Farm and Farmer Characteristics and Off-Farm Work: Evidence from Algeria

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Abstract

Off-farm work is a widespread, two-edged, phenomenon that can help both the survival, and the demise, of small and medium sized agricultural exploitations. Given the prevalence of poverty in rural areas, non-farm income has been credited with helping farmers to survive. But the observed shrinking of rural areas has also raised the question of whether off-farm work is pulling farmers permanently away from farming. This paper explores the impact of farmer characteristics on the decision to work off-farm in developing countries where this phenomenon has been largely neglected. A review of theory and prior empirical work suggests four main hypotheses which we test empirically. The results suggest that while some farmer characteristics appear to be universal, others appear to be country or culture specific.

Keywords: Off-farm work; rural areas; portfolio theory; theory of labour supply; developing countries.

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Abstract

Off-farm work is a widespread, two-edged, phenomenon that can help both the survival, and the demise, of small and medium sized agricultural exploitations. Given the prevalence of poverty in rural areas, non-farm income has been credited with helping farmers to survive. But the observed shrinking of rural areas has also raised the question of whether off-farm work is pulling farmers permanently away from farming. This paper explores the impact of farmer characteristics on the decision to work off-farm in developing countries where this phenomenon has been largely neglected. A review of theory and prior empirical work suggests four main hypotheses which we test empirically. The results suggest that while some farmer characteristics appear to be universal, others appear to be country or culture specific.

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1. Introduction

Off-farm work has been pervasive for centuries in rural areas, and has long been recognised as a global phenomenon (Cavazzani and Fuller 1982). Off-farm work is a well-studied phenomenon in industrialised countries. However, the ever-changing economic, social, and technological realities which have taken place over the last three decades are giving a new meaning to off-farm work. Following a major crisis in the 1980s (Lobao and Meyer 2001), US farmers experienced more than a 50% drop in real net farm income between 2013 and 2018 (USDA 2019a). The most recent statistics show that half of farm households were losing money on farming, and were relying on off-farm income to support their families (USDA 2019b). It is therefore not surprising that for more than thirty years the US has witnessed a continued exit of households from agriculture (Mishra *et al.* 2014). Similarly, social, economic, and environmental factors have resulted in a significant farming abandonment in Europe (Terres *et al.* 2015). Thus, it seems legitimate to ask whether off-farm work has played a role in the disappearance of farms or, whether it has actually helped farmers hold on to their rural livelihoods (Goetz and Debertin 2001).

Off-farm activity can be seen as a means of adapting farmers' resources (labour and capital) to a productive environment that is constantly changing (Fuller 1975). For example, Kousar and Abdulai (2016) find that off-farm work increases investment in soil-improvement. Thus, from this perspective, off-farm work strengthens the link between farmers and their land because it allows them to increase their income and reduce the risks associated with that income. Through off-farm work, the factors of production (labour and capital) are more effectively exploited. Unexploited agricultural resources, owing to seasonality in the agricultural production cycle, for example, may be employed in other sectors rather than remaining inactive. More importantly, off-farm work enables the survival and viability of farms, therefore helping to preserve rural areas and promote rural lifestyles. An economically viable farm can then be transferred to younger generations, thereby ensuring its long-term survival (Landais 1998).

However, off-farm work can also be seen as a means of keeping small, unproductive farms in business. From this perspective, off-farm work slows down the growth of large scale farms that may be far more efficient. Some also perceive the adoption of off-farm work by farmers as leading to the neglect of the countryside (McNally 2002), thereby lowering farm efficiency (Goodwin and Mishra 2004), or even to the abandonment of farming (Goetz and Debertin 2001).

In the developing world, off-farm work is viewed mainly as a means of survival. More often than not, farming does not secure a sufficient income. Seasonality, climatic and other natural risks have always governed both the level and risk of farm income. Thus, poverty remains prevalent in rural areas, with 78% of the poor living in such areas (World Bank 2014). A natural question would therefore be whether farm and farmer characteristics in less developed countries have a different impact on off-farm work when compared with those of developed nations.

The main purpose of this paper is to examine off-farm work in a developing country context. Off-farm work as a phenomenon has attracted a lot of attention in the developed world. The vast majority of empirical studies have focused on a handful of industrialised economies. In contrast, off-farm work in the developing world has largely been neglected by academics and policy makers alike. Our main contribution is to use farm-level survey data from a developing country, namely Algeria. Although developing countries are heterogeneous and might not be well represented by a single country, we contend that we can still learn from this data given that Algeria shares many developing countries characteristics. Indeed, Algerian farmers have faced similar problems to those encountered by farmers in other developing countries, including institutional and environmental constraints (Laoubi and Yamao 2012; Bryld 2003; Hudson 1987; FAO 2017; FAO 2019). Our paper can therefore usefully bring to light whether some divergence exists between developed and developing worlds' ruralities, using the Algerian farmer as a representative case.

A secondary purpose of this paper is to address potential mis-specification problems. There are both theoretical and empirical research that have attempted to explain why farmers work off-farm. However, to our knowledge, each of the existing studies has focused on a limited number of farm or farmer characteristics. The associated empirical models of these individual studies are therefore likely to be mis-specified, as potential explanatory factors are neglected. Our contribution is to fill this gap in the literature by considering more factors than previous individual studies. To this end, we use a sample of 270 farms selected from three major agricultural regions in Algeria. A detailed questionnaire was administered and provided various farm and farmer's characteristics. The dimensions of these characteristics were reduced using principal component analysis. Finally, we use two probability models to assess the impact of these characteristics on the probability of off-farm work.

The remainder of the paper is divided into 5 sections. Section 2 discusses the pervasiveness of off-farm work worldwide and offers some basic statistics on this practice in several developed and developing countries. In Section 3, we provide a detailed survey of the existing literature, discuss the relevance of the two main theories linked to off-farm work to developing countries, and propose four hypotheses to be tested empirically. Section 4 presents our sampling approach and empirical methodology. Section 5 presents and discusses the results. The final section concludes with a summary of the main findings.

2. Off-farm work across the globe

In this paper, off-farm work describes a situation whereby a farmer is not fully invested (in terms of labour power and/or capital) in farm activities (Mishra and Goodwin 1997). Off-farm work is sometimes called part-time agriculture, or pluriactivity (Boudy 2009).

Off-farm work is widely practiced throughout the world. Boudy (2009)'s survey of surveys shows that off-farm work occurrence is ubiquitous. However, contrary to expectations, off-farm work appears to be more prevalent in developed than developing countries. For example, off-farm work is practiced by far more farmers in Norway (74.6%), the United States (54.8%), and Switzerland (52.8%) than in Morocco (21.2%) and Syria (31.4%). Such a divergence could be explained by the high level of skill among farmers in developed countries compared to the poor human capital quality in the developing world.

In most countries, off-farm work appears to be motivated by necessity rather than choice. In the US, Pederson *et al.* (2000) found that farmers mitigate economic problems by engaging in non-agricultural activities to generate additional income. In Canada, farm income fell from 90% of total income in the 1940s to 52% in the 1980s (Bollman and Smith 1987). A survey in Wales (UK) revealed that 93% of rural households earn part of their income from off-farm work (Bateman and Ray 1994). In Greece, off-farm work serves as a solution to underemployment and supports low income farmers (Damianos *et al.* 1991). Financially struggling sugarcane growers in Central Queensland, Australia, rely on off-farm work for up to 49% of their income (Windle and Rolfe 2005). In China, off-farm work was estimated to be between 35% and 65% of total labour income in 2008 and has been increasing since then (Ma *et al.* 2018).

In Algeria the only known survey dates back to the 1970s. The survey showed that the majority of farmers combined agricultural and external activities and that between 64% and 84% of farmers with off-farm jobs eventually left agriculture (Chaulet 1987). More recently, Bouchakour and Bedrani (2015) pointed to the increasing pressure on Algerian farmers to leave their farms and take up lucrative employment or business in non-agricultural sectors.

3. Literature survey and hypotheses development

Our initial assumptions are based on the theoretical model of Matshe and Young (2004). In this model, the farmer maximises a utility function, and decides on the optimal time to allocate to off-farm work. This allocation depends on the wage rate in the labour market and the farmer's reservation wage (the marginal value of agricultural work). The reservation wage, in turn, is determined by other exogenous variables, including the prices of inputs and outputs, the characteristics of the operation, and the characteristics of agricultural households and individuals (Matshe and Young 2004).

Farmers are not immune to risk (Serra *et al.* 2005). One of the most recent models to consider the risk of agricultural income is that of Andersson *et al.* (2003). In this model, multiple jobs are the result of portfolio optimization, which takes into account agricultural and non-agricultural income as well as the risks associated with these incomes. An important prediction of this model is that farmers are willing to sacrifice some income in order to reduce income risk. For instance, farmers are willing to take on additional low income off-farm work provided that such income is less risky than farm income and/or weakly correlated with farm income.

A combination of the implications of these theoretical models and the results found in previous studies will form the basis upon which we propose our hypotheses.

3.1 Human capital

Theoretically, the effect of education on off-farm work is ambiguous (Huffman 1980). While a higher level of education leads to a higher off-farm salary, it also leads to increased farmer productivity. Therefore, the aggregate effect can go in either direction (Ahituv and Ḳimḥi 2002).

The majority of the literature reviewed in this paper found a positive net effect of education and human capital on off-farm work. The argument is that educated farmers are more skilled and thus better qualified to get off-farm jobs. Evidence from less developed countries is provided by the work of Matshe and Young (2004), Bojnec *et al.* (2003), Martinez Jr *et al.* (2014) and Abdulai and Delgado (1999). Evidence from the industrialised economies includes Alasia *et al.* (2009), Gould and Saupe (1989) and Goodwin and Mishra (1997). This positive effect has been confirmed by several other studies (Lim-Applegate *et al.* 2002; Mishra and Morehart 2001; Liu *et al.* 2013; Brosig *et al.* 2009; Benjamin and Ḳimḥi 2006; and Gunter and McNamara 1990).

Since the theoretical predictions are ambiguous, we will state our hypothesis based on the majority of empirical studies:

H1: Farmers with more human capital are more likely to work off-farm.

3.2 Age

Age represents the normal life cycle wage pattern (Gould and Saupe 1989) and is a proxy for the 'experience' component of human capital (Gunter and McNamara 1990). However, the literature has mainly found a non-linear (hump-shaped) effect of age on off-farm work (Sumner 1982; Huffman 1980; Lass and Gempesaw 1992). The same effect is found for both developed (Benjamin and Ḳimḥi 2006; Alasia *et al.* 2009; Gunter and McNamara 1990; Serra *et al.* 2005) and developing countries (Abdulai and Delgado 1999; Ḳimḥi and Rapaport 2004; Martinez Jr *et al.* 2014).

Nevertheless, a minority of studies failed to find the hump shape effect, with strictly negative (Bojnec *et al.* 2003), strictly positive (Tavernier *et al.* 1997; Matshe and Young 2004), and mixed effects (Gould and Saupe 1989).

Based on the above discussion we propose the following hypothesis:

H2: Other things being equal, age has a hump-shaped effect on the probability of off-farm work (positive for young farmers and negative for old farmers).

3.3 The household financial position

The financial situation of agricultural households is linked to the neoclassical model as well as portfolio theory. Less well-off farmers have a low reservation wage, and are thus more likely to accept work outside agriculture. Similarly, poorer farmers are more risk averse and must diversify their labour portfolio by increasing the share of off-farm work in their portfolio. However, Reardon *et al.* (1992) argue that household income can actually increase off-farm work, though they also report that the empirical evidence is ambiguous.

Most studies, however, find an unambiguous negative relation between household income and off-farm work in developed countries (Crabtree 1994; Tavernier *et al.* 1997; Serra *et al.* 2005; Lass and Gempesaw 1992). Finally, we found a single study on a developing country (Zimbabwe) with the same negative effect (Matshe and Young 2004).

Based on the empirical results mentioned above, we advance the following hypothesis:

H3: Households with more financial resources are less likely to work off-farm.

3.4 Household size

Research from the developing world shows that bigger households have a greater motivation to find ways to diversify their income (Zhao 2014; Brosig *et al.* 2009; Deininger and Olinto 2001; Matshe and Young 2004). However, some studies have also found either no significant impact of household size on off-farm work (Abdulai and Delgado 1999; Lass and Gempesaw 1992), or even a negative impact (Chang and Mishra 2008; Bojnec *et al.* 2003; Mishra and Goodwin 1997). The effect of household size is therefore not necessarily homogeneous, probably due to country specific moderating factors.

Similar to most developing countries, the rural population in Algeria is relatively poor. Thus, Algerian farmers are likely to feel pressure to reduce their reservation wages if their families are large. Moreover, a high number of dependents also means that the farmer is reluctant to put more weight on risky income, and will therefore tend to reduce this risk by taking off-farm work, which may be less volatile. In addition, all but one study reviewed on developing countries found a positive effect of family size on multiple jobs. We therefore put forward the following hypothesis:

H4: The larger the household the more likely it is that the farmer works off-farm.

3.5 Control variables

Farmers' characteristics are not the only drivers of off-farm decisions. External drivers, therefore, need to be partialled-out in order to obtain consistent estimates of the impact of farmer characteristics on off-farm work decisions. We use four control variables, and briefly describe the rationale for including these control variables next.

3.5.1 Geography

Empirical evidence shows that the importance of off-farm income varies by region and is highly sensitive to the structure of the local economy (Hearn *et al.* 1996). Liu *et al.* (2013) and Sofer (2001) show a negative correlation between proximity to towns and off-farm activities. However, Matshe and Young (2004) find no significant connection between proximity and off-farm work.

3.5.2 Farm income

According to the neoclassical model, farm income increases the reservation wage. Sofer (2001) concluded that one of the most important factors stimulating the rate of off-farm work is declining farm income. Overall, the vast majority of empirical studies reveal a negative relation between farm income and off-farm work (Gunter and McNamara 1990; Lass and Gempesaw 1992; Serra *et al.* 2005; Benjamin 1994; Woldehanna *et al.* 2000; Matshe and Young 2004).

3.5.3 Equipment

Previous studies are unanimous that investment in farm equipment has a positive impact on farm income. It lowers income risk and therefore lowers the need for off-farm work. Andersson *et al.* (2003) argue that if agricultural households cannot diversify their investments, the advantage of off-farm work in terms of risk reduction becomes very important. The model produced by Ahituv and Ḳimḥi (2002) predicts a similar effect. Therefore, better equipped farmers have greater ability to diversify their production, thus reducing their income risk. This is confirmed by Anseeuw and Laurent (2007) who claim that households that already possessed large facilities showed less need to work outside their farm environments.

3.5.4 Farm size

Similar to equipment, the size of the farm increases farm income and reduces farm income risk. Therefore, farm size is expected to reduce the likelihood of off-farm work. However, the empirical results are not unanimous. In areas with more generous climatic conditions, there is a clear inverse relationship between farm size and off-farm work (Serra *et al.* 2005; Alasia *et al.* 2009; Benjamin and Kimhi 2006; Deininger and Olinto 2001). However, for countries with less favourable conditions, studies could not find conclusive evidence (Abdulai and Delgado 1999; Kimhi and Rapaport 2004; Brosig *et al.* 2009). To circumvent the potential mediating effect of climatic conditions, we use both total arable area and total irrigated area as proxies for size in our study.

4. Sample and method

4.1 Sampling

Our sampling frame consists of the central part of Algeria. We chose three provinces: Blida, Medea, and Djelfa spanning the north, middle and upper south of the country. For each province we chose three municipalities (the largest plain, largest foothill, and largest mountain municipalities). Our sample size is dictated by our limited research resources. We therefore selected, randomly, 30 farms from each municipality, giving a total of 270 farms.

The first author approached the agriculture authorities within each of the three provinces to help draw a random list of farms and obtain the necessary authorisations and recommendations to enable us to approach individual farmers. Various university documents and credentials were required before help was provided by these authorities.

The drawing of the list of farmers was carried out by the Agriculture Service Office within each province. For bureaucratic reasons, we were not given access to the full list of farmers. Instead, the Agriculture Service Office drew the required number of farms randomly and put us in direct contact with the respective municipality delegates who, in turn, put us in direct contact with the requested number of farmers.

Although our sampling at the municipality level is random, our sample is based on a mixture of quota and purposeful sampling at the province and regional levels. Our choice of quotas of 30 farms per municipality and three municipalities per province was dictated both by our limited resources and by our aim to have a balanced mixture of proximity to the capital, Algiers, as well as a balanced mixture of the existing topographies.

Because of the potential for a low response rate, we requested from the authorities a random list of 60 farmers from each municipality, or a total of 540. The strategy was to replace non-responding farmers with alternative, randomly drawn, farmers until the target number of 30 from each municipality was reached.

Our choice of the central part of the country is based on three considerations. First, Algeria is the largest country in Africa and mostly arid or semi-arid. Apart from the extreme north of the country, farming is very sparse. However, farming in the northern part of the country is homogeneous. The central part of the country is therefore representative of the eastern and western parts. Second, obtaining high response rates via means other than personal contact is impossible. Even personal contact required long negotiations and recommendations by local authorities. Attempting to enlarge our sample proved impossible. Third, our hypotheses include topography as a characteristic that influences off-farm work. Therefore, we needed to select areas and regions that fit our research objectives by being able to collect a sample that includes the topography dimension. Most of other provinces in Algeria fail to have this geographic characteristic.

Overall, we believe that a mixture of purposeful and quota sampling fits our research objectives.

4.2 The questionnaire

A detailed questionnaire was administered to respondents in order to collect information on individual farmers as well as details on their households and farms. The design of the questionnaire was based on prior literature, with the main questions focusing on the farm and farmer's characteristics. We collected information on gender, marital status, age, experience as a farmer, education (6 levels), qualifications (4 levels), the number of boys, girls and persons who left the household, the number of rooms, total arable area, and total irrigated area. The dichotomous questions were as follows: (i) whether a farmer owns a car, truck, van, traction equipment, irrigation equipment, and/or livestock; (ii) whether a farmer's household enjoys adequate levels of consumption of goods and services; and (iii) whether the farm has satisfactory levels of farm income.

The pilot study was carried out using three farmers from Bouarfa municipality in Blida province. Three main lessons were drawn. First, farmers would not answer questions stated in terms of the number of hours or days worked on or off-farm, but welcomed categorical questions that could be answered with yes or no. Second, farmers refused to disclose their income or its distribution. Nevertheless, they did not object to disclosing the distribution proportion of their income. Lastly, a number of questions appeared to be ambiguous to respondents, and were re-worded in the final version of the questionnaire.

The questionnaire was administered by the first author and two research assistants who were trained to administer the questionnaire during the pilot stage. Data collection and the completion of the questionnaire were undertaken directly by the investigator and the research assistants. The personal contact undertaken by the investigating team had many benefits. First, the response rate was very high and only a handful of farmers refused to participate. This was due partly to official authorisations and recommendations granted by the authorities, but also as a result of the investigators attending in person and guaranteeing full anonymity. Second, thanks to local traditions and customs, the investigators were treated as guests. Farmers were therefore less reserved about answering our questions. Finally, the investigators were able to explain or rephrase certain questions when respondents did not appear to understand them.

4.3 Principal component analysis

In our questionnaire, we asked multiple questions to cover certain characteristics or factors. These common characteristics were then extracted using Principal Component Analysis. For example, we have four questions (items) in which we ask if the farmer has a truck, a pickup truck, traction equipment, and irrigation equipment. These four items represent a single factor that we call “equipment factor”. This factor can then be used as a predictor in a probability model. For more details see Carricano *et al.* (2010).

4.4 Probability models

As our dependent variable is categorical, probability models such as the probit and ordered probit are appropriate for estimating relations and making inferences. These models are amply described in the statistics literature (see, for example, Greene 2010; Carricano *et al.* 2010; Pétry 2003). In a probit model, the aim is to explain the probability that a farmer works off-farm using a set of explanatory variables. With the intensity of off-farm work we have three categories which are modelled adequately using an ordered probit model.

5. Results

5.1 Descriptive statistics

Table 1 provides some basic statistics for the continuous variables. The average age, which is relatively high at 53.81 years, indicates an apparent aging of the farming population. Many farmers exceed retirement age (the oldest is 90 years), but there are also very young farmers (the youngest at 18 years). Unfortunately, there are many more elderly farmers than young, as indicated by the standard deviation, which suggests that about 95% of the population of farmers is between 28 and 80 years ($53.81 \pm 2 \times 12.99$).

Households are generally large with an average of 6.71 members per household, but there are extreme sizes of up to 18 members. The average house size is around 4 rooms (but varies between 1 and 14 rooms).

There is a large variability in farm size. While the average farm has 15.72 hectares (ha) of arable land, the standard deviation is 23.69 ha, indicating the existence of relatively large farms in the sample. In contrast, the irrigated areas within these farms are much smaller, with an average of 5.26 ha.

Our sample is dominated by married farmers (92.6%) and males (98.5%). Illiteracy represents 28.9% of our sample, whereas 55.6% have primary or lower education, and 37.4% have middle or secondary education. Only 7% of farmers have a university education. More than 70% of farmers have no diploma and only 21.5% have some sort of degree (only 5.2% have an engineering degree).

Of the 270 farmers, 151 or 55.9% confirmed that they have off-farm jobs. The majority (59.6%) of these 151 farmers indicated that most of their income comes from outside the farm. The off-farm work destinations are dominated by three sectors: public service (public administration) (39.7%); trade (23.2%); and the liberal professions (14.6%). Finally, farmers with off-farm jobs tend to stay close to home, the majority (65.6%) working within their own municipality. Only 3% work outside their own province.

[Table 1 about here]

5.2 Principal component analysis

Before proceeding with the estimation of the probability models, we need to reduce the dimension of several variables. Although our sample is relatively large, we have a considerable number of potential explanatory variables. Many of these variables were found to be highly correlated and can therefore produce problems of multicollinearity. The method of principal components can therefore help reduce the number of variables to a manageable level.

Table 2 presents the results of a principal components analysis for five groups of variables representing the farmer's human capital, household size, the financial position of the household, farm equipment, and farm income.

For the farmer's human capital, we collected two pieces of information about the level of education and qualifications of the respondents. The estimates give two components (or factors), but only one component has an eigenvalue greater than 1. According to the Kaiser rule (see Carricano *et al.* 2010), factors whose eigenvalues are lower than 1 are not significant. The two variables (education and diploma) are adequately represented by a single factor accounting for over 77% of the variance of the two original variables. These two variables are highly correlated, so this explains their equal loadings. We extracted this factor as an explanatory variable.

For household size, we have three original variables: the number of boys, the number of girls, and the number of people who left the household. One factor, explaining 42.48% of the variance of three variables, is significant (eigenvalue = 1.275), the two other factors have eigenvalues less than 1.

The household financial position is measured by of four variables, namely the number of rooms, ownership of a car, coverage of food, and clothing needs. The magnitude of these variables reflects the well-being of a household. A factor explaining over 50% of the variation of the four measures is significant with an important eigenvalue of more than 2. By checking the factor loadings we find that the food and clothing needs are the most important contributors in defining the factor "financial position", the car and the number of rooms have smaller loadings but nevertheless significant.

The last two factors are extracted in the same way. The "equipment" factor reflects the availability of the means of production, whereas the "income" factor reflects the profitability of the farm.

The five factors were extracted by SPSS using the regression method. These variables are standardized with zero mean and unit variance.

[Table 2 about here]

5.3 Results of probability model of off-farm work

Table 3 presents the results of estimating a probit model that explains the probability that a farmer currently has an off-farm job. The dependent variable is a dummy which equals 1 if the respondent has off-farm work and zero otherwise, and the independent variables are a mixture of binary (dummy) and scale variables. The control variables include topography, farm income, equipment, and size. We include two topography dummies, mountain and foothill, which are contrasted with the plain dummy. Farm income and equipment are factors extracted in the previous section. Farm size is proxied by two variables, namely total arable area (TAA) and total irrigated area (TIA). We use TIA because irrigated land is less sensitive to climate volatility.

Our hypotheses are tested using five variables. Human capital, financial position, and household size are factors extracted from the principal component analysis in the previous section. We use age and age squared to capture possible non-linearity in the effect of age, as explained previously.

The estimation results of Table 3 show that nine out of the twelve variables are significant. The likelihood ratio statistic is 83.39 and has a p-value of less than 0.001. This indicates a strong fit against an intercept-only model. Figure 1 shows several diagnostic and goodness of fit plots. Panel A plots studentized residuals against predicted probabilities. Only a handful of observations fall outside the approximate ∓ 2 range, thus indicating the absence of severe outliers. Panel B shows Cook's distance, which measures the influence of individual cases.

Again, only a small number of observations seem to be above the 0.02 line. To assess the influence of these observations, we excluded cases that exceeded 0.015 (about 4/N) and re-run the probit model to check whether these observations have influenced the estimated coefficients. The coefficients were slightly different but neither the scale nor the signs changed. The only exception is the "Financial Position" coefficient, which more than doubled to -0.247 with a p-value of 0.04.

Panel C of Figure 1 presents a separation plot (Greenhill *et al.* 2011), which shows increasing probabilities (dark line) and predicted outcome (vertical bars). The plot shows a good level of predictability with only a few white areas above 0.5 probability. Indeed, the estimated model makes 196 out of 270 correct predictions, thereby producing 72.6% accuracy.

We now turn to the estimation results. For the control variables, the topography effect is significant and negative for both mountain and foothill farmers. Both types of farmers are less likely to have off-farm jobs compared with the plain farmers, probably because of the proximity of plain farmers to business and industrial centres. However, foothill farmers are less likely to work off-farm than mountain farmers. As expected, the low productivity of mountain farms seems to provide greater incentives to farmers to find off-farm work. Farm income is negatively but insignificantly related to the probability of off-farm work. This is possibly due to the high correlation between farm income and farm equipment. Farm income has a highly significant negative coefficient, suggesting that more and better equipment greatly reduces the probability of a farmer seeking off-farm work. Finally, TAA is insignificant while TIA is highly significant and has a negative coefficient, suggesting that increasing irrigated land reduces the probability of off-farm work.

The factor 'human capital' is highly influential. The coefficient associated with this factor is the largest in absolute value (compared with the other factors). The coefficient is positive (0.399) and highly significant (p-value = 0.001). It implies that improved skills of farmers significantly increase the probability of opting for off-farm work. Our first hypothesis that human capital increases the probability of off-farm work is therefore supported by the empirical model.

The Age hypothesis is also supported by the data. Both age and age squared are significant and of opposite sign. The coefficient of 'Age' is positive (0.098) and significant at the 5% level (p-value = 0.038). The quadratic term (Age^2) is negative, as expected, and highly significant (p-value = 0.015). The value of the coefficient appears very small (-0.001) but its effect remains significant nonetheless. Panel D of Figure 1 shows the effect of age on a farm operator between 18 and 80 years old. It is clear that the effect of age is positive for younger ages (between 18 and 50 years). However, from 50 years onwards this effect becomes negative. This leads us to say that the empirical evidence supports our hypothesis that age has a positive effect for young farmers, but negative for older farmers, on the probability of off-farm work.

Finally, the third and fourth hypotheses are not supported as the factors 'financial position' and 'household size' do not show significant coefficients.

[Table 3 about here]

[Figure 1 about here]

5.4 Robustness checks

The above results are based on the assumption that off-farm work is a binary choice, that is to say, the farmer may choose between working off-farm or be mono-active. In this section, we relax this constraint by assuming that there are two levels of off-farm intensity: moderate, and intensive. The dependent variable is defined at three levels, namely: mono active; moderate (off-farm income less than 50%); and intensive (off-farm income more than 50%).

This type of limited dependent variables is adequately modelled by the ordered probit model, which explains the probability of three levels of intensity of off-farm work (none, moderate, and intensive). The results are summarised in Table 4. The likelihood ratio test suggests a good fit and an overall significance of the variables included in the model (the ratio is 101.40 with a p-value < 0.001).

The two threshold coefficients, μ_1 and μ_2, are insignificant at any reasonable level of significance, suggesting that the three levels of off-farm work are driven mainly by the independent variables. The results are very similar to those of the simple probit, except for farm income, which, contrary to expectations, is now significant and positive. However, the conclusions on the hypotheses side are identical. We can therefore conclude that the same factors that influence the decision to work off-farm also determine the decision on the intensity of off-farm activities.

[Table 4 about here]

6. Discussion and conclusions

This paper aimed to empirically test a set of four hypotheses related to the impact of farmer's characteristics on off-farm work. The hypotheses are drawn both from theory (the neoclassical model and portfolio theory) and prior empirical work. Although the context is the Algerian farmer, we believe lessons can be drawn for many developing countries, especially those that share common features with Algeria.

Topography, equipment, and size inhibit off-farm work. This suggests that size, proximity, and productivity matter. First, plain farmers are more likely to work off-farm than foothill farmers, who in turn are more likely to work off-farm than mountain farmers. Although this appears to be puzzling, it could simply be the outcome of push and pull factors. In the plain, land is of generally good quality (weak push factors), and farmers being very close to industrial areas have a strong pull towards taking an off-farm job. In mountain areas, farming is more difficult (strong push factors) but transaction costs are higher (weak pull factors). On the other hand, in foothill areas, it is cheaper to access off-farm work (strong pull factor) but these farms are more productive than those in the mountains (weak push factors). The combination of these two factors reduces off-farm work in the foothills. Second, farm productivity is extremely important as a push factor. Farmers with more equipment are significantly less likely to take off-farm jobs. Third, irrigated land area has a similar negative effect on off-farm work.

We carried out formal testing of our hypotheses using probability models. The first hypothesis (the positive effect of human capital) is confirmed, which is in line with the majority of studies (Matshe and Young 2004; Bojnec *et al.* 2003; Martinez Jr *et al.* 2014; Alasia *et al.* 2009; Liu *et al.* 2013; Brosig *et al.* 2009). Indeed, this variable has the strongest impact of all of the factors. However, as discussed in the literature review, human capital can have both positive and negative effects, depending on what kind of skills the human capital entails. The strong positive effect of human capital can only be interpreted in the sense that the skill implied by human capital in Algeria is general rather than farm specific. General skill is more likely to be productive in, and attractive to, non-agricultural activities in the administrative, industrial, business, and commercial sectors. Thus, in the case of Algeria, education does not seem to promote farm productivity. It actually encourages farmers to supplement their income from outside the farm. Our results are therefore more in-line with the argument of Huffman (1980) that in the absence of increased productivity, higher levels of education lead to a higher incidence of off-farm work. If the education of farmers were directed towards developing agricultural skills, this would have increased both agricultural and non-agricultural income.

This is the case of the theoretical expectation of the ambiguous effect of education of Ahituv and Kimhi (2002). Our results clearly reject this view. Prior studies throughout the developing world are unanimous concerning the positive effect of education on off-farm work (Matshe and Young 2004; Bojnec *et al.* 2003; Martinez Jr *et al.* 2014; Abdulai and Delgado 1999). This points to the fact that education in these countries may be too general to be useful in farming, thus making the pull forces of the business and industry sectors too strong to resist. Surprisingly, this problem appears to be endemic in developed economies as well. For example, many studies have confirmed the positive effect of education on off-farm work in Canada and the USA (Alasia *et al.* 2009; Mishra and Morehart 2001; Liu *et al.* 2013; Brosig *et al.* 2009). This is contrary to expectations, because we would assume that education in developed economies would be more focused and would hence raise farmers' productivity (and in turn lower the need to work off-farm). Our empirical evidence points to the possibility that the education systems in both developed and developing economies are not designed to benefit agriculture (Reimers and Klasen 2013; Pretty 1995).

We found strong evidence to support the second hypothesis. Farmer age has a hump-shaped effect on off-farm work, peaking at the age of 50. Previous research has suggested a non-linear effect of age on off-farm work (Sumner 1982; Lass and Gempesaw II 1992). Our result is consistent with the results of Benjamin and Ḳimḥi (2006) for France, Alasia *et al.* (2009) for Canada, Gunter and McNamara (1990) for the USA, Abdulai and Delgado (1999) for Ghana, Corsi and Salvioni (2012) for Italy, and Martinez Jr *et al.* (2014) for Indonesia. This result is not surprising because the similarity in human biology leads to comparable life cycles in the physical ability and experience of farmers across both developed and developing worlds. Nevertheless, there are non-biological differences, including nutrition, healthcare, education, and social assistance. This is why it seems more likely for age to peak at an earlier stage in more developed economies. For example, Alasia *et al.* (2009) find a peak of 35 years for Canada, and Gunter and McNamara (1990) estimate the peak at 40 years for the USA.

The results for the household financial position are mixed in our study. Using the full sample, we find no significant effect. However, by removing a few influential observations, financial position produces a negative and significant impact on off-farm work. Previous studies across the world have found a negative effect of household income on off-farm work. For example, Edmond and Crabtree (1994) for Scotland, Deininger and Olinto (2001) for Colombia, Serra *et al.* (2005) for the US, and Matshe and Young (2004) for Zimbabwe, have all found a negative and significant effect. Our primary result is not consistent with these studies and can be explained by the inconsistent implications of portfolio theory as discussed in the hypothesis development section (Reardon *et al.* 1992). However, a better explanation would be our indirect measure of household income as our respondents would not agree to give income figures on their household members. Our principal component measuring household income therefore may be biased, leading to some influential cases obscuring the effect of the financial position of farm households. This is possibly why removing observations with large Cook's distances yields results that are more consistent with the prior literature. One general lesson to be taken from this research is that there is no good alternative to collecting level measures of household income, preferably detailed income from each household member.

The final hypothesis is clearly rejected. Household size has no effect on the choice of off-farm work or the intensity of off-farm work. This hypothesis predicts that household size is positively associated with the likelihood of off-farm work. Our research has found no effect of family size on off-farm work. Our rejection of this hypothesis is strong since the results are robust to the definitions of off-farm work (choice of off-farm work, intensity of off-farm work). Our findings (of no household size effect) are consistent with studies on Zimbabwe (Matshe and Young 2004), Ghana (Abdulai and Delgado 1999), and the USA (Lass and Gempesaw 1992). On the other hand, our results are inconsistent with studies on China (Zhao 2014; Brosig *et al.* 2009), Colombia (Deininger and Olinto 2001), the USA (Chang and Mishra 2008), and Slovenia (Bojnec *et al.* 2003). Clearly, all expectations (positive, negative, and no effect) can be found in the developing as well as developed world. Thus, there is no obvious north/south divide in terms of the impact of household size on off-farm work. We can only speculate that the effect of household size is probably moderated by country-specific and other cultural factors.

In this paper, we have demonstrated that off-farm work is a complex phenomenon involving several factors. Our findings suggest that several fundamentals are at work in determining farmers' choice for off-farm work. The impact of age appears to be universal, showing a hump-shaped pattern. The only difference across the developing/developed divide is probably the peak at which farmers start decreasing their off-farm work. Our estimate is around 50 years, whereas this figure is much lower in developed countries. There is also no apparent difference in the effect of household size. Negative, positive, and no effect have been found in both developing and developed countries. We could not find any study explaining why the correlation of household size with off-farm work is so irregular across countries. We therefore believe that this question is worthy of further investigation. Household income has been shown to have a negative effect on off-farm work in both developing and developed countries. Our results only partially align with existing work, and we suspect that our measure of household income is imprecise, leading to an insignificant statistical result. Finally, there is also no apparent north/south divide in terms of human capital. Our study supports the positive impact of human capital factor on off-farm work found both in the developing and developed economies. This implies that education and training institutions and policies in both developed and developing countries have failed to promote farm productivity. Education and training policies might therefore be universally applicable.

Although the general conclusion must be that of homogeneity in the impact of farmers' characteristics across developed and developing countries, we cannot claim that we provide a definitive answer. Data collection in the developing world is extremely difficult and the collected information, despite best efforts, is often inaccurate. Our study therefore needs to be complemented with additional studies using data from developing countries in order to better understand this important phenomenon.

One obvious limitation of our study is the small sample size. Although we argue for the validity of our purposeful sampling, we recognise the importance of a bigger sample. In addition to resource constraints, we faced serious difficulties in making respondents reveal whether or not they had a second job. Indeed, most of the interviewed farmers believed that having an off-farm job was illegal. It took a great deal of effort to convince them to disclose information relating to off-farm work. However, although limited, our sample is valuable and rich enough to convey relevant and reliable information on off-farm work. Another limitation is the consideration of farmers' off-farm work rather than farm household off-farm work. Indeed, as a referee pointed out, most farms worldwide are family-based. Therefore, future studies should consider the off-farm activities of both the farmer and the spouse as a farm can survive by the spouse working off-farm. Finally, because of the data difficulties encountered, we were unable to collect the level of farm and off-farm activities and/or income. Clearly, having level data offers a more nuanced analysis and future work should be focused on level farm data wherever possible.

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List of Tables.

Table 1. Descriptive statistics

	Minimum	Maximum	Sample Mean	Standard Deviation
Age	18	90	53.81	12.99
Persons living in household	1	18	6.71	2.63
House size (number of rooms)	1	14	4.03	1.98
Total Arable Area (hectares)	0	250	15.72	23.69
Irrigated Area (hectates)	0	95	5.26	9.49

Notes: N=270. A value of zero for farm size indicates and area of less than one hectare.

Table 2. Principal component analysis of the five factors

Component	Eigenvalue	% Variance	% Cumulative	Variables (Items)	Loading
Factor: Human Capital					
1	1.54	77.01	77.01	Education	0.87
2	0.46	22.98	100.00	Diploma	0.87
Factor: Household Size					
1	1.27	42.48	42.48	Number of boys	0.71
2	0.91	30.37	72.86	Number of girls	0.63
3	0.81	27.13	100.00	Number of persons who left the household	0.60
Factor: Financial Position					
1	2.09	52.41	52.41	Number of rooms	0.38
2	0.99	24.86	77.28	Own car	0.45
3	0.82	20.53	97.82	Adequate consumption	0.93
4	0.08	2.18	100.00	Adequate clothing	0.93
Factor: Equipment					
1	1.41	35.45	35.45	Own truck	0.52
2	0.98	24.66	60.12	Own van	0.65
3	0.90	22.56	82.68	Traction vehicle	0.62
4	0.69	17.31	100.00	Irrigation equipment	0.57
Factor: Farm Income					
1	1.59	79.96	79.96	Satisfactory production	0.89
2	0.40	20.03	100.00	Satisfactory earnings	0.89

Table 3. Simple probit model results

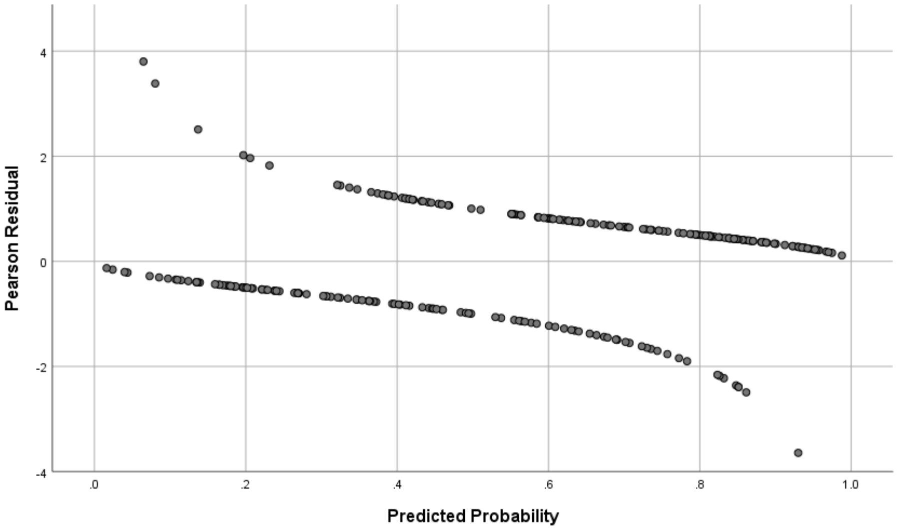
	Coefficient	St. Error	Wald Chi-Square	p-value
		Control		
Intercept	-1.087	1.2277	0.783	0.376
Topography : Mountain	-0.703	0.2212	10.094	0.001
Topography : Foothill	-1.003	0.2208	20.639	0.000
Farm Income	-0.055	0.0900	0.370	0.543
Equipment	-0.266	0.0988	7.232	0.007
Total Irrigated Area	-0.030	0.0119	6.480	0.011
Total Arable Area	0.006	0.0045	1.756	0.185
		Hypotheses		
H1: Human Capital	0.399	0.1165	11.744	0.001
H2: Age	0.098	0.0471	4.303	0.038
Age^2	-0.001	0.0005	5.928	0.015
H3: Financial Position	-0.110	0.0953	1.324	0.250
H4: Household Size	0.061	0.1067	0.325	0.569

Notes: The model is $P(Pluriactive) = \Phi(\alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \cdots + \alpha_k Z_k)$, where the αs are coefficients, the Zs are explanatory variables and $\Phi(.)$ is the cumulative normal distribution. The mountain and foothill areas are contrasted with the plain area.

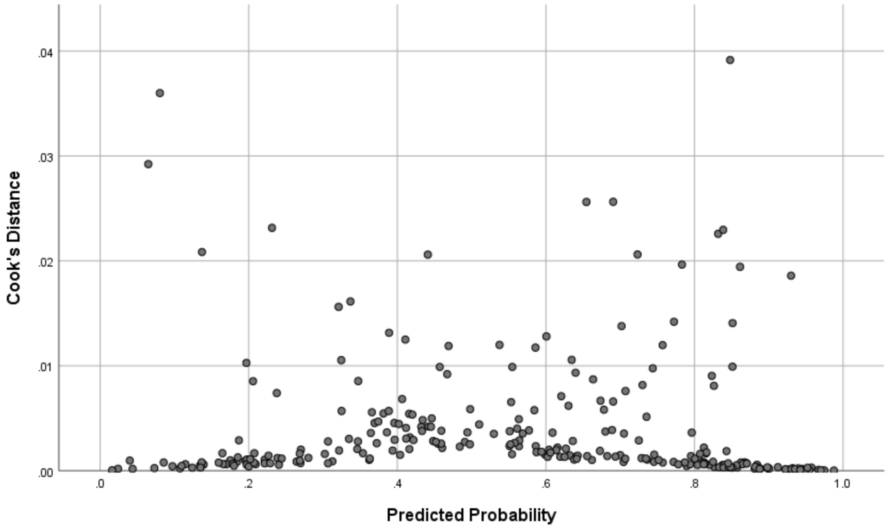
Table 4. Ordinal probit model results

	Coefficient	St. Error	Wald Chi-Square	p-value
		Control		
Threshold μ_1	0.627	1.1046	0.322	0.570
Threshold μ_2	1.389	1.1064	1.576	0.209
Topography : Mountain	-0.870	0.1954	19.819	0.000
Topography : Foothill	-1.117	0.1942	33.047	0.000
Farm Income	0.159	0.0785	4.121	0.042
Equipment	-0.255	0.0891	8.200	0.004
Total Irrigated Area	-0.036	0.0109	10.834	0.001
Total Arable Area	0.004	0.0033	1.398	0.237
		Hypotheses		
H1: Human Capital	0.308	0.0956	10.387	0.001
H2: Age	0.080	0.0424	3.544	0.060
Age^2	-0.001	0.0004	4.688	0.030
H3: Financial Position	-0.058	0.0814	0.513	0.474
H4: Household Size	0.021	0.0926	0.052	0.820

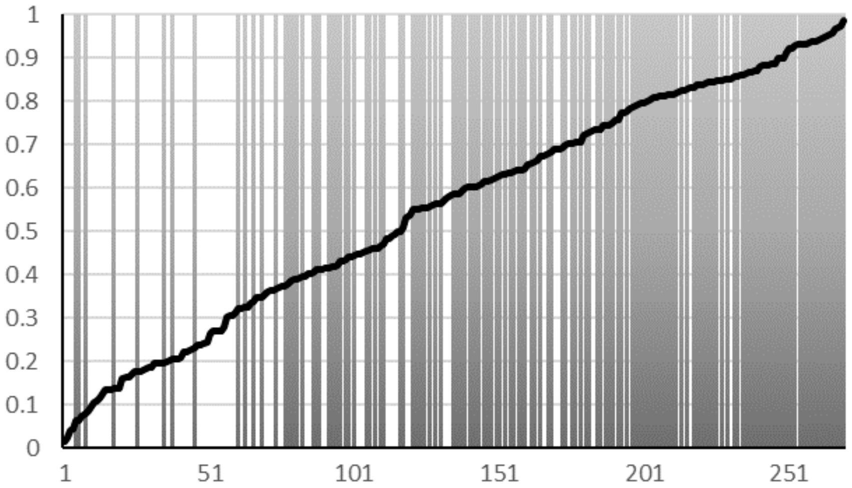
Notes: The mountain and foothill areas are contrasted with the plain area.



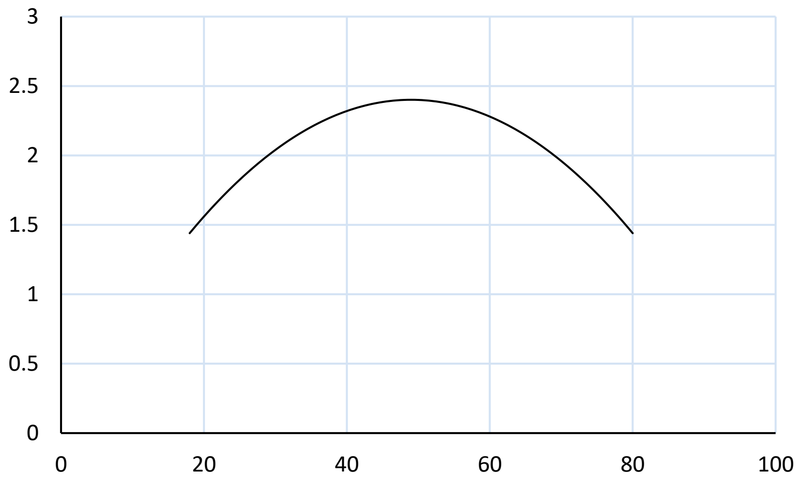
Panel A. Pearson Residuals



Panel B. Cook's Distance



Panel C. Separation Plot.



Panel D. The implied age effect ($0.098Age - 0.001Age^2$)

Figure 1 Diagnostics graphs for the probit model