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# Adoption of Improved Seeds and Market Participation of Family Farms: The Case of Maize Cultivation in Cameroon

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**Abstract:** In most countries of the world, the rural areas is that which is essentially covered of poor. This fact, the fight against poverty in the rural areas is a major challenge for development actors. One of the ways to improve the living conditions of rural people is to further promote the commercial transformation of agriculture, the source of their livelihood, by encouraging them to participate in the markets for agricultural goods. To this end, the adoption of improved agricultural technologies is a lever on which this struggle can be based. This paper assesses the impact of improved maize seed adoption on market participation of Cameroonian Small Farmers. The data are from a sample of 160 adopters and 99 non-adopters of improved maize seed, result from an investigation carried out within the framework of the project of Reinforcement of the Partnerships of the Agronomic research in Cameroon and prepared by the Agricultural Institute of Research for the Development. We use the comparison of means test for the quantities of maize sold and the gamma generalized linear regression model. The result of the test reveals that adopters of improved maize seed have on average 0.065 ton of maize quantity sold moreover than non-adopters. As for the result of the model, it shows that improved maize seeds have a positive and significant impact on market participation. In other words, the results show that the quantity of maize for sale increases by 90.3% for the Farmers that adopt improved maize seed and 89.2% for those do not adopt it. The Cameroonian government must implement policies that make improved maize seeds available to farmers, followed by training in the new agricultural practices and policies for the actual development of road infrastructures to serve the markets.

**Keywords:** Adoption of Improved Seeds, Maize, Market Participation, Gamma Generalized Linear Regression Model

## 1. Introduction

In most countries of the world like Cameroon, agriculture remains the engine of economic and social development. Globally, it is mostly practiced by Family Farms (FFs) which, [1] represents more than 90% of the Farms, provides more than 80% of the world's food in terms of value and [2] live mostly in rural areas. In Cameroon, [3] it accounts for more than 50% of employment, contributes to 24% of GDP, occupies 75% of the working population and creates market opportunities for other sectors of activity. Despite this proven importance, [4] 90.4% of the poor are mostly in rural areas. The poverty rate was 52.1% in 2001, 55.0% in 2007 and 56.8% in 2014 in rural areas and 17.9% in 2001, 12.2% in 2007 and 8.9% in 2014 in urban areas [4].

Obviously, the disparities observed probably are income opportunities that people have in their home environment. Many solutions to reduce rural poverty have been proposed in the literature [5-9]. One of them is to promote the commercial transformation of subsistence agriculture. In addition to its crucial role in improving the food security, nutrition and economic well-being of smallholder farmers, commercialization of subsistence agriculture is a key pathway to economic development in Developing Countries (DC) [10-13]. Income from market participation increases farmers' access to diverse and nutritious foods [14, 11] and improves access to non-food products and services [15-17]. Hence, [18] market participation by Small Farmers (SFs) is a strategy to be promoted by DC in order to achieve real agricultural transformation.

Several authors see the adoption of improved technologies (new agricultural practices, improved high-yielding varieties, etc.) as a means to build on this strategy since it remains essential in the transformation of farming systems [19-21]. Several authors see the adoption of improved technologies (new agricultural practices, improved high-yielding varieties, etc.) as a means on which to base this strategy since it remains essential in the transformation of agricultural systems [19-23]. In fact, the productivity gains achieved through the adoption of these technologies improve household food supply on the one hand and, on the other, the production of food surpluses useful for supplying markets [24]. Indeed, increasing the productivity potential and consequently the marketable surpluses of FFs requires, among other things, a substantial diffusion of agricultural innovations. According to [11], improving access to innovations for FFs would increase their participation in the market. In this work, we focus on improved maize seed innovations.

After wheat and rice, maize is the most widely grown cereal in the world [25]. Its use around the world depends on crops, ethnic groups and producers' needs [26]. Indeed, [27] cereals constitute the basis of human nutrition with 36.2% of calorific and 40% of protein intake, including 19.5% and 22% for maize. In Cameroon, maize is among the crops with one of the highest production levels (41%) out of the 77% of cereal availability since it is the most cultivated and consumed cereal throughout the country [28, 29], far ahead of sorghum, wheat and rice. By allowing SFs to have access to the market like coffee or cocoa, [30] maize is the main source of income for more than three million Cameroonian AEPs and plays a leading role in the food security of the population. It is grown in the far north (Adamaoua, North), west and northwest, central (Lekie, Mbam) and southern forest zone (Moungo) regions. Increasing the production potential and participation of SFs in the maize market via the adoption of improved maize seed innovations would be a guise to reduce hunger and poverty afflicting rural Cameroon. For, [31] the opportunities for market development are particularly favourable in view of the ever increasing trend in national, regional and international demand.

Although the level of maize production compared to other cereals is high, [25] the expansion of the maize sector in Cameroon faces several challenges, accentuating the deficit between supply and demand, among which [28, 26, 32] the seasonal fluctuation of market prices, low and surplus volumes of marketed crop, low volumes of operations, unorganized marketing channels, very high marketing costs. In this context, given the low maize yields in SFs fields, it will be more difficult to cope with the projected increase in various demands [33], especially since, [26] its family self-consumption due to a diverse range of use absorbs more than half of the production. On this, improvement of maize marketing channels especially a considerable improvement of its production via practices that include in the production process improved seeds are undoubtedly the means to increase the participation of SFs in the maize market.

Indeed, [11] argues that choices of agricultural production technology are inextricably linked to choices of market values. According to [34], the decision to adopt a new practice is seen as an investment decision. From this perspective, [11] argues that farmers using modern highly productive technologies produce more market value than those using traditional production technologies. The promotion of agricultural technological advances, therefore, has the potential to act as a key element that causes high market output. Some authors [35, 24, 19, 36] find that adoption of agricultural technologies has a positive and significant impact on market participation. Although no study in Cameroon has identified the need to explore this relationship.

In Cameroon, research organizations such as the Institute of Agricultural Research for Development (IRAD) and the International Institute of Tropical Agriculture (IITA) have integrated into their activities a multitude of programs and projects focused on seed improvement for several crops including maize. The trade-off between different varieties is based on a set of criteria including those related to marketing constraints [37]. Although a large literature in SSA indicates that agriculture is a source of livelihood, [19] farmers in Sub-Saharan Africa face the low marketable outputs. Here he notes that one of the major challenges is the adoption of agricultural varieties for crop production. However, in view of the acceptance of adoption of agricultural innovations by some farmers, questioning the impact of adoption of new maize varieties on the integration of its market by the SFs becomes essential to further promote their use and improve its production in Cameroon. The objective of this paper is to assess the impact of the adoption of improved maize seeds on the market participation of SFs in Cameroon. The rest of the work is organized as sections 2, 3, 4 and 5 present the literature review, methodology, results and conclusion respectively.

## 2. Review of Literature

The relationship between adoption of improved agricultural technologies and market participation of SFs draws its theoretical anchor from the economic analysis of decision making [19]. On the one hand, we have authors who, due to the inextricable link, argue that farmers' market participation and new technology adoption decisions are interdependent [19, 38-40]. According to [38], the decision to adopt a new practice is seen as an investment decision. Clearly, [11] farmers using modern highly productive technologies are more likely to produce a marketable crop surplus than those using traditional technologies. By adopting an agricultural technology, the farmer finds it a way to increase his or her previously reduced agricultural production, which is generally divided between consumption and sale. The choice of available agricultural technologies is determined by the need to increase production and productivity [35]. The adoption of new agricultural technologies is a form of catalyst for higher market

participation through the sales potential it offers to SFs. According to [11], the effect of this adoption on market participation is manifested in very high productivity.

On the other hand, we have authors for whom the gains from the adoption of new technologies in terms of farmers' market participation is still not a certainty insofar as most agricultural commodity markets are generally subject to failures in their functioning and structure [41, 42]. In fact, the failures are often such that farmers are unable to earn significant income from the marketed crop surpluses. This, in turn, can be a source of demotivation for their participation in the market. According to [43], in addition to the issues of market participation and adoption of improved agricultural technologies, other conditions, such as improved institutional development and infrastructure, must be in place for the desired effect to be achieved.

Empirically, few studies show the link between the adoption of new technology and market integration in EPIs [44-46]. However, in a study of a sample of 300 households in the Orimia region of Ethiopia, [35] assess the impact of the adoption of improved maize varieties on farmers' market participation. The results show that maize technologies had a robust and positive impact on crop surplus to the market. [36] assess the determinants of adoption and the casual impact of adoption of improved chickpea technologies on market integration in rural Ethiopia. The results of the analysis revealed that the adoption of improved agricultural technologies has a positive and significant impact on marketed surpluses. Also in this country, the work done by [19] on a sample of 2675 farmers, reveals that the use of improved agricultural inputs significantly affects the marketable surplus production of farmers and that the application of high yielding varieties increases the surplus agricultural production by 7.39% per year.

Studies in Asia have also found similar results. In a sample of 700 households in rural Timor-Leste, [24] examine the role of high-yielding maize varieties as one of the main drivers of smallholder farmers market participation. The results reveal significant positive impacts of technology adoption on farmers market participation. [38] also examines the impacts of agricultural technology adoption on poverty reduction in rural Bangladesh. The results show a robust and positive impact of agricultural technology adoption on the welfare of farm households. Similarly, [47] conduct an impact study in rural China and found that adoption of agricultural technologies has a positive impact on farmers welfare and thus improves their income.

# 3. Methodological

### *3.1. Data Source*

The data used are from a survey conducted as part of the Strengthening Agricultural Research Partnerships in Cameroon project, developed by the Institute of Agricultural Research for Development. This database initially included 497 FFs collected in the West and Central regions. After purifying the database according to a certain number of criteria, we retained 259 FFs, divided into 160 adopters and 99 non-adopters of improved maize seeds.

### *3.2. Presentation and Justification of Model Variables*

Participation in the maize SFs market is the dependent variable approximated by the logarithm of the quantity of maize sold (*ln (Qty_MaizeSold*)) [37, 26, 48]. The values taken by this quantity were determined by the following formula:

$$\ln(\text{Qty\_MaizeSold}) = \ln(\text{proportion of sales} \times \text{total corn production}) \quad (1)$$

The explanatory variables are of two groups. On the one hand, we have the socio-economic variables namely: *(i)* the gender of the Farm (*Sex_Farm*) is captured by the binary variable with 1 if the Farmers is male and 0 Otherwise. According to [49] and [50], female-headed Farmers are more capable of participating in markets than male-headed ones; *(ii)* the age of the Farmers (*Age_Farmers*) is captured by the number of years the Farmers has been alive. The amount of market surplus may decrease with the age of the farmers since productivity tends to decrease with age [51]; *(iii)* marital statute (*Marital_Statute*) is a dichotomous variable with 1 if the Farmers is living as a couple and 0 otherwise. The Farmers who lives in a couple unlike the one who lives alone, is more involved in work and has more responsibility that requires cash income compelling him to increase his surplus market production; *(iv)* the area sown to maize is captured by the logarithm of the number of hectare sown to maize (*ln (Surface_CornGrounds*)). According to [48], the area allocated contributes positively to market participation via effects in terms of increased harvest; *(v)* the level of education of the Farmers (*Level_EduFarmers*) is a dichotomous variable with 1 if the Farmers has at least a secondary level and 0 otherwise. A high level of education constitutes a competent human capital for the management and marketing of the agricultural activity [52], and allows the Farmers to better understand its local environment by ensuring the best use of existing resources [53]; *(vi)* the region of residence of Farmers (Region_Farmers) is a binary variable with 1 if the Farmer resides in the West and 0 otherwise; *(vii)* total production is captured by the logarithm of the total quantity of maize produced (*ln (Qty_TotMaizeProd)*) by an Farmer; *(viii)* home consumption is captured by the logarithm of the quantity of self-consumed maize (*ln (Qty_TotMaizeCrop*)) by an Farmer The food reserve for self-consumption dictates the surplus crop for sale [54]; *(ix)* the amount of production lost after harvest is captured by the logarithm of the amount of post-harvest loss (*ln (Qty_LostPostHarvest)*). The amount of production lost after harvest decreases the amount available to the Farmer and therefore its expected quantity for sale; (*x)* the distance captured by the logarithm of the distance to the nearest market (*ln (Dist_Market)*). The distance to market imposes a

transaction cost on the Farmers and determines its volume of crop to be sold [21]; *(xi)* the number of years put into farming is captured by the Farmer's experience (*Farmer_Exp*) in Agriculture; *(xii)* the transport cost is captured by the logarithm of the transport related charges (*ln (Transport_Charges)*) for transporting maize to market. When transport costs are high, they tend to limit the flow of agricultural products to the market.

And on the other hand, the variables of endowments in resources namely: *(xiii*) membership in a farmers organization (*Members_0rgPeasant*) is a binary variable with 1 if the Farmer is a member of a peasant organization and 0 otherwise. Membership in a peasant organization is a factor that, because of the agricultural training, technical assistance and good prices that the peasant organization generally offers to members to increase their productivity, contributes positively to market participation; *(vix)* Labour captured by the logarithm of the number of labour (*ln (Number_Labour)*) employed in the SFs. In their study, [55] demonstrated the role of labour in market participation; *(xv)* adoption of traditional maize seed captured by the dichotomous variable with 1 if the FF adopts the other maize seed and 0 otherwise; *(xvi)* adoption of improved maize seed captured by the dichotomous variable with 1 if the FF adopts the new maize seed and 0 otherwise.

### *3.3. Analytical Instruments*

To achieve our objectives, we use a methodological approach structured around a descriptive analysis on the one hand and an econometric analysis on the other.

#### *3.3.1. Descriptive Analysis*

It is carried out by univariate and bivariate analyses of specific variables to highlight the main characteristics of FFs. Using the comparison of means test, we proceed to a comparative analysis of the average sale volumes between adopters and non-adopters of improved maize seeds. An interdependence test was conducted to highlight the relationships between selling behaviour and certain socio-economic characteristics of individuals.

#### *3.3.2. Econometric Analysis*

For the following reasons: firstly, the absence of selectivity and endogenous bias in the sample, i.e. the number of AEs whose quantity of maize sold is zero on ten, i.e. negligible from a statistical point of view; secondly, the nature of the explanatory factors, i.e. the explanatory variables selected are both quantitative and qualitative; and thirdly, the characteristic of the dependent variable, i.e. it takes its values from the set of positive real numbers excluding zero ($IR_{+}^{*}$). Given the insignificant number of its zero values in the sample, we choose to replace them by 0.01. Therefore, its distribution approaches that of a gamma distribution. This leads us to the estimation technique of the gamma generalized linear regression model. This estimation technique allows us to capture and assess the sensitivity of the quantity of maize sold for FFs adopting new improved seed varieties. The simplified version of the model is as follows:

$$ln\,[E\,(MSi)] = X_i\beta \quad (2)$$

With *E (MSi)* the mathematical expectation of the quantity of corn sold from $i^{th}$SF, the vector of explanatory variables retained above and the vector of coefficients associated with the explanatory variables of the model.

## 4. Results

### *4.1. Presentation and Interpretation of Descriptive Statistics Results*

Total maize production (see table 2 in the appendix) varies between 8.75 $10^{-28}$ kg and 85 ton. It is estimated at an average of 3.325 ton. The average value (see table 3 in the appendix) differs significantly between regions, i.e. 1.8 and 4.7 ton in the Central and Western regions of Cameroon respectively. With regard to the management of this harvest, it appears (see table 4 in the appendix) that 3.86% of the farms do not sell their production, 93.05% sell part of it and 3.09% sell their entire harvest. In general, sale volumes vary between 0 and 72 ton and average 2.5 ton. They are 1.3 and 3.5 ton in the Centre and West respectively. This would suggest that the western region is the one that markets more maize. This is observed through the market participation rates, which show that 45.78% and 54.22% of farmers in the Central and Western regions respectively sell their production. In addition, it appears (see table 5 in the appendix) that the farmers travel an average of 5.6 km or 10.56 km to sell their harvest in the nearest local or urban markets, respectively. In addition, it should be noted that this sale activity is not without impact on costs, such as transaction costs, which are essentially made up of transport costs and other marketing expenses (licence, security, counter rental, etc.). Transport costs (see table 2 in the appendix) are estimated at an average of 10 Euro.

According to the results of table 5 (see appendix), 70.28% of the population of market SFs are men and 81.53% live in couples. 59.44% of SFs have a school level of at most primary school and 40.56% at least secondary school. They are on average 43 years old and have 4 years of experience in agriculture. If we look at the age groups, we can see that the 35-44 and 45-54 age groups are the most representative with 30.52% of the SFs each. Half of the farms in the sample, i.e. 50.01%, belong to farmers associations. In terms of factorial endowments, the average area is estimated at 1.43 ha for sellers against 0.62 ha for non-sellers. The value of this area is a minimum of 0.01225 ha and a maximum of 24.15 ha for sellers against 0.004 ha and 1.8 ha for non-sellers. Regarding the labour force, it is 6 individuals for the merchant farms and 3 individuals for the non-merchant farms. Concerning the use of new maize seeds, 62.25% of sellers are adopters and 37.75% are non-adopters. Indeed, the FFs with sales targets have a tendency to adopt the innovation of improved maize seeds. This

assumes that there is a positive relationship between adoption of agricultural innovation and sale capacity.

The test of comparison of means (cf. table 6 in the appendix) for the quantity of maize intended for sale reveals that the adopters of improved maize seeds have on average 0.065 ton of maize quantity sold moreover than non-adopters and significant at the threshold of 5%. As for the results of the interdependence test (table 7 in the appendix), it appears that there is a relationship of dependence between sales and the explanatory variables such as the level of education, the region of residence, the quantity of the crop consumed by the farmers and the quantity lost from the said crop. On the other hand, the said test does not reveal any relationship between the adoption of improved maize seeds and the quantity sold.

However, a test of multicollinearity through the analysis of the variance-covariance matrix of the explanatory factors of the model was carried out. The result of this test reveals the convincing presence of a risk of multicollinearity at the 5% threshold (cf. table 8 in the appendix). However, this risk was invalidated by the VIF test (see table 9 in the appendix), for certain variables, except for the variables post-harvest loss, self-consumption quantity, quantity produced, experience and age of the Farmer. To solve this multicollinearity problem and considering the robustness of the model, the variables post-harvest loss quantity, transport costs, membership in a peasant organization, and marital statute were removed from the model.

### *4.2. Presentation and Interpretation of Econometric Results*

The estimation results in Table 1 show a positive and significant effect of adoption of improved maize seeds on the quantities of maize sold. Such a result was found by [19, 24] and [35] in their work. Indeed, the quantities of maize sold increase by 90.3% when the FF adopts improved maize seeds. This result is to be encouraged in Cameroon especially since most farmers are SFs producing maize in small portions of land. Sustainable intensification of improved seeds is a good option to increase production and reduce poverty of maize SFs through increasing their marketable surplus production. The results also show that the adoption of other maize seed has a significant positive effect on the quantities of maize sold. These other maize seeds increase the quantity of maize sold by 89.2% in the SFs that use them. It follows that although the difference between the marginal effects of adoption of improved and unimproved maize seed on the quantity of maize sold is small.

However, the small difference between the marginal effects of market participation of adopters and non-adopters of improved maize seed may be related to several reasons. One reason is the consumption patterns of households when harvests are high. Indeed, increased harvests for most households are generally accompanied by a near-proportional increase in consumption needs, to the detriment of sale needs. There is also a strong diversification of activities developed by households. In Cameroon, and in some regions such as the West, many SFs are involved in agro-pastoral activities. As a result, the quantities of maize production that can be marketed are for the most part directed towards managing these activities.

This model also shows that the amount of maize production, distance to market, experience, western region and area planted to maize have a positive and significant effect on participation in the maize market. These variables were also found to favourably affect the share of maize quantities sold. The amount of corn production held by the SF plays a favourable role in market participation. In fact, the higher the quantity of harvest, the more the SF sells the considerable quantities of maize to the market. The sign of the variable distance to market is counter intuitive. This result was also found by [56-58]. It is in contradiction with the work of [59, 35] for whom distance to market hinders the access of AEs to market. Our result can be justified by the fact that the greater the distance to the market, the higher transaction costs and the greater the incentive for the SFs to increase the proportion of sales to cover expenses and generate more profits. The sign of the SF experience variable is an expected result. Greater experience increases the level of market participation [55]. Indeed, the more years the SF accumulates in agricultural activity, the more expertise it acquires which develops its capacities and uses of agricultural techniques that allow it to increase its quantities produced and consequently those marketed. As regards the regions studied, unlike the Central Cameroon region, the Western region has a positive and significant effect on sales volumes. This result can be justified by the fact that the West region has assets that make it highly dependent on maize, such as its topography, climate, multiple agro-pastoral and agro-industrial activities, and the strong diversity in the forms of maize consumption related to customs. The area planted to maize has a positive and significant effect on market participation. This result was found by [35, 19, 49]. Increase in cultivated area followed by improved practices lead to returns to scale sources of increase in quantities sold.

On the other hand, the quantity of self-consumption of maize, the level of secondary education and the age of the SF have a negative and significant effect on market participation. The relationship between the amount of self-consumed maize and the amount of maize sold is a result that supports those obtained by [60, 61]. Indeed, food sovereignty remains a priority for rural households. This is because, ceteris paribus, they give priority to their autonomous consumption to the detriment of sales. The observed effect of the level of secondary education is a counterintuitive result. The sign of the secondary education level variable can be translated by the fact that the SFs in Cameroon have more general knowledge and less knowledge of high yield agricultural practices. This unintentionally reduces their participation in the market. The sign of the observed age variable reflects the idea that, the age of a farmer leads to a corresponding decrease in the level of market participation, indicating that young farmers are more likely to participate in the market. This result can be explained by the fact that, [62, 63] older SFs develop, over time, a high dependence for subsistence production.

***Table 1.*** *Effect of adoption of improved maize seed on quantities of maize sold.*

| Variables | Coef. | \|z\| | Confidence interval | |
|---|---|---|---|---|
| ln (Qty_TotMaizeCrop) | -0.0892417 | (6.06)*** | -0.1181146 | -0.0603689 |
| ln (Qty_TotMaizeProd) | 0.1865612 | (12.34)*** | 0.1569303 | 0.2161921 |
| ln (Dist_Market) | 0.0400418 | (1.75)* | -0.0048515 | 0.084935 |
| Farmer_Exp | 0.0226504 | (1.92)* | -0.0004995 | 0.0458004 |
| Western Region | 0.0809795 | (2.30)** | 0.0120737 | 0.1498854 |
| ln (Surface_CornGrounds) | 0.0545477 | (3.19)*** | 0.0209919 | 0.0881035 |
| Level_Education at least equal to Secondary | -0.0775548 | (2.42)** | -0.1402616 | -0.0148479 |
| Sex_Male | 0.0355174 | (1.04) | -0.0312587 | 0.1022935 |
| Age_Farmer | -0.0033015 | (1.65)* | -0.0072251 | 0.0006222 |
| ln (Number_Labour) | 0.0251302 | (1.16) | -0.0173114 | 0.0675717 |
| Adoption of new corn seeds | 0.9025946 | (9.37)*** | 0.7138522 | 1.091337 |
| Adoption of other corn seeds | 0.8924579 | (9.44)*** | 0.7070952 | 1.077821 |
| Number of observations | 259 | | | |
| AIC | 5.776472 | | | |
| Scale parameter | 0.0586966 | | | |
| Deviance | 0.4162324 | | | |
| Pearson | 0.058696 | | | |

Notes: |t| is the absolute value of the student statistic. *, ** and *** significance at 10%, 5% and 1% respectively. "n" and "k" are respectively the sample size and the number of explanatory variables in the model (excluding the constant term).
Source: Authors.

# 5. Conclusion

The fight against poverty in the rural world is a major challenge for development actors. One of the ways to improve the living conditions of rural people is to further promote the commercial transformation of agriculture, the source of their livelihood, by encouraging them to participate in the markets for agricultural goods. To this end, the adoption of improved agricultural technologies is a lever on which this struggle can be based. This study assesses the impact of the adoption of improved maize seed on SFFs market participation in Cameroon. The sample was drawn from a survey carried out within the framework of the RPRC project developed by IRAD and includes 160 adopters and 99 non-adopters of improved maize seed. The statistical exploitation was done using the comparison of means test and the empirical one using the gamma generalized linear regression model. The result of the test reveals that adopters of improved maize seed have on average 0.065 ton of maize quantity sold moreover than non-adopters. As for the result of the model, it shows that improved maize seeds have a positive and significant impact on market participation. In other words, the results show that the quantity of maize for sale increases by 90.3% for the SFs that adopts improved maize seed and 89.2% for the SFs that does not adopt. Based on the results, the government should implement strategies to make improved maize seeds available to farmers in a sustainable and sincere manner, followed by training in the new agricultural practices and undertake policies for the real development of road infrastructure to serve the markets.

# Appendix

***Table 2.*** *Statistical description of variables (n=259).*

| Variables | Measure | Average | Standard deviation | Min | Max |
|---|---|---|---|---|---|
| Quantity of maize for sale | kg | 2481.537 | 5526.577 | 0 | 72 250 |
| Amount of post-harvest loss | kg | 201.9711 | 506.3981 | 0 | 5 000 |
| Quantity of production consumed by the company | kg | 641.6667 | 1070.269 | 0 | 8 500 |
| Total quantity produced | kg | 3325.175 | 6666.909 | 8.75.10-28 | 85 000 |
| Experience of the Farmer in Agriculture | Number of years | 4.177606 | 1.938822 | 1 | 7 |
| Adoption of seed other than improved maize seed | 1=adopts, 0=does not adopt | | | 0 | 1 |
| Transportation costs | £ (Euro) | 10 | 29.65 | 0 | 274.12 |

Source: Authors.

***Table 3.*** *Distribution of SFs according to their typology.*

| Typology of AEs | Does not sell anything | Sells a part | Sells all |
|---|---|---|---|
| Frequency (%) | 3.86 | 93.05 | 3.09 |

Source: Authors.

***Table 4.*** *Bivariate distributions of SFs according to some variables (Average total production, Average sale and Decision to sell) and residence sites.*

| Variables | Sites | |
|---|---|---|
| | **West n=136** | **Central n=123** |
| Average total production | 4700.162 | 1804.865 |
| Average sale | 3546.656 | 1303.845 |
| Decision to Sell (Participation Rate) | | |
| Does not sell anything | (10) 1 | (90) 9 |
| Sells | (54.22) 135 | (45.78) 114 |

Source: Authors.

***Table 5.*** *Bivariate distributions of SFs according to some socio-economic characteristics and the decision to sell.*

| Variables | Decision to Sell | |
|---|---|---|
| | **Does not sell anything n=10** | **Sells n=249** |
| Binary variables | | |
| Gender of Farmer | | |
| Woman | (50) 5 | (29.72) 74 |
| Male | (50) 5 | (70.28) 175 |
| Marital statute | | |
| Lives with a partner | (80) 8 | (81.53) 203 |
| Not living with a partner | (20) 2 | (18.47) 46 |
| Level_Education of Farmer | | |
| At least secondary | (80) 8 | (40.56) 101 |
| At the most primary | (20) 2 | (59.44) 148 |
| Member_OrgPeasant | | |
| Join | (50) 5 | (51.01) 127 |
| Does not adhere | (50) 5 | (48.99) 122 |
| Adopt improved maize varieties | | |
| Adopt | (50) 5 | (37.75) 155 |
| Do not adopt | (50) 5 | (62.25) 94 |
| Continuous variables | | |
| Age by band | | |
| < 25 years | (10) 1 | (3.21) 8 |
| 25 - 34 | (10) 1 | (21.69) 54 |
| 35 - 44 | (60) 6 | (30.52) 76 |
| 45 - 54 | (20) 2 | (30.52) 76 |
| 55 - 65 | (0) 0 | (9.64) 24 |
| 65 + | (0) 0 | (4.42) 11 |
| Age of Farmer | 37.7 | 43.00803 |
| Area allocated to corn | 0.619075 | 1.434891 |
| Number of manpower employed | 2.8 | 5.62249 |
| Farmer experience in agriculture | 2.8 | 4.232932 |
| Distance to nearest local market | 4.81 | 5.60502 |
| Distance to nearest urban market | 6.658 | 10.55799 |
| Transport costs incurred by the Farmer (en Euro) | 0.17 | 10.37 |

Note: Values without brackets and with brackets are absolute frequencies and percentage counts, respectively (for the binary variable section and the first row of the continuous variable section). For the rows of the continuous variable section (except the first row), the values represent the means of variables.
Source: Authors.

***Table 6.*** *Comparison tests of means and variances of market production surplus.*

| Variable | | | Adopters | Groups | Non-adopters |
|---|---|---|---|---|---|
| Ln (sales volume) | Number of observations | | 160 | | 99 |
| | Average | | 6.832433 | | 6.399061 |
| | (Standard deviation) | | (1.766487) | | (2.138747) |
| | Comparison of averages | DL=257 | t=-1.7680 | $Pdiff_{<0}$=0.0391 | $Pdiff_{\#0}$=0.0783 |
| | Comparison of variances | DL=98.159 | f=1.4659 | $Pratio_{>1}$=0.0161 | $Pratio_{\#1}$=0.0322 |

Note: t and f are Student and Fisher statistics respectively
Source: Authors.

***Table 7.*** *Test of interdependence between the decision to sell and socio-economic variables.*

| Socio-economic variables | Decision to sell | | | Results H0: independence |
|---|---|---|---|---|
| | Does not sell anything n=10 | Sells n=249 | Total | |
| Age by group | | | | |
| < 25 years | 1 | 8 | 9 | Pearson chi2(5)=6.2905 Pr=0.279 |
| 25 - 34 | 1 | 54 | 55 | |
| 35 - 44 | 6 | 76 | 82 | |
| 45 - 54 | 2 | 76 | 78 | |
| 55 - 65 | 0 | 24 | 24 | |
| 65 + | 0 | 11 | 11 | |
| Member_OrgPeasant | | | | |
| Belongs to | 5 | 127 | 132 | Pearson chi2(1)=0.0039 Pr=0.950 |
| Does not belong | 5 | 122 | 127 | |
| Adoption of new corn seed | | | | |
| Adopt | 5 | 155 | 160 | Pearson chi2(1)=0.6109 Pr=0.434 |
| Do not adopt | 5 | 94 | 99 | |
| Gender of Farmer | | | | |
| Woman | 5 | 74 | 79 | Pearson chi2(1)=1.8654 Pr=0.172 |
| Male | 5 | 175 | 180 | |
| Level_Education of Famer | | | | |
| High school and up | 8 | 101 | 109 | Pearson chi2(1)=6.1349 Pr=0.013 |
| At the most primary | 2 | 148 | 150 | |
| Marital_statute | | | | |
| Lives with a partner | 8 | 203 | 211 | Pearson chi2(1)=0.0148 Pr=0.903 |
| Not living with a partner | 2 | 46 | 48 | |
| Region of residence | | | | |
| West | 1 | 135 | 136 | Pearson chi2(1)=7.5376 Pr=0.006 |
| Center | 9 | 114 | 123 | |
| Proportion of the crop consumed by the farm | | | | |
| =0 | 0 | 8 | 8 | Pearson chi2(3)=187.50 Pr=0.000 |
| 0-50 | 0 | 218 | 218 | |
| 50-100 | 3 | 23 | 26 | |
| =100 | 7 | 0 | 7 | |
| Proportion of post-harvest losses | | | | |
| =0 | 7 | 63 | 70 | Pearson chi2(2)=9.7462 Pr=0.008 |
| 0-50 | 3 | 185 | 188 | |
| 50- 100 | 0 | 1 | 1 | |

Source: Authors.

***Table 8.*** *Multicollinearity test.*

| | Qty_Lost. | Qty_Tot autoc. | Qty_Tot prod | Mat. statute | Dist_Market | Dist_ city | Farmer_Exp | Region |
|---|---|---|---|---|---|---|---|---|
| Qty_lostPostHeavest | 1,0000 | | | | | | | |
| Qty_TotMaizeautoc. | 0,5809* | 1,0000 | | | | | | |
| Qty_TotMaizeprod | 0,7520* | 0,7609* | 1,0000 | | | | | |
| Mat. statute | 0,0798 | 0,0935 | 0,1197 | 1,0000 | | | | |
| Dist_Market | -0,0586 | -0,0692 | -0,0493 | -0,1078 | 1,0000 | | | |
| Dist_city | -0,0326 | -0,0617 | 0,0046 | -0,0501 | 0,0395 | 1,0000 | | |
| Farmer_Exp | 0,1204 | 0,1524* | 0,1945* | 0,2440* | 0,0802 | -0,0640 | 1,0000 | |
| Region | 0,0729 | 0,2705* | 0,2173* | 0,0240 | -0,2465* | 0,1316* | 0,1552* | 1,0000 |
| Surface_CornGrounds | 0,3265* | 0,4995* | 0,4333* | 0,0886 | -0,1391* | -0,0255 | 0,2383* | 0,3173* |
| Member_OrgPeasant | 0,0711 | 0,1271* | 0,1345* | 0,0688 | -0,1072 | -0,1291* | 0,2098* | -0,0203 |
| Level_EduFarmer | 0,0064 | 0,0078 | 0,0115 | -0,1167 | -0,1440* | -0,0311 | -0,2520* | 0,0746 |
| Sex_Farmer | 0,1298* | 0,1391* | 0,1843* | 0,0941 | -0,0757 | 0,1866* | -0,0302 | 0,1928* |
| Age_Farmer | 0,1265* | 0,0876 | 0,1507* | 0,2302* | -0,0232 | 0,0174 | 0,7245* | 0,1365* |
| Number_Labour | 0,2295* | 0,2811* | 0,2686* | 0,1779* | -0,1620* | -0,0163 | 0,3007* | 0,1288* |
| Cost T. | -0,0417 | 0,0283 | 0,1054 | 0,0882 | -0,1043 | 0,2263* | 0,1621* | 0,2355* |
| Adopt | -0,0253 | -0,0419 | -0,0458 | 0,0542 | -0,0234 | -0,0232 | 0,1092 | 0,1748* |

***Table 8.*** *Continued.*

| | Superf_ CornGr | Member_ | Level_Ed | Sex_Fa | Age_Far | NumberLabour | Cost T. | Adopt. |
|---|---|---|---|---|---|---|---|---|
| Qty_lostPostHeavest | | | | | | | | |
| Qty_TotMaizeautoc. | | | | | | | | |
| Qty_TotMaizeprod | | | | | | | | |
| Mat. statute | | | | | | | | |
| Dist_Market | | | | | | | | |
| Dist_city | | | | | | | | |
| Farmer_Exp | | | | | | | | |
| Region | | | | | | | | |
| Surface_CornGrounds | 1,0000 | | | | | | | |
| Member_OrgPeasant | 0,1903* | 1,0000 | | | | | | |
| Level_EduFarmer | 0,0535 | 0,1322* | 1,0000 | | | | | |
| Sex_Farmer | 0,1147 | -0,0124 | 0,0721 | 1,0000 | | | | |
| Age_Farmer | 0,2858* | 0,2139* | -0,1908* | 0,0283 | 1,0000 | | | |
| Number_Labour | 0,5856* | 0,1657* | 0,0464 | 0,0762 | 0,3137* | 1,0000 | | |
| Cost T. | 0,0931 | 0,0950 | 0,0209 | 0,0998 | 0,0999 | 0,0965 | 1,0000 | |
| Adopt | 0,1322* | 0,1344* | -0,0054 | 0,0139 | 0,2449* | 0,0924 | 0,0873 | 1,0000 |

Note: * symbolizes the significance of the test at the 5% level.
Source: Author.

***Table 9.*** *The results of the VIF test.*

| Variables | VIF | 1/VIF |
|---|---|---|
| Ln (Qty_LostPostHeaverst) | 7,29 | 0,137113 |
| Ln (Qty_TotMaizeAutocon) | 16,05 | 0,062305 |
| Ln (Qty_TotProd) | 20,51 | 0,048760 |
| Marital_statute | 1,16 | 0,865017 |
| Ln (Dist_Market) | 1,26 | 0,792932 |
| Ln (Dist_City) | 1,30 | 0,771841 |
| Farmer_Exp | 2,49 | 0,401924 |
| Region | 1,56 | 0,640665 |
| Ln (Surface_CornGrounds) | 1,57 | 0,638456 |
| Member_OrgPeasant | 1,25 | 0,797963 |
| Level_Edu | 1,20 | 0,834839 |
| Sex_Farmer | 1,13 | 0,885622 |
| Age_Farmer | 2,39 | 0,418508 |
| Ln (Number_Labour) | 1,29 | 0,776258 |
| Ln (Transport costs) | 1,20 | 0,830868 |
| Adoption of improved maize seed | 1,16 | 0,859019 |
| Average | 3,93 | |

Test decision rule
When $0 < 1/VIF < 0.50$, then there is a risk of multicollinearity between the variable concerned and other variables (which can be determined using the variance-covariance matrix)
When we have $0.50 \leq 1/VIF \leq 1$, then there is no risk of multicollinearity.

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