

33 provide suitable revenue to sustain the household over an entire year. Therefore, there is a
34 need for the family household to look for an extra revenue to support the household.

35 **Methodology**

36 Sources of data

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

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

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

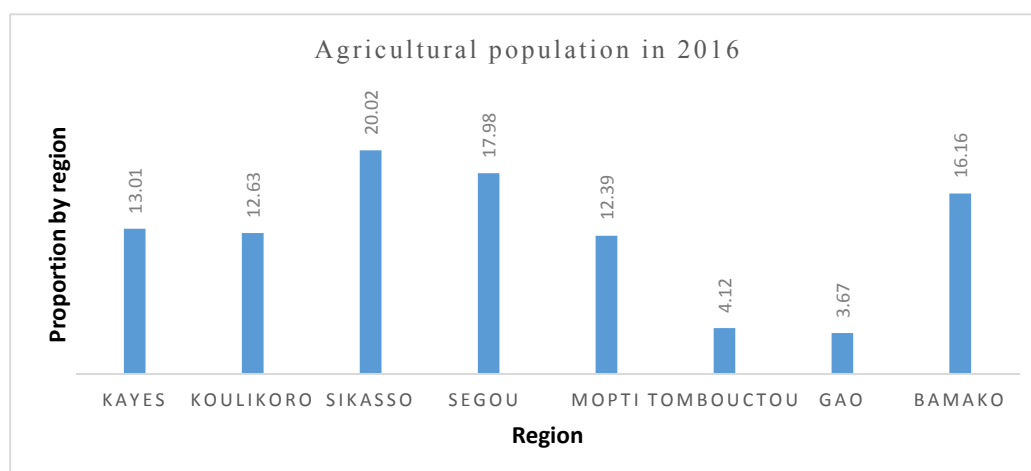
65 This section provided information on the destination of the migrants, the reason of
 66 migration, and the remittances during the last twelve months (description, amount if it is
 67 money, level, and their share of food consumption). For 2014/2015, crop year had a
 68 complete data and hence was used in this research. After cleaning data, the exploitations
 69 with all the information available for the modules were gathered. The survey contains 2
 70 331 exploitations over 474 enumerations sections.

71 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

72 With a very neglect rate of non-reply during the survey, the Malian agricultural population
 73 in 2016 was about 14 408 458 individuals. From the figure 1 the distribution of
 74 agricultural population by region except Kidal due to the insecurity, showed that more
 75 than one-fifth of the agricultural workers are living in the region of Sikasso (20.02 %).
 76 This was followed by the region of Ségou with 17.98% of the agricultural population. The
 77 region of Gao reported the lowest rate of agricultural population in Mali.

78 Figure 1: Agricultural population by region except Kidal.



79 *Source: Author's field research*

80 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

81 *Source: Author's field research*

82 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

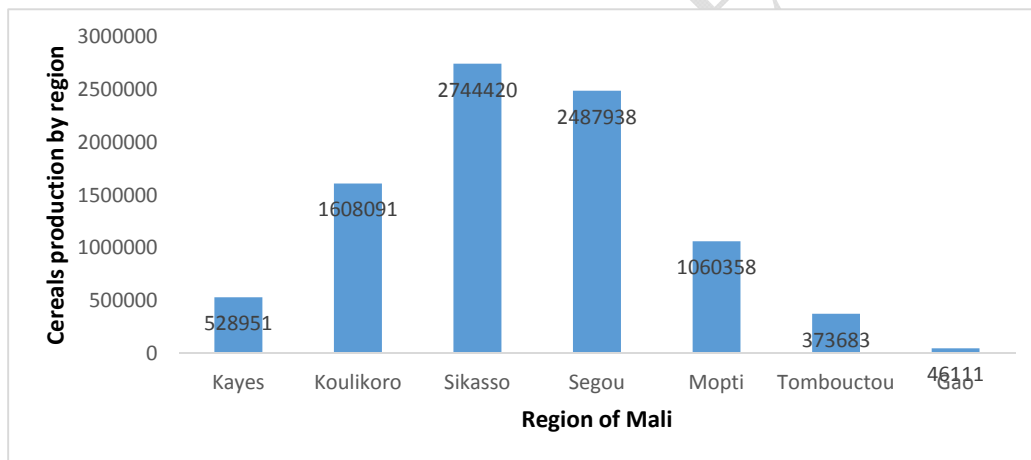
60 years and more	690 824	98.5	10 500	1.5	701 325
Total	14 050 201	97.5	358 247	2.5	14 408 458

83 *Source: Author's field research*

84 *Some descriptive statistics on the agricultural sector and migration:*

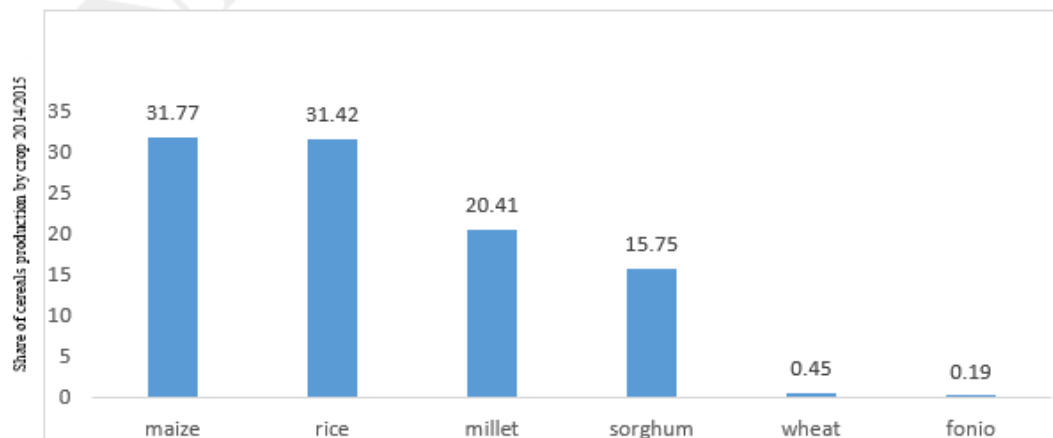
85 The 2014/2015 crop year recorded an estimated of 8,849,551 tons of cereals production
 86 (rain season and dry season crop). In this quantity produced are including 2,811,385 tons
 87 of maize, 2,780,905 tons of rice, 1,806,559 tons of millet, 1,393,826 tons of sorghum,
 88 40,137 tons of wheat and 16,740 tons of fonio. The quantity of cereals produced varies
 89 largely from region to another region in Mali. Sikasso first comes and follow by Segou. In
 90 terms of cereals production the regions of Gao and Kayes produce less cereals compare to
 91 other regions.

92 Figure 2: Cereals production per region (2014/2015 rainy season)



93 *Source: Author's field research*

Figure 3: Share of cereals production by crop 2014/2015



94 *Source: Author's field research*

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

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

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

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

120 *Technique of production and migration*

121 Table 4 displays a correlation analysis between the participation in migration and the
122 ownership of certain agricultural equipment. The proportion of exploitation (household)
123 with a hoe, a plough, and a cart is higher in the exploitations involved in migration than
124 farming households without migrant. Thus, it is about 5.6% concerning household with
125 internal migrant, 8.3% in household with international migrant and 4.3% in household

126 without migrant. It is the same for the proportion of household owing a hoe plus cart and
 127 oxen this is also relatively higher in household involved in migration than those without
 128 migrant (23.2% for household with internal migrant, 27.9% for household with
 129 international migrant and 19.5% for household without migrant). . In addition, farmers
 130 owing only a hoe, an ox of tillage and a plough are higher than exploitation not involved
 131 in migration. In fact, the proportion of household with multiple equipment is higher
 132 among those participating in the migration than those who do not participate. However,
 133 looking well at the situation, the observed difference is not generally significant,
 134 specifically with respect to the possession of complete a hoe plus plough and seeder. Less
 135 than 5% of exploitations of the whole country owing the complete combination of
 136 equipment. These results show that except a relative mechanization of exploitation
 137 production, the equipment is still incomplete for most of the majority of the exploitation
 138 according to their participation in migration (their migratory status).

139 Average expenditures of hired labour were almost twice high in exploitation with
 140 member(s) participating in international migration than other group of farmers. From
 141 Table 4, farmers with international migrant had an average hired labour expenditure of
 142 52,343 Francs CFA 29,316 Francs CFA for household involved in internal migration and
 143 23,626 Francs CFA for household who do not participating in migration. Therefore, the
 144 observed differences are considerably high. However, in terms of exploitation usage of
 145 fertilizer those involved in international migration spend less on fertilizer. Among the
 146 inputs, is the expenditure on fertilizer was higher than the other inputs regardless of the
 147 migratory status of the exploitation.

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

152 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

153 *Source: Author's field research*

154 In the country as a whole, average production varies between 1,900 tons for maize and
155 3,259 tons for rice. However, the major staple crops in the country are rice, millet,
156 sorghum and maize while cotton is the only cash crop. Except for cotton, the average
157 production of the staple crops was higher for farming households participating in
158 migration. On the other hand, yields per hectare are lower for farmers with a member
159 involved in migration, especially international migration. These results suggested that
160 production is higher because farmers exploits larger areas, which is in line with the Malian
161 family farming based on agricultural extension. The availability of equipment and the use
162 of new farming practices do not favour an increase in agricultural yields. [4] showed that
163 several factors may explain this situation. In fact, the soils of the plots exploited by
164 migrant families may be of a lower quality than those of non-migrants, which could be the
165 cause of the departure to the migration of certain members of the household. In addition,
166 the activities and types of crops chosen may be different depending on the migratory

167 status. Moreover, the misuse of newly acquired equipment by exploitation participating in
 168 migration may result in lower yields. Finally, the imperfections of the labour and capital
 169 markets can lead to a difference in the opportunity costs of the factors of production
 170 according to the migratory status. [5] has also made similar arguments on the relationship
 171 between migration and yield. The explanation is that, the existence of a behaviour of
 172 collection of rent (rent - seeking behaviours) made possible by migrant remittances that
 173 make it less imperative to balance production and food needs. The technical inefficiency
 174 of household participating in the migration, i.e. their inability to reach the highest possible
 175 level of production with a certain amount of factor, can be explained by this "opportunistic
 176 behaviour[6].

177 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

178 *Source: Author's field research*

179 Data analysis

180 Theoretical model

181 According to [5], migration of a family member and its financial after-effects meet two
 182 essential purposes: firstly, the migration might contribute to ease the constraint of credit

183 and risk constraints faced by rural household and facilitate technological change through
 184 remittances [5, 6]. Finally, migration can be seen as part of a diversification strategy,
 185 aimed at protecting households from production failure or income risk in agricultural
 186 sector. Therefore, migration as a strategy means that remittances from migrant labours
 187 respond to shocks affecting the recipient families in origin countries [8]. In some cases,
 188 moral hazard is probable to appear as shocks like climatic issue, which are not directly
 189 observable by the migrants in his own place. This situation can be analysed in a consistent
 190 theoretical framework used by [5].

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

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

195 The probable production level is then given as

$$196 \quad E(Y) = p(le)Y_h + [1 - p(le)]Y_l$$

197 (1)

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

$$199 \quad \Pi = Y - x \tag{2}$$

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

203 Considering that $v(le)$ is the non-use of labour for the household, with
 204 $v(0) = 0$, $v' > 0$ and $v'' > 0$.

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

$$207 \quad EU = E(C) - v(le) \tag{3}$$

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

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

$$211 \quad C = \Pi + R + \bar{Y} \tag{4}$$

$$212 \quad 1 - l = \text{loisir} \tag{5}$$

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

$$216 \begin{cases} Y_h > Y_l \\ \Pi_h + \bar{Y} \geq \bar{C} \\ \Pi_l + \bar{Y} < \bar{C} \end{cases}$$

217 Where Π_h (Π_l) denotes net income from farm production when output level is Y_h (Y_l),
218 and \bar{C} can be interpreted as the level of consumption such as the basic needs are satisfied.
219 Assume that, remittances be part of an implicit contract between migrants and their
220 recipient origin families (exploitations), it is an informal arrangement, which rest on a
221 sense of distributive justice. Concerning the justice involves that the migrants have the
222 duty to satisfy the basic needs of their families whenever they are not able to do it
223 themselves (i.e whenever C fails below \bar{C}).

224 In particular, a clause in the contract binds the migrants to send funds (or consumer goods)
225 each time their families cannot establish entitlement over an adequate amount of food
226 through purchase or through food production. Such a transfer of general purchasing power
227 from the migrants to their families may be viewed as an informal tax aimed at re-
228 allocating incomes between the modern capitalist sector, located either in Mali or abroad,
229 and the subsistence farming sector. This family solidarity serves as a substitute for the
230 welfare state of industrialised societies and, by guaranteeing subsistence, provides what
231 may be called a poverty insurance. The implementation of distributive justice as described
232 above is not Pareto efficient, however, if we assume that the household's effort level is
233 unobservable by the migrant. Imperfect monitoring of effort implies that the migrant
234 cannot ascertain whether low yields in his family's fields are due to his relatives' idleness
235 or to unfavourable weather conditions (or any other unfavourable state of nature). It may
236 thus induce the household to shirk and to rely on the migrant for her subsistence.

237 Following [9], an effective way to prevent the occurrence of moral hazard is to use
238 punishment strategies. The migrant may in fact, threaten his family to break the
239 contractual arrangement by suspending remittances. Since the loss of the migrant's
240 financial support is very costly in intertemporal utility terms, the family has a strong
241 incentive not to shirk. This implies, however, that the migrant is able to check his family's

242 work performance. A comparison of family output with that of others can serve as an
243 indicator of effort. Such a scheme is often referred to as "yardstick competition" in
244 industrial or labour economics [10],[11]). Though compensation schemes based on
245 relative performance may provide an efficient mechanism for monitoring productivity,
246 collusive manipulation by participating firms or workers is often an important limitation
247 of yardstick competition [10]. In the particular case of the Kayes area, some scope for
248 collusion is undeniably present. Agricultural households may for example collude in order
249 to send false signals to the migrants. Acts of collusion, such as the announcement of
250 fictitious natural disasters, were actually observed in the area. Moreover, peer pressure
251 could make family output an unreliable signal, for "zealous" families (i.e. those that do not
252 take advantage of their informational rent) could well be constrained by others to reduce
253 their labour effort. Ex- ante financial support is, according to [9], another way to prevent
254 opportunistic behaviour. In the case of the Kayes area, survey data suggest that even if the
255 bulk of remittances occurred after the harvest has been realised, the migrants supply some
256 liquid assets prior to the crop season so that their families may have access to key factors
257 of production.

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

$$269 \quad \Psi = h\left(\frac{N_m}{N}\right)$$

270 (6)

271 Ψ is assumed to be positively correlated with the number of family emigrants N_m
272 divided by the number of family members residing in the country of origin N . The higher

273 the ratio, the smaller the number of individuals being financially supported by each
 274 emigrant and the more the insurance mechanism.

275 *Insurance mechanism reliability and level of effort:*

276 The presence of a relationship contractual between emigrants and their families of origin
 277 imply that when families suffering a shortfall in income receive an amount of remittances

278 R in such a way that $R \geq \bar{C} - \Pi - \bar{Y}$ with probability Ψ and $R < \bar{C} - \Pi - \bar{Y}$ with $(1 - \Psi)$.

279 For simplifying the model, we can assume that the migrants send either an amount strictly

280 equals to the deficit of consumption ($R = \bar{C} - \Pi - \bar{Y}$) with probability Ψ or no remittances

281 at all ($R = 0$) with probability $(1 - \Psi)$, whenever, $Y = Y_l$

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

$$283 \quad E(R) = \Psi[1 - p(le)](\bar{C} - \Pi_l - \bar{Y}) \quad (7)$$

284 The optimisation facing each household is to choose a level of labour effort that

285 maximises expected utility, where expected utility is given by:

$$286 \quad EU = E(\Pi) + E(R) + \bar{Y} - v(le) \quad (8)$$

$$287 \quad \Leftrightarrow EU = (1 - \Psi)(\Pi_l + \bar{Y}) + \Psi\bar{C} + p(le)[(\Pi_h - \Pi_l) + \Psi(\Pi_l + \bar{Y} - \bar{C})] - v(le)$$

288 This first-order condition is

$$289 \quad \frac{v'(le)}{p'(le)} = (\Pi_h - \Pi_l) + \Psi(\Pi_l + \bar{Y} - \bar{C}) \quad (9)$$

290 Starting from equation (9), the effect of increasing Ψ on optimal le can be derived from

291 differentiating the first-order condition. The resulting expression is as follow:

292

$$293 \quad \left[\frac{v''(le) p'(le) - v'(le) p''(le)}{[p'(le)]^2} \right] dle = d\Delta\Pi + (\Pi_l + \bar{Y} - \bar{C})d\Psi + \Psi d\Pi_l + \Psi d\bar{Y} - \Psi d\bar{C}$$

294 (10)

295 (+) (-) (+) (+) (-)

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

297 Summary of the result of the comparative experiments on the level of effort derived from

298 the model is:

299 $le^* = le^* (\Delta\Pi, -\Psi, +\Pi_l, +\bar{Y}, -\bar{C})$

300 (11)

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

307 From the literature, technical efficiency is defined as follows:

308
$$TE = \frac{\text{realised output}}{\text{Maximum output}}$$

309 The maximum output in the model above Y_h corresponds to a level of effort \bar{le} , such that
 310 $p(\bar{le}) = 1$. Technical efficiency may then be written as:

311
$$TE = \frac{E(Y)}{Y_h} = \frac{p(le)(Y_h - Y_l) + Y_l}{Y_h} \quad (12)$$

312 It follows that:

313
$$TE'(le) = \frac{p'(le)(Y_h - Y_l)}{Y_h} > 0 \quad (13)$$

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

316 Extension of the model: aversion of the risk hypothesis

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

319 $EU = \log(C) - v(le)$

320 (3bis)

321 So it becomes possible to show that:

322
$$EU = p(le) \cdot \{ \log(\Pi_h + \bar{Y}) - \log(\Pi_l + \bar{Y}) + \Psi [\log(\Pi_l + \bar{Y}) - \log \bar{C}] \} + \Psi \log \bar{C} \\ + (1 - \Psi) \log(\Pi_l + \bar{Y}) - v(le) \quad (8bis)$$

323 Which gives the first order condition

$$324 \quad \frac{v'(le)}{p'(le)} = \log(\Pi_h + \bar{Y}) + \Psi[\log(\Pi_l + \bar{Y}) - \log \bar{C}] \quad (9bis)$$

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

332 **The econometric model:**

333 Here is the function of the production technology on each plot

$$334 \quad g(X_{ih}, W_i, G_{ih}, \mu_h, \theta_{ih}), \quad (14.a)$$

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

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

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

$$343 \quad \ln Y_{ih} = \ln g(X_{ih}, W_i, G_{ih}) + \mu_h + \theta_{ih} \quad (14.b)$$

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

350 While it is possible to argue for one or the other model, unobserved heterogeneity and
 351 embodied in the error component μ_h are the key problem with the random effects

352 approach, therefore, may be correlated with observed inputs. The traditional technique to
353 deal with this problem is to exploit a fixed effects procedure, i.e. to remove the household-
354 specific effect μ_h by transforming the data into deviations from household means [13]. In
355 that case, sufficient conditions for the OLS estimates from the transformed variables to be
356 unbiased and consistent is that the elements X and W are uncorrelated with the classical
357 disturbance term θ .

358 [14] proposed a test for orthogonality of the random effects and the regressors. It is based
359 on the thought that under the hypothesis of no correlation. The random effects and the
360 fixed effects estimates should not differ systematically. The basic idea of the test is that,
361 under the hypothesis of independence, the estimators within and Generalized Least
362 Squares are not significantly different.

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

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

377 Specification of the model:

378 Before estimating the model, we have to choose the specific functional form
379 $g(X_{ih}, W_i, G_{ih})$. For that, we assume that the process of the production on a plot i from an
380 exploitation h determined by Cobb-Douglas production function. In this case, we
381 estimate:

382 $\ln y_{ih} = \alpha + \beta_x \ln X_{ih} + \beta_k W_i + \beta_N G_{ih} + \mu_h$ (15)

383 Where,

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

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

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

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

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

394 $\hat{\mu}_h = \beta_a + \beta_k Z_h + \varepsilon$

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

398 Dependent variables:

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

405 Explanatory variables:

406 The explanatory variables used in the regression are:

407 Area: The Malian’s agriculture remains extensive. The increase of agricultural output
408 remains linked to the expansion of the cultivated areas. All the plots of land of the
409 exploitations samples are measured during the first move of the survey. When several

410 speculations are cultivated on the same plot of land, is made an evaluation of the
411 proportion occupied by each of them;

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

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

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

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

425 For the technical efficiency regression, the explanatory variables are:

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

431 Characteristics of the household head: the household head is the main decision maker at
432 the production unit level. Its ability to make good decisions and ensure better execution is
433 important for the proper running of the exploitation. Despite the theoretical and even
434 empirical controversy surrounding the role of education on agricultural productivity, we
435 expect that it will have a positive impact in the sense that it is important to us to strengthen
436 its capacity to absorb new farming practices. In a society, still marked by cultural
437 heaviness, it is thought that men are better equipped to master a unit of production and
438 consumption. Therefore, a negative sign of the sex variable of the farm manager is
439 expected, which takes the value of one if woman and zero if not. The manager's ethnicity
440 is also integrated into the model;

441 Other variables such as the proportion of plots grown with improved seeds and locality
442 characteristics across the region of residence introduced in the model.

443 **Results and discussions**

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

449 *Descriptive statistics of the variables used in the model:*

450 Table 1 reveals the descriptive statistics of the variables used in the present study. The
451 data employed in the estimation includes 37175 individuals sharing between 2331 farm
452 households (13.82 individuals' in average per household with a standard deviation of
453 9.06) through the nine regions of Mali except Kidal because of the insecurity of this
454 region. This data is a representative survey of 2331 households statistically distributed in
455 the country. Children represented 33.99 % aged less or equal to 14 years old of the
456 sampled individuals and the work-force age going from 15 to 65 years old accounted for
457 60.28 %, while the retired or the elders above 65 years represented 5.80 %. Males
458 represent 53.0 % of the sampled individuals of the whole sample and the remaining 47.0%
459 were females. The educational level from the sample showed that 72.38% had no formal
460 educational, 17.47% had primary while only 9.46% had education up to secondary or
461 professional educational level. For the university level, the percentage is very low in the
462 agricultural production sector.

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

472 standard deviation of 20.61, which simply show that there is a big difference between the
 473 sizes cultivated.

474 The proportion of young population in the population in Mali is very considerable, and
 475 this is evident in the sampled population. The average age is about 29.32 years old with
 476 21.64 as standard deviation. This situation is associated with our variable of interest,
 477 migration, which is very widespread in the Sahel especially in Mali our study area. Indeed,
 478 the phenomena of migration in Mali is the consequence of unemployment and the difficult
 479 economics conditions of the country, which push the population to emigrate. Regarding to
 480 our sampled population, there is an average emigrant of 0.40 by household.

481 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
	None	4346	51.27
Use of manure and fertilizer	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

482 *Source: Author's field research*

483 Estimates of production function

484 The econometric results is presented in table 6. A multiple regression was estimated for
485 the main staple crops in the country (millet, sorghum, rice, maize and bean) jointly and
486 separately. It gives the elasticities of production in relation to the different factors used
487 such as input (fertilizer and manure). The Adjusted R square shows that 62.5% of the
488 variability of the plot production is explained by the explanatory variables used in the
489 model. Seed is an important factor that influences the yield in terms of quantity and in
490 terms of the quality of the seed used for the production. From the results, it was observed
491 that the quantity of seed is positively significant in explaining the output of farmers. The
492 use of improved seed other than local seeds for the first year was statistically significant
493 but negative in explaining the yield of farmers. However, improved seed for the third year
494 had a positive sign and significant. The area coefficient is positive and significant at 10%;
495 this situation indicates that the marginal yield of the area is not zero. First, this result is
496 coherent with the theory and it confirms the extensive nature of agriculture in Mali. The
497 results **showed** that the number of agricultural workers (family labour and hired labour)
498 significantly influence the production on the plots. Therefore, it can be argued that the
499 coefficient associated with the logarithm of the number of both workers on the plot are
500 significant. This **suggested** that the constant of the production function varies according to
501 the number of agricultural assets. This circumstance indicates that the potential of these
502 factors of production are still to be exploited. Consequently, it confirms the hypothesis
503 that, there is a surplus of workers in farms production in developing countries, which
504 reinforced Lewis' model done in 1954: "labour can move from the traditional sector to the
505 modern sector without loss of production in the traditional sector" [15]. In this case, the

506 departure of one or more members in migration should not negatively influence
 507 agricultural work because, as [16] argued, migration takes workers but not work, hence,
 508 "the effort of those who remain adjusts". Once the use of the hired labour is positive and
 509 significantly different from zero, it indicate that farms could compensate for the departure
 510 of agricultural assets by using additional labour. The mechanization of the production
 511 system can also help reduce the need for agricultural assets. The use of fertilizers and
 512 manure have a positive influence on the level of production. Production is higher for
 513 newly developed plots according to the farmers. Probably because these plots are more
 514 fertile. As expected, pure cultivation (a single crop on the plot) favours increased
 515 production compared to the crop association. Production is higher in a plot managed by a
 516 man compare to a plot managed by a woman. This situation is in line with several studies
 517 done on measuring men and women's agricultural output [17].

518 Regarding the labour force, the working population is not significant, however, the
 519 category elder's population is statistically significant at 10% and affects negatively the
 520 production. This situation can be explained as the fact that the elder's population do not
 521 have the work force to work decently in the farm. In terms of gender issue, the result
 522 showed that the plot controlled by women are less productive than the one controlled by
 523 men, which is similar with the results found by [4]. Explaining this outcome, women in
 524 rural area in Mali mostly use most of their time working for men instead of working for
 525 themselves and also, this can due to the limited resources by rural women. In fact,
 526 referring to the Food and Agriculture Organization of the United Nations (FAO), in
 527 underdeveloped nations, rural women act as a keystone of family agriculture that is small-
 528 scale production and daily household subsistence.

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

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

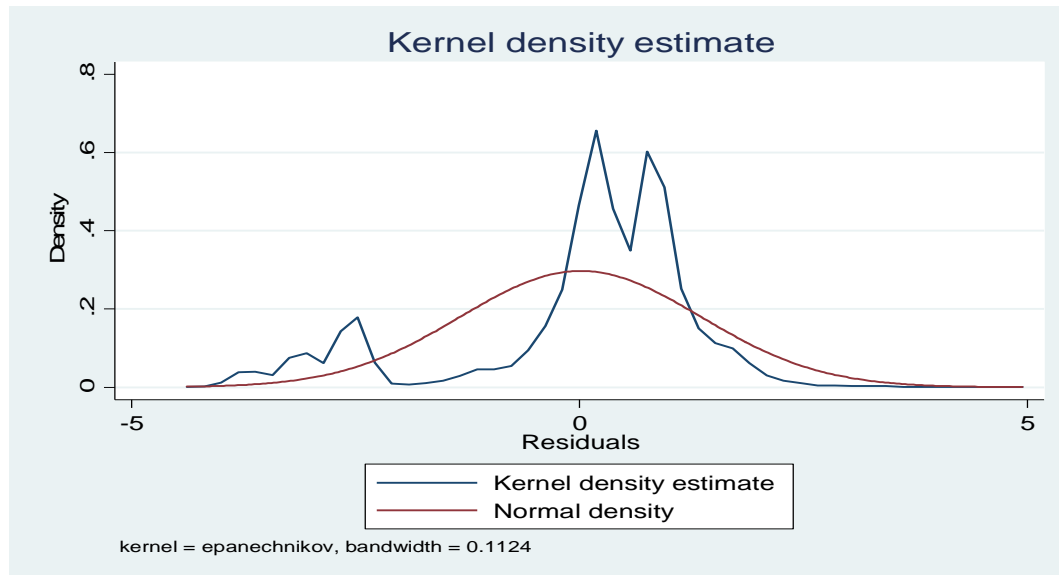
Log (production)	Coefficient	S. Error	t	P>t	[95% Conf. Interval]
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Constant	3.61***	0.05	68.33	0.00	3.51	3.71
Seed [Ref. Local seed]						
Improved seed for first year	-0.36***	0.07	-5.23	0.00	-0.50	-0.23
Improved seed for 2 ^d year	0.12	0.10	1.26	0.207	-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

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

539 *Source: author's field research*

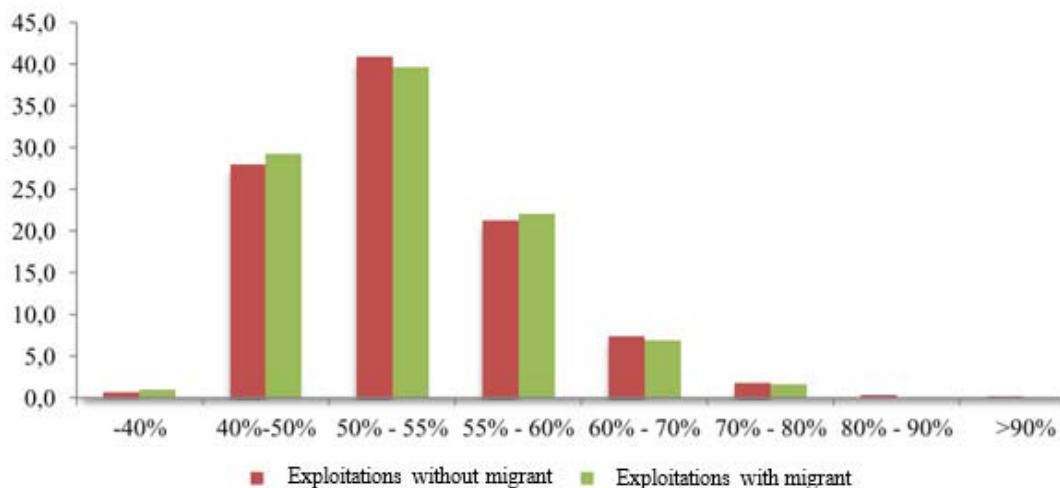
540 Figure 4 : Sharing of fixed effects



541 *Source: Author's field research*

542 Once technical efficiency's estimation of agricultural unit is available. We are now
543 checking whether it is a decreasing function of the reliability of the insurance mechanism.
544 Therefore, we estimated an equation of the predicted value of the fixed effect as a function
545 of a vector of observable characteristics of the operation and the insurance mechanism
546 measured by Ψ . Due to the aspect of data (cross sectional), we ran only one model with
547 internal migration (rural to urban migration) because the data did not contain much
548 exploitations involved in international migration. The results of technical efficiency
549 regressions are presented in table 8. The coefficient associated with the rate of migration is
550 significant and held a negative sign. This means that the null hypothesis of moral hazard is
551 not rejected. The presence of opportunistic behaviour might well be facilitated by the
552 existence of an implicit contract between migrants and their families behind.

553 Figure 5 : Distribution of the exploitations according to the technical efficiency by
554 migration status



555 *Source: author's field research*

556 *Production function ran separately for each crop:*

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

568 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.
	3.96***/0.		4.40***/0.	3.09***/0.	3.25***/0.
Constant	13	3.80/0.15	07	12	11
					0.09**/0.0
Log (Area)	0.03/0.04	-0.05/0.04	-0.01/0.01	0.07*/0.04	4
Log (Hired labour)	0.12***/0.	0.03/0.04	0.00/0.02	0.05*/0.03	0.17***/0.

	04				03
	0.12**/0.0			0.14***/0.	0.11**/0.0
Log (Family labour)	6	0.06/0.06	-0.03/0.03	05	5
Input [Ref. No use of manure and fertilizer]					
Manure or Fertilizer	0.21***/0.	0.65***/0.		1.36***/0.	0.56***/0.
	07	08	0.04/0.05	09	07
Manure and Fertilizer	0.76***/0.	0.92***/0.		1.38***/0.	0.36**/0.1
	10	13	0.04/0.07	10	7
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		0.30***/0.0			0.42***/0.0
	0.06/0.08	9	0.01/0.04	0.08/0.07	8
Secondary & professional	0.29***/0.0				0.41***/0.0
	9	0.18/0.13	0.08/0.09	-0.09/0.10	9
University level	-0.05/0.74	0.24/0.22	-0.08/0.05	0.26/0.25	0.81***/0.1
					3
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

569 Standard error after /. ***, **, * significance level respectively 1%, 5% and 10%

570 Source: author's field research

571 Conclusion

572 The principal component of this objective was to highlight the existence of a moral hazard
573 phenomenon that would be the cause of poor agricultural output obtained by exploitations

574 with at least one member living outside their locality. A remark, most of the researches
575 have been focused on the international migration, but the present study mostly focused on
576 the impact of internal migration on agricultural productivity. Because more than 95% of
577 the whole migrants move inside the country. The theoretical model used in this research,
578 proposed by [5], showed that the farmers exercise lower average level of effort in doing
579 farm activities once they are insured by receiving transfer from migrants. The forecast of
580 the theoretical model was tested using the estimation by the fixed effects method of a
581 production frontier. The indicator of the reliability of the insurance mechanism, measured
582 by the ration of migration (ration of migration is to the number of migrants over the size of
583 the exploitation) seems determine the technical inefficiency of agricultural exploitations.
584 [5] obtained this conclusion with regard to the Kayes region (international migration).
585 Although some previous studies conducted regional analysis, this present study was
586 estimated based on national impact and have also concentrated on the impact of internal
587 migration which is the most dominant migration type in Mali.

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