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DETERMINANTS OF ON-FARM DIVERSIFICATION AMONG RURAL HOUSEHOLDS: EMPIRICAL EVIDENCE FROM NORTHERN ALGERIA

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Abstract

This study aims to analyze the determinants and patterns of the on-farm diversification among the agricultural producers in Algeria. The study uses a sample of agricultural producers randomly and proportionally selected from Northern Algeria and the data obtained was analyzed using three adequate regression models. Results indicate that, on the technical aspects, the farmers who have larger farm size, access to market information, more full land employment and an irrigation system, those who own machinery and livestock holdings are more likely to diversify, whereas those with off-farm income are likely to specialize. In order to promote crop diversification, providing farm machinery through easy loans and improving access to market information and irrigation technologies should be given attention. Farmer's experience and his age are the major socio-economic determinants of farm diversification. The implication is drawn for provision of enabling socio-economic environment for the establishment of more diversification.
Keywords: *Farm income, diversification, rural development, risk management, algeria*
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1. Introduction

The agricultural diversification has been considered one of the most likely strategies to promote the agricultural development. The diversification is the adjustment of farming, which combines various or complimentary agricultural activities and moves agricultural resources to higher returns of their allocation.

In Algerian economic settings, the contribution of the agricultural sector in the national economy has a decreasing tendency. Although, a multitude of government programs has been promoted in the last three decades for rural and agricultural development, while the rural population has not been much better off. However, a full employment of agricultural resources makes it more possible. But, only 0.38 percent of total land area is now permanently farmed. On the other hand, the rural population has dramatically decreased from 52.03 in 1985 to 26.29 percent of the total population. This reflects two facts: first, the migration of rural population to the urban areas is caused by the inadequacy of the socioeconomic settings and the degradation of the living standard conditions through the successive failures of public policies. The second fact is that the agricultural resources are not fully used, causing distortions and regressive consequences on the agricultural output level by staying far below what it otherwise would be.

The inadequacy and the failures of government programs for agricultural and rural development continue to let the farmers handling many uncertainty sources in their activities. The nature of the northern Algerian agriculture and its observed activities serves as either pull or push factors and the general motive of farm households to raise their living standards underpin the evidence of the pursuance of income diversification by farm households in the Northern region of Algeria.

Currently, farm income diversification is not seen as an indication of deficient agricultural practices or as an emergency solution, but rather as a long-term strategy of farm households and a contribution to the sustainable development in rural areas.

Despite the recurrent observations that diversification plays an important role in agriculture, it is remarkable that there is a total absence of studies on the factors that affect farm diversification in Algeria. The main purpose of this study was to determine the factors affecting on-farm diversification.

Some basic concepts and issues on the farm diversification are discussed in section 2. The description of the methodology is given in section 3. Results and discussion are presented in section 4 followed by the concluding remarks in section 5.

2. Farm Diversification: Concepts and Issues

Agricultural economists have largely studied farm diversification strategies. This section could be grouped in three main subsections: the first subsection reviews the concept of farm diversification, the second subsection explores the determinants of farm diversification, with special focus on developing countries, and the third one presents some facts and problems of farm diversification in Algerian agriculture.

2.1. Definition of Farm Diversification: The Risk Considerations

Farm diversification is the most important risk management strategies in agriculture. Basically, the farm diversification is a strategy long used by farmers in order to deal with price, input and output uncertainty. The idea behind a diversification strategy is to let profits from one type of livestock or crop enterprise more than offset losses in another enterprise. The farm diversification is defined commonly as the diversity of income sources for a farmer. Consequently, we can distinguish the on-farm and the off-farm diversification, since the two strategies could be strongly related (see McNamara & Weiss, 2005). As this study focus on the on-farm diversification, the off-farm diversification will not be considered in the observed phenomena.

Thus, the on-farm diversification[1] is defined here as the allocation of resources (land and labor) generating more than one agricultural product. In other words, the production of additional crops to existing ones at farm level (Dorjee *et al*., 2003). Accordingly, most farms produce more than one product, and this raises the question of the reason for the diversification. According to Mundlak (2001), the possible reasons are: (a) interdependence in agricultural production, (b) Better utilization of some fixed inputs, (c) savings due to the vertical integration, and (d) risk management. Only the last one will be highlighted in our study with respect of some considerations on the nature of the agricultural diversification in Algeria (see Table 2). There are two major diversification strategies for farmers: crop rotation and intercropping. This study highlights the second one, defined as the simultaneous production of additional outputs. There is empirical evidence that risk reduction is the most important reason for farm diversification (Chavas, 2001, Lin *et al*., 1974). Hence, through diversification, farmers spread the risk of loss over several commodities and may reduce the risk of loss from the farm as a whole. Anderson *et al*., (2002), by applying dynamic portfolio model, find that a lower return in agriculture could be compensated by risk adverse farmers, when farm

diversification are risk-reduction activities. In this sense the diversification of portfolio activities could reduce the exposure to several sources of uncertainty that affect farms (climatic factors, pests and diseases, price and polices related to agricultural production, marketing and trade uncertainties). Then an increase of farm diversification could be considered as a response to avoid these uncertainties. Therefore, this study assumes that the on-farm enterprise diversification can be an efficient risk management mechanism by stabilizing expected returns in an uncertain environment (McNamara & Weiss, 2005).

Transforming monoculture into diversified agriculture can not only promote the full employment of resources, but also bridge the market efficiency gap. The diversified agriculture has been equally considered a major strategy to conquer many challenges faced by farmers and to respond to opportunities. It improves farmers' nutrition, and more dynamic farmers can diversify agricultural products to meet changing consumption patterns as consumers become rich and urbanization develops rapidly. The diversification can also allow farmers to increase revenue by supplying products to potential export market.

2.2. On the Determinants of Farm Diversification in Developing Countries

There are several fundamental determinants of on-farm diversification could be of interest. According to Pope and Prescott (1980), the relationship between diversification and farm size is an indicator of tradeoffs between risk reduction and possible economies of size in a particular activity. That is, if there are substantial economies of scale in a particular activity, one clearly gives up a large expected return in order to insure against risk through diversification. Besides, there is policy interest in promoting diversified small farms. Another major motive of on-farm diversification is risk minimization. If the profits from different activities are negatively correlated with each other, it is possible to reduce the variability (risk) of total income by attributing the risk to various activities (Robison & Barry, 1987; Newbery & Stiglitz, 1981).
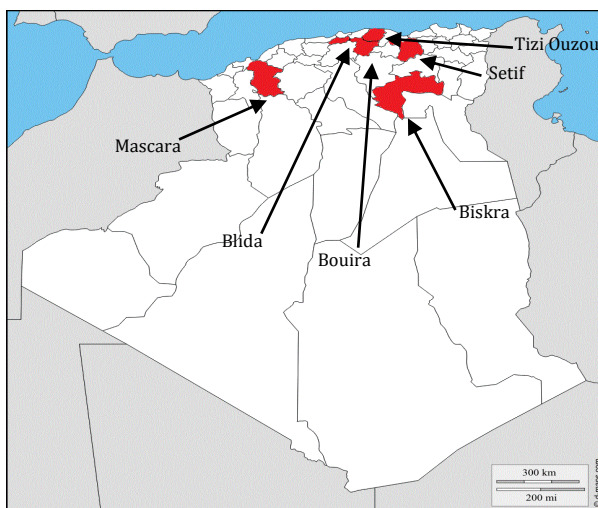
The agricultural activities are, with the availability of production technology, changed in response to the market signals. More specifically, it is a change in the product (or enterprise) choice and input use decisions forced by market signal and profit maximization (Pingali & Rosegrant, 1995). At the farm level, the diversification represents a change in the underlying characteristics of the farm system such that farming and products are more aligned with the social, technical and economic settings (Barghouti *et al.*, 2004).

However, the determinants of farm diversification may be different from one geographical location to another owing to spatial variations of rural economies across the regions (Abdullai & Crolerees, 2000; Minot *et al.*, 2006; Knudsen & Tidsskrift, 2007). Moreover, farmers are confronted by different incentives and constraints due to the differences in transaction costs and market prices they face. This culminated into heterogeneity in the kind of income diversification strategies that farmers pursue (Barrett *et al.*, 2005). Therefore, assessing the determinants of income diversification in the Northern Algeria is expected to appropriately facilitate the provision of public goods (infrastructure, extension service delivery, research) and rural development programs.

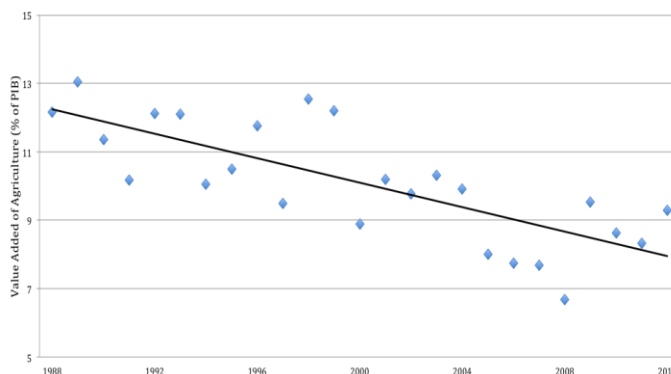## 2.3. Farm Diversification in Algeria: Facts and Problems

Algeria is a Mediterranean costal country located in Northern Africa. It covers a total area of 2,381,741 km^2 (is the second largest country in Africa after the Sudan, but nearly nine tenths of its land is in the six Saharan areas). Topographically, Algeria is divided into two main regions: the humid, sub-humid and semi-arid zones in the Northern region, and steppe, arid and desert (called commonly the Grand Sahara) zones in the South region. The study was conducted in six provinces (called Wilaya) of the Northern region. These pro-

vinces represent a wide range of agro-ecological variability. Figure 1 represents the location of six provinces in the Northern Algeria. Out of six provinces, Mascara was selected from the West of the region, Blida, Bouira, and Tizi Ouzou were selected from the central region, while Setif and Biskra were selected from the East. Besides, there was no prior study on farm diversification conducted in this area.

Figure 1. Map of Algeria displaying the study area.

However, the contribution of the agricultural sector to the GDP becomes increasingly a serious problem[2]. As shown in the Figure 2, the vertical axe represents the portion of value added of agricultural sector in the GDP, since the horizontal axe represents time in years (1988-2014). Obviously, there is a clear decreasing tendency in the values, which attain the value of 9.3% in 2014, since it was on average of 11.47 before 2000. In 2000, the government promotes the National Agricultural Development Plan having as objective the improvement of the level of food security and support of farmers. Many adjustments and joint-projects have made on this program, but with insignificant results on the agricultural performances. Because we can observe until now the increasing migratory flows of rural population and the net decreasing of returns in agricultural activities.

Figure 2. The evolution of the value added of agriculture
(Share in GDP) in Algeria (1988-2014)

Particularly, on the diversification and competitiveness of Algerian agriculture, the diversification index is low with a value of 2.5 regarding the average of 8.7 for the African countries (OCDE, 2010), and extremely low, regarding their neighbors (33.7 for Tunisia, and 37.8 for Morocco). Therefore, the diversification of Algerian agriculture is, however, probably constrained by price factors and many non-price factors.

Agricultural production in the Northern region is generally characterized by a high degree of instability and climate variability. This is mainly attributed to the nature of the agricultural production which is associated with a high degree of uncertainty which arises from the dependency of the agricultural production on uncontrollable weather conditions (erratic and variable rainfall) which caused great fluctuations on crop yield, on one hand, and large fluctuations in input and output prices on the other hand. It is argued that diversifying by growing more enterprises may lead to farm income stability.

In the absence of capital markets, stock markets, and insurance[3] alternatives, the farm income diversification in Algerian agriculture seems to be the only option offered to the farmers as a risk management device rather than an alternative among others. This fact leads to give more attention for studying farm diversification as a serious problem in Algerian agriculture. Defining the factors influencing farm diversification in this context helps public policy makers to improve the performances in agricultural production patterns.

3. Data and Empirical Method

3.1. The Study Area

The investigation of this study is conducted in the Algerian agricultural sector, with special focus on agricultural producers in the northern provinces (wilaya) of the country. The northern region of Algeria is divided into 32 provinces. From this region, six representative provinces are selected for this study, including Mascara, Blida, Bouira, Tizi Ouzou, Setif and Biskra (see Figure 1).

Mixed farming system with the predominance of crop production is dominant in the selected districts. The production system in the region is both rain-fed and irrigated systems, where the rain-fed production system being the most dominant. The major known problems in these areas are unreliable rainfall, low adoption of modern technologies, backward infrastructure facilities, and deterioration of soil fertility.

3.2. Sampling and Data

This study was conducted within the National Research Program on Farming and Agricultural Cooperatives over the period of 2012-2014, where we used the data generated among agricultural producers drown from the 6 provinces. The random sampling technique was employed in selecting a target of 550 agricultural producers[4] from the study area. The survey is realized through detailed interviews realized across the entire sample. We aimed to develop a questionnaire that was well adapted to the agricultural producers in order to capture several agricultural producers' characteristics, mainly the technical aspect (such as farm size, farm machinery, irrigation, farmer income, farm organization, and farm market environment) and the socioeconomic aspect (such as farmer age, his experience and schooling, his marital status, and his household).

3.3. Econometric Model

We investigate the following general form:
$$D_i = \beta X + \xi \; ; \qquad i = 1, 2, 3 \; ; \qquad \xi \sim \mathcal{N}(0, \sigma^2). \tag{1}$$

where D_i represents one of the three dependent variables, X is a vector of exogenous explanatory variables, β is a vector of unknown parameters, and ξ represents the farm specific error as a standard cumulative normal with mean zero and variance σ^2.

Dependent Variable: The dependent variable used is the farm output diversification. Obviously, the characteristics of diversification measures depend on the nature of the problem studied. We utilize then a variety of diversification measures. Hence, three measures of diversification are considered, which they had been largely used in empirical studies of output diversification issues. We cannot ascertain that the modeling should yield identical results.

We define A_k as the crop acreage in activity k, and let $p_k = A_k/\Sigma A_k$ denote proportion of income from crop *k*. Then the following measures are considered (Berry, 1971; Hackbart and Anderson, 1978; Pope and Prescott, 1980):

$D_1 = \Sigma\ I[p_k]$ as then number of enterprises; where I denotes a 1/0 indicator;

$D_2 = \Sigma\ p_k^2$ as the Herfindahl index; and

$D_3 = \Sigma\ p_k\ log(1/p_k)$ as the entropy index.

We note that the Herfindahl index and the entropy index can be computed such that they are bounded by zero and one. The Herfindahl index takes the value of 1 when there is a complete specialization and 0 when N is sufficiently large, i.e. complete diversification. On the other hand, the entropy index, established by Theil (1971), and developed by Hackbart and Anderson (1978), approaches to zero when there is a complete specialization.

Explanatory Variables: On the basis of the recent theoretical framework, we derived some hypotheses regarding farm diversification, as technical constraints, organizational form, and other socioeconomic factors, which could be important variables in farm output diversification decision. These explanatory variables are identified based on a review of recent empirical studies and modern economic theory. As limited by our sample, the functional form of the relationship is:

$$D_{ik} = f(T_k,\ W_k,\ Z_k) \qquad\qquad i = 1, 2, 3 \quad \text{and} \quad k = 1, \ldots, N \qquad\qquad (2)$$

where D_{ik} is the *i*th diversification measure on the *k*th farm, T_k represents variables set of technical constraints, W_k is a vector representing farm organizational form (captured by a design variable for family farm, collective farm, and rental farm), Z_k represents variables set of socioeconomic factors.

Variables set of technical constraints includes: farm size as a continuous variable referring to the total landholding by the farmer measured in hectares; irrigated farmland as a continuous variable measured as the proportion of the effectively irrigated area regarding the total farm landholding; farm machinery as a dummy variable indicating if farmer own the machinery (combines or hard technological equipment) and takes the value of 1 if the farmer owns the machinery, 0 if he doesn't; off-farm income as a dummy variable indicating if the farmer has an income from non-agricultural activity, it takes the value of 1 if the farmer has earnings from an extra-agricultural activities, and 0 if he hasn't; livestock as a dummy variable taking the value of 1 if the farmer owns livestock assets, and 0 if he doesn't; and access to market information as a dummy variable taking the value of 1 if the farmer has access to market information, and 0 if he hasn't.

Variables set of main socioeconomic factors includes: farmer age as a continuous variable referring to the age of farm operator measured in years; household size as a continuous variable referring to the size of the farmer's household measured in number of his family members; educational level as a continuous variable referring to the formal schooling of farmer measured in years of schooling; marital status as a dummy variable taking the value of 1 if the farmer is married, and 0 otherwise; and farmer experience as a continuous variable referring to his farming experience in years.

Regarding the nature of the three measures of diversification, two appropriate regression

models were employed. We used the ordinary least squares for the first measure, D_1. Hence, for the two other measures, D_2 and D_3, Tobit regression was used to analyze the covariates of farm output diversification. The Tobit approach has been applied in previous studies of on-farm diversification (e.g. Pieniadz *et al*., 2009; Aihonsu *et al*., 2011; Mesfin *et al*., 2011; Agyeman *et al*., 2014). This model is appropriate since the dependent variable is an index that takes values between 0 and 1 inclusive, as a special case of censored regression models, and employ the maximum likelihood estimation technique which estimates the likelihood of farm diversification. The maximum likelihood estimation produces consistent estimates of the parameters of the Tobit model, under appropriate assumptions, such as homoscedasticity and normality of the error terms. According to Wooldridge (2002) and Greene (2003), the estimated coefficients identify the marginal effect of the explanatory variables on the farm output diversification decision.

4. Results and Discussions

The major findings of the study are in the following subsections. The first subsection deals with the main characteristics of sample agricultural producers, while the second describes the trends of farm output diversification in the study area. The final subsection discusses the key factors influencing the farmer's diversification decision.

Table 1. Summary Statistics of Main Characteristics of the Sample Agricultural Producers in Northern Algeria

Variables	Mean	S.D.
D1	3.2	2.42
D_2	0.29	0.27
D_3	0.42	0.25
Technical constraints		
Farm size	17.54	24.28
Irrigated farmland	17.94	22.30
Land use ratio	20.34	45.27
Farm machinery	0.47	0.49
Off-farm income	0.35	0.39
Livestock	0.50	0.51
Access to market information	0.35	0.47
Farm organizational form		
Family farm	0.63	0.48
Leasing	0.02	0.16
Collective farm	0.33	0.47
Socioeconomic characteristics		
Farmer age	51.36	13.30
Household size	8.7	4.15
Farmer educational level	7.10	10.34
Farmer marital status	0.90	0.28
Farmer experience	19.45	23.71

4.1. Descriptive Statistics on Sample of Agricultural Producers

The main characteristics of sample agricultural producers in the study area are presented in Table 1. The average of landholding in the study area is much more than the national average, which is 4.29 hectares. Similarly, it seems that the effectively irrigated farmland is slightly equivalent to the farm size (17.9 hectares). This situation supposes the existence of scale constraints facing the agricultural producers in the study area. About 47% of the sample agricultural producers owns hard specialized machinery. This indicates that a considerable proportion of agricultural producers (53%) use different contractual arrangements to get access to farm equipment.

Furthermore, about 35% of the agricultural producers are engaged in off-farm activities generating a non-farming income. This indicates that considerable proportion of agricultural producers have access to non-farm income sources. This situation is supposed to encourage the use of non-farm income as a hedge against the different production failure risks. Besides, we have the half of the sample agricultural producers in the study area owning livestock assets. Moreover, about 35% of the agricultural producers in the study area have a direct access to market information, which means that 65% haven't the access to different sources of information about prices, demand and supply for crops.

Regarding the farm's organizational form, results in Table 1 indicate that the family farm is the dominant form of farm organization in Northern Algeria (63%). The collective State-owned farm is the second dominant form with a proportion of 33%, and the rental farm is not well-developed form in Algerian agriculture (about 2%).

The socioeconomic profile of the sample agricultural producers in the study area is summarized as following. The average age of the agricultural producer in the study area is above 51 years. Around an average of 8 persons per household, the agricultural producer in the study area maintain a large household size, allowing the flexibility to pool resources and risk share by taking advantage of household return to scale and labor supply. The descriptive statistics indicate that the majority (90%) of the agricultural producers are married. About the educational level, the descriptive statistics show a low average of farmer's schooling years (about 7 years), i.e. primary school. This suggests lower investment in human capital among the agricultural producers in the study area. On the other hand, the average of farmer's experience in agricultural activities was found to be 19 years (with higher standard deviation, 23.7).

4.2. Trends of Farm Output Diversification

Table 2 shows the means of three diversification measures (Columns 2, 3, and 4) used in this study and the percentages of intercropping and crop rotation practices (Columns 5 and 6) in diversified farms, regarding the regional location (Columns 1) in the Northern Algeria. The ordering of the six provinces is from the West (Mascara) to the East (Biskra) of the country.

Obviously, we can observe regularities in terms of diversification indexes regarding the regional location of agricultural producers. The measures D_1 and D_3 show higher values in the East (Setif and Biskra) and the West (Mascara), where the central northern Algeria (Blida, Bouira, and Tizi Ouzou) show lower values. On the other hand, the measure D_2 shows higher values in the central North of the country.

The survey result indicated that the farm output diversification plays a significant role. The entire of the agricultural producers diversify their farm output for one major reason: minimizing risks due to the loss from other enterprises and from specialization. As shown in Table 1, the mean number of enterprises (D_1) held by an agricultural producer is 3 enterprises in his farm as one production unit. The Herfindahl index shows a mean of 0.29, and the en-

tropy index, a mean of 0.42. Thus, these results indicate that the agricultural producers in the study area adopt the diversification strategy for their farm output as the principal device for risk management.

Table 2. Patterns of Farm Diversification in the Study Area

Wilaya (Provinces)	D_1	D_2	D_3	Intercropping (%)	Rotation (%)	Specialization (%)
Mascara	3.94	0.12	0.54	52.44	19.24	28.32
Blida	3.12	0.22	0.49	61.38	11.19	27.43
Bouira	2.54	0.54	0.17	25.90	21.35	52.75
Tizi Ouzou	1.23	0.46	0.11	37.34	20.74	41.92
Setif	2.64	0.33	0.31	81.33	08.86	09.81
Biskra	4.65	0.08	0.65	79.26	17.91	02.83

The focal point here is that the agricultural producers in central areas, compared with two other regions, show a higher potential for gains from specialization, while they also opt for the diversification (by a mean of 2 enterprises at least, and higher values of the Herfindahl index in Bouira and Tizi Ouzou). Although in the two extreme regions (the west and the east of the country, with special focus on Biskra), the agricultural producers show higher degrees of diversification.

The intercropping and crop rotation percentages are derived from the diversified farms (86.05% of the total sample). The evidence suggested here is that the intercropping practice is the most dominant pattern of diversification in the study area. However, these differences may be attributed to variables that are not important for classifying the different districts, as having different farming systems or the differentiating factor might be simply the location of farms in the study area.

4.3. The Key Factors Influencing the Farm Output Diversification

The results of the regression that analyzed covariates of farm output diversification are summarized and presented in Table 3. Before the modeling procedures, the multicollinearity was checked using variance inflation factor for continuous variables and contingency coefficients for dummy variables. The calculated variance inflation factor values are all less than 10 (the cutoff point) and contingency coefficients were less than 0.75 (the cutoff point), which indicated that multicollinearity is not a serious problem. Since the Tobit model has a Probit component and its results are sensitive to the assumption of homoscedasticity, a robust standard error Tobit regression was run. The relatively high values of the fit measures and the high significance of the test statistics allude to a good model fit and the relevance of variables.

The farm size, as measured by the total landholding by the agricultural producers has, in spite of the insignificant probability levels of marginal effects, positive non-linear relationship to the farm output diversification measures. Therefore, this result indicates that the full employment of landholding encourages scale economies, and hence, higher risks. These results shed some light on the nature of the tradeoff between scale economies and risk reduction. Accordingly, agricultural producer with larger land size may be more intent upon engaging in the diversified farming, since he faces higher risk variance of production. This finding suggests that the policy can help improve the agricultural producers' lives, through promoting the diversification. The result is consistent with the findings by Pope and Prescott (1980), Abdulai and Crolerees (2000) in Southern Mali, Summer and Wolf (2000) in the US, McNamara and Weiss (2005) in Austria, Mackinnon *et al.* (2008) in Western Europe, Mesfin

et al. (2011) in Ethiopia, Aihonsu *et al*. (2011) in Nigeria, Meraner *et al.* (2015) in Netherlands.

Table 3. Regression Results on the Three Farm Diversification Measures

Explanatory variables	Dependent variables		
	D_1	D_2	D_3
Technical constraints			
Farm size	−0.004 (−1.400)	−0.001 (−1.278)	−0.0009 (−1.563)
(Farm size)^2	0.0003 (1.471)	−0.0009 (−1.424)	0.0007 (1.697)*
Irrigated farmland	0.003 (1.241)	−0.0006 (−0.588)	0.0002 (0.412)
Farm machinery	0.221 (2.914)***	−0.089 (−3.337)***	0.045 (2.994)***
Off-farm income	−0.066 (−0.773)	0.016 (0.551)	−0.013 (−0.788)
Livestock	1.898 (20.02)***	−0.656 (−18.98)***	0.432 (22.66)***
Information access	0.199 (2.276)**	0.051 (1.707)*	0.036 (2.047)***
Farm organizational form			
Family farm	2.340 (4.679)***	−0.187 (−1.142)	0.395 (2.933)***
Leasing	0.411 (4.202)***	0.103 (0.532)	−0.274 (−2.379)**
Collective farm	−2.138 (−3.201)***	0.085 (0.511)	−0.243 (−2.371)**
Socioeconomic characteristics			
Farmer age	−0.053 (−2.648)***	−0.013 (−2.062)**	−0.009 (−2.453)**
(Farmer age)^2	0.0005 (2.680)***	0.0001 (1.867)*	0.0009 (2.392)**
Household size	0.006 (0.748)	0.0008 (0.300)	0.001 (0.954)
Educational level	−0.053 (−1.797)*	−0.006 (−0.619)	−0.007 (−1.226)
Marital status	−0.263 (−2.081)**	−0.072 (−1.688)*	−0.051 (−2.013)**
Experience	−1.631 (−6.301)***	0.183 (5.537)***	−0.125 (−6.232)***
R^2	0.87	0.26	0.17
Log-likelihood	−245.59***	−164.81***	−206.69***

Note: The parameter estimates are significantly different from zero at the *** 99%, ** 95%, and * 90%.

Irrigation intensity was found to be positively affecting farm output diversification with no significant probability level. Agricultural producers who have access to irrigation technologies have opportunities to grow more crops. This is observed in the study area where agricultural producers having access to irrigation grow vegetables on their farms. The result of this study is in line with the explanation of Lonnie *et al*. (1989) who found a positive relationship between irrigation and enterprise diversification.

It is evident from the result that the agricultural producer who owns farm machinery (combines or hard technological equipment) are more likely to diversify because they can properly perform different farming operations on time and can market their production easily. The variable is significant at 1% probability level for each diversification measure. The result is consistent with the finding of Seng (2014) and Mesfin (2011). The coefficient of livestock ownership is positive for the three measures, and significant at 1% indicating a positive relationship between livestock ownership and farm output diversification. The explanation for the result is, livestock as measure of wealth and for complementarity issues, may act as insurance against crop production risks, bearing a positive relationship with farm output diversification. Thus, agricultural producers holding livestock assets are more likely to grow more crops. Access to market information significantly affects farm output diversification at 5% for D_1, 10% for D_2 and 10% for D_3. Agricultural producers having access to market information are more likely to diversify their production since they have the information related to supply, demand and prices of most crops.

The significance levels vary with the measure of diversification for the organizational form dummies. Further, the signs among the different measures are not consistent. However, the evidence suggests that family farms are more diversified than other farms.

The educational level was not associated with farm output diversification in our study. This suggests that wage rates are not influenced by the education measure we used, completion of general education. Similarly, marital status and household size also was not associated with farm output diversification in our study, since the signs among the different measures are not consistent.

Finally, the farm operator's age variable was significantly related to the diversification measures, and had a significant non-linear effect on the farm output diversification. The parameter estimates suggest a negative but diminishing impact of age on the farm output diversification. Besides, there is further evidence on the farmer experience. Table 3 indicates that younger or less experienced farmers are more specialized. One might speculate that younger farmers are less risk-averse. But, more plausibly, young farmers may start small and specialized and perhaps become more diversified as they expand their operation. This may be indicative of capital shortages for young farmers. Also, it may be difficult for less experienced farmers to manage diverse activities (Pope and Prescott, 1980).

5. Conclusion

Considering the importance of on-farm diversification as a risk management strategy and an instrument for ensuring food security, the present study was conceived to analysis the patterns and determinants of on-farm diversification at farm level in Algeria.

The study reports evidences on the diversification patterns adopted in the Northern Algeria, suggesting that intercropping strategy is the most dominant pattern. Besides, three measures were considered to measure on-farm diversification (enterprise number, Herfindahl index, entropy index). The models estimates indicate that, on the technical constraints: farm size, irrigation intensity, machinery ownership, livestock holding, and access to market information, and on the side of farm's socioeconomic aspects: farmer's age and his experience, are found to be the most important factors that significantly influence on-farm diversification. There is also evidence that family farms are more diversified than farms with other

organizational forms. These considerations indicate that economic analysis of diversification needs further research in order to outline more on the ability of farms to ensure and promote the income stability in Algerian settings.

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[1] We mention here that the concepts of "on-farm diversification" and "farm output diversification" are used as having the same meaning and definition.

[2] Statistical data on Algeria are provided from FAO website (2015) « www.faostat.org »

[3] The most of Algerian farmers have not the willingness to ensure their productions on the basis on ideological background. This is because the Islamic Doctrines prohibit all kinds of insurance. Since there is a many private and public insurance companies, farmers are requested legally only to ensure their hard equipment and against natural catastrophes. Others kinds of insurance (for example, against price fluctuations) are optional; consequently, farmers face alone all other risks.

[4] We should emphasize on the use of concept of "farmer" in our context. The concept of "farmer" refers, generally, to the individual exercise of agricultural activities. While in Algerian context, "farmer" is more an administrative status rather than an effective exercise. We can observe "farmers" with anything have to do with agricultural activities. For this reason, we use "agricultural producers" to exclude "the farmer as status". The sample is selected among farmers having effective agricultural activities.