other than local seeds for the first year was statistically significant but negative in explaining the yield of farmers. However, improved seed for the third year had a positive sign and significant. The area coefficient is positive and significant at 10%; this situation indicates that the marginal yield of the area is not zero. First, this result is coherent with the theory and it confirms the extensive nature of agriculture in Mali. The results showed that the number of agricultural workers (family labour and hired labour) significantly influence the production on the plots. Therefore, it can be argued that the

coefficient associated with the logarithm of the number of both workers on the plot are significant. This suggested that the constant of the production function varies according to the number of agricultural assets. This circumstance indicates that the potential of these factors of production are still to be exploited. Consequently, it confirms the hypothesis that, there is a surplus of workers in farms production in developing countries, which reinforced Lewis' model done in 1954: "labour can move from the traditional sector to the modern sector without loss of production in the traditional sector" [15]. In this case, the departure of one or more members in migration should not negatively influence agricultural work because, as [16] argued, migration takes workers but not work, hence, "the effort of those who remain adjusts". Once the use of the hired labour is positive and significantly different from zero, it indicate that farms could compensate for the departure of agricultural assets by using additional labour. The mechanization of the production system can also help reduce the need for agricultural assets. The use of fertilizers and manure have a positive influence on the level of production. Production is higher for newly developed plots according to the farmers. Probably because these plots are more fertile. As expected, pure cultivation (a single crop on the plot) favours increased production compared to the crop association. Production is higher in a plot managed by a man compare to a plot managed by a woman. This situation is in line with several studies done on measuring men and women's agricultural output [17].

Regarding the labour force, the working population is not significant, however, the category elder's population is statistically significant at 10% and affects negatively the production. This situation can be explained as the fact that the elder's population do not have the work force to work decently in the farm. In terms of gender issue, the result showed that the plot controlled by women are less productive than the one controlled by men, which is similar with the results found by [4]. Explaining this outcome, women in rural area in Mali mostly use most of their time working for men instead of working for themselves and also, this can due to

Table 6. Descriptive statistics of the variables used in the models

Variable	**Number**	**Mean**	**Std. Dev.**
Production (in Kg)	8477	113.59	206.81
Area (in hectare)	8477	6.85	20.61
Number of migrant by household	8477	0.40	1.16
Average age	8477	29.32	21.64
Household size	8477	13.82	9.06
Variables	**Modality**	**Number**	**Frequency**
Age of the household member	Children (<=14 years)	2876	33.93
	Working age (15-65 years)	5110	60.28
	Vieux (>65 years)	491	5.79
Sex of the household member	Male	4493	53
	Female	3984	47
Level of education of the household member	Non educated	6136	72.38
	Primary school	1481	17.47
	Secondary & professional	802	9.46
	University level	58	0.68
Mode of plot's ploughing	No ploughing	719	8.48
	Manual	961	11.34
	plough	464	54.74
	Manual et plough	1957	23.09
	Mechanic	159	1.88
	Manual et mechanic	26	0.31
	plough et mechanic	15	0.18
Use of manure and fertilizer	None	4346	51.27
	Manure or fertilizer	318	37.51
	Manure and fertilizer	951	11.22
Mode of cropping	Pure	7752	91.45
	Association of crops	725	8.55

Source: Author's field research

the limited resources by rural women. In fact, referring to the Food and Agriculture Organization of the United Nations (FAO), in underdeveloped nations, rural women act as a keystone of family agriculture that is small-scale production and daily household subsistence.

Migration variable is statistically significant and held a negative sign that means it has a negative impact on the output of the several crops used in the model. Our finding is related to the results of [18,19]. Migration plays important role in time of food shortage in the rural area in Mali [20]. Especially through the remittances send by migrants to their respective family members behind. Migration contributes also to diversify the sources of earnings, which allows the household to overcome the weaknesses of market in the rural area and also restraints of credit and insurance.

Once technical efficiency's estimation of agricultural unit is available. We are now checking whether it is a decreasing function of the reliability of the insurance mechanism. Therefore, we estimated an equation of the predicted value of the fixed effect as a function of a vector of observable characteristics of the operation and the insurance mechanism measured by Ψ. Due to the aspect of data (cross sectional), we ran only one model with internal migration (rural to urban migration) because the data did not contain much exploitations involved in international migration.

The results of technical efficiency regressions are presented in Table 8. The coefficient associated with the rate of migration is significant and held a negative sign. This means that the null hypothesis of moral hazard is not rejected. The presence of opportunistic behaviour might well be facilitated by the existence of an implicit contract between migrants and their families behind.

4.3 Production Function Ran Separately for Each Crop

The regression ran separately, the results changed from one crop to another crop. Our interested variable that is migration has an impact at 10% only on the yield of maize. That effect is statistically significant and negative, which is beyond our expectation. Maize and groundnut production demand labour intensive for its practices. The labour both hired labour and family labour are statistically significant and positive for these crops. The variable area is significant and positive for maize and groundnut cultivation, this situation is understandable because Malian agricultural is based on extensive agriculture. The input fertilizer and manure and the labour both hired labour and family labour are statistically significant and positive for the crops (millet, sorghum, maize and peanut). Association of crops is negative for the maize crop such as more number of plants in one acre and also due to less sunlight can make difficult crop to grow effortlessly or easily.

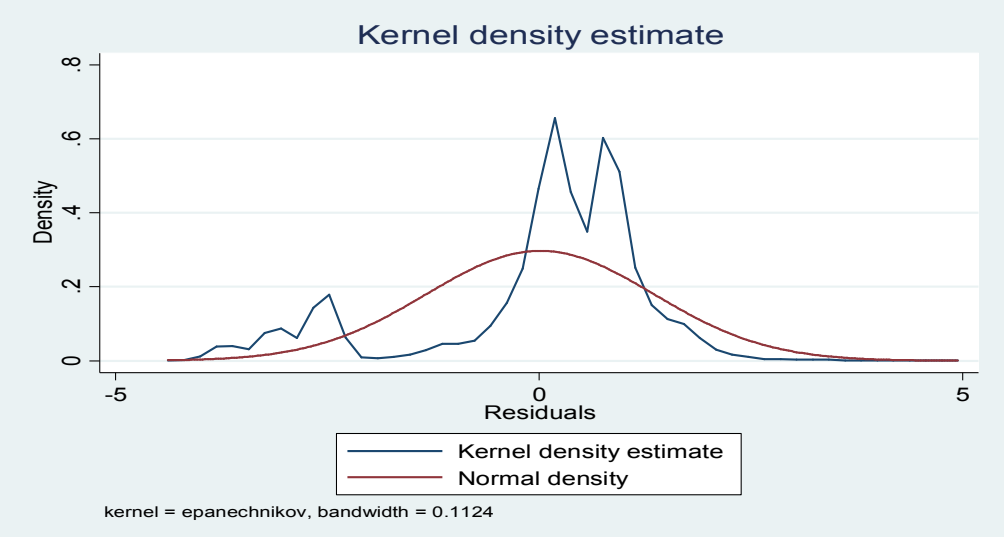

Fig. 4. Sharing of fixed effects
Source: Author's field research

Table 7. Jointly modelling of the production function of the growing staple crops in Mali

Log (production)	Coefficient	S. Error	t	P>t	[95% Conf.	Interval]
Constant	3.61***	0.05	68.33	0.00	3.51	3.71
Seed [Ref. Local seed]						
Improved seed for first year	-0.36***	0.07	-5.23	0.00	-0.50	-0.23
Improved seed for 2^{d} year	0.12	0.10	1.26	0.207	-0.07	0.31
Improved seed for third year	0.32***	0.11	2.98	0.003	0.11	0.53
Improved seed unknown year	-0.17**	0.07	-2.53	0.011	-0.31	-0.04
Quantity of seed used/plot	0.02**	0.01	2.23	0.026	0.00	0.04
Log (Area)	0.02*	0.01	1.70	0.09	0.00	0.05
Log (Hired labour)	0.03**	0.01	2.69	0.01	0.01	0.06
Log (Family labour**)**	0.10***	0.02	4.77	0.00	0.06	0.15
Input [Ref. No use of manure and fertilizer]						
Manure or Fertilizer	0.58***	0.03	18.44	0.00	0.52	0.64
Manure and Fertilizer	0.77***	0.05	16.81	0.00	0.68	0.86
Mode of Cropping [Ref. Monoculture]						
Association de cultures	-0.21***	0.06	-3.49	0.00	-0.33	-0.09
Level of schooling [Ref. Non educated]						
Primary school	0.14***	0.04	3.77	0.00	0.07	0.21
Secondary& professional	0.13***	0.05	2.87	0.00	0.04	0.22
University level	0.23	0.18	1.30	0.19	-0.12	0.58
Age [Ref. (<=14 years)]						
Working age (15-65 years)	-0.04	0.03	-1.41	0.16	-0.10	0.02
Elders (>65 years)	-0.12*	0.06	-1.35	0.06	-0.19	0.006
Sex [Ref. Male]						
Female	-0.04	0.03	-1.42	0.15	-0.10	0.02
Migration (0=No, 1=Yes)	-0.10*	0.04	-2.43	0.02	-0.18	-0.01

****p<0.001 indicates significance at 1%, **p<0.05 indicates significance at 5%, *p<0.01 indicates significance at 10%*

Source: Author's field research

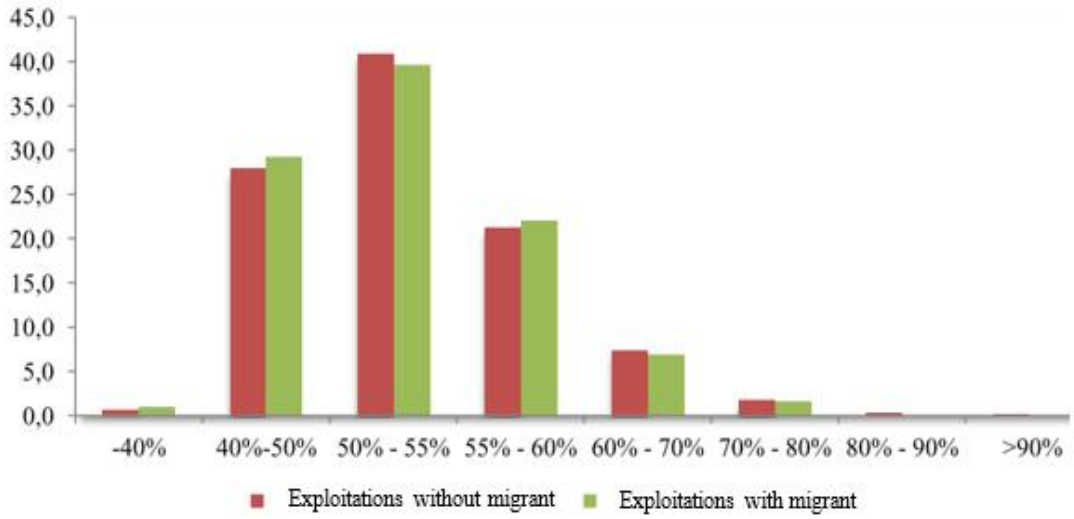

Fig. 5. Distribution of the exploitations according to the technical efficiency by migration status

Source: Author's field research

Table 8. Production function ran for each crop separately

Variables	Millet	Sorghum	Rice	Maize	Peanut
Log (production)	**Coef/SE.**	**Coef/SE.**	**Coef/SE.**	**Coef/SE.**	**Coef/SE.**
Constant	3.96***/0.13	3.80/0.15	4.40***/0.07	3.09***/0.12	3.25***/0.11
Log (Area)	0.03/0.04	-0.05/0.04	-0.01/0.01	0.07*/0.04	0.09**/0.04
Log (Hired labour)	0.12***/0.04	0.03/0.04	0.00/0.02	0.05*/0.03	0.17***/0.03
Log (Family labour)	0.12**/0.06	0.06/0.06	-0.03/0.03	0.14***/0.05	0.11**/0.05
Input [Ref. No use of manure and fertilizer]					
Manure or Fertilizer	0.21***/0.07	0.65***/0.08	0.04/0.05	1.36***/0.09	0.56***/0.07
Manure and Fertilizer	0.76***/0.10	0.92***/0.13	0.04/0.07	1.38***/0.10	0.36**/0.17
Mode of Cropping [Ref. Monoculture]					
Association of cultures	0.13/0.11	-0.26/0.14	-0.05/0.09	-0.54***/0.16	0.20/0.16
Level of schooling [Ref. Non educated]					
Primary school	0.06/0.08	0.30***/0.09	0.01/0.04	0.08/0.07	0.42***/0.08
Secondary& professional	0.29***/0.09	0.18/0.13	0.08/0.09	-0.09/0.10	0.41***/0.09
University level	-0.05/0.74	0.24/0.22	-0.08/0.05	0.26/0.25	0.81***/0.13
Age [Ref. (<=14 years)]					
Working age (15-65 years)	0.19***/0.07	0.19**/0.08	0.05/0.05	0.04/0.07	-0.04/0.07
Elders (>65 years)	0.49***/0.16	0.31**/0.15	0.18/0.07	-0.05/0.15	0.21/0.26
Sex [Ref. Male]					
Female	0.10***/0.06	-0.07/0.08	-0.10**/0.05	-0.06/0.06	0.08/0.07
Migration (0=No, 1=Yes)	-0.29/0.23	-0.23/0.18	0.05/0.06	-0.11*/0.06	-0.07/0.05
Number of observation	1917	1538	1019	1340	1493

*Standard error after /. ***, **, * significance level respectively 1%, 5% and 10%*
Source: Author's field research

5. CONCLUSION

The principal component of this objective was to highlight the existence of a moral hazard phenomenon that would be the cause of poor agricultural output obtained by exploitations with at least one member living outside their locality. A remark, most of the researches have been focused on the international migration, but the present study mostly focused on the impact of internal migration on agricultural productivity. Because more than 95% of the whole migrants move inside the country. The theoretical model used in this research, proposed by [5], showed that the farmers exercise lower average level of effort in doing farm activities once they are insured by receiving transfer from migrants. The forecast of the theoretical model was tested using the estimation by the fixed effects method of a production frontier. The indicator of the reliability of the insurance mechanism, measured by the ration of migration (ration of migration is to the number of migrants over the size of the exploitation) seems determine the technical inefficiency of agricultural exploitations. [5] obtained this conclusion with regard to the Kayes region (international migration). Although some previous studies conducted regional analysis, this present study was estimated based on national impact and have also concentrated on the impact of internal migration which is the most dominant migration type in Mali.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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