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Submitted Article

Health and Women's Role in Agricultural Production Efficiency

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Abstract *The aim of this article is to examine the direct and indirect links between production efficiency and farmers' health. Using a sample of male farm leaders, the role of both genders' health in production efficiency is measured. More specifically, the effect of the farm household's health through the direct effect of the male farmer's health and the indirect effect of the woman's health on production efficiency is examined. An increase in the frequency of illness of the female in the family farm decreases production efficiency, suggesting distinct gender roles in the agricultural household.*

Key words: Production efficiency, male and female's health, DEA, gender roles.

JEL codes: I10, I15, I19, O13, O47, Q12.

This article analyzes the role that women play in farm and household decision making and productive efficiency. Recent studies have demonstrated the significant role of farmer's health on agricultural production efficiency, (Asenso-Okyere et al. 2011; Croppenstedt and Muller 2000; Egbetokum et al. 2012; Loureiro 2009) and most studies conclude that poor farmer's health negatively affects production efficiency (Fox et al. 2004; Olivier et al. 2004; Ulimwengu 2009 and Egbetokum et al. 2012). Farmer's health can often be determined by the misuse of chemicals and pesticides on the farm (Pingali and Agnes 1994) and by the lack of nutrients in their diet.

As shown by Fox et al. (2004), Olivier et al. (2004), Ulimwengu (2009), and Egbetokum et al. (2012), poor farmers' health reduces productivity and income caused by days lost due to illness. Furthermore, medical expenditures are negatively correlated with agricultural production efficiency (Egbetokum et al. 2012). Thus, even though farmers increase medical expenditures, agricultural production efficiency is reduced.

Farmers' health may also be affected by routine accidents that occur in the agricultural sector. Worldwide, millions of injuries occur in agriculture every year, with at least 170,000 of them being fatal (Loureiro 2009). Many of the non-fatal accidents result in long-term diseases, disorders, a reduction of physical mobility, and reduced working capacity (Loureiro 2009). Agricultural accidents in Greece occur twice as often as non-agricultural labor accidents. More than 38,000 agricultural accidents are recorded each year, while only 16,800 non-agricultural labor accidents occur; the vast majority (90%) of the injured are men (Chalea 2003).

Systematic epidemiological surveys have reached similar conclusions; that is, good farmer's health is of great importance for the respective economies of each country since the sustainability and viability of economic and social development in a country depends largely on the health sector (McNamara, Ulimwengu, and Leonard 2010; Ulimwengu 2009). In addition, investing in the health sector in rural areas will not only improve crop yield for farmers, it will also increase their income (ibid.).

The present article extends previous research on the relation of farmers' health and agricultural productivity by also considering the health of women, whose important role in agricultural production is illustrated through our findings.

Women's health in a family affects the other members of the household, as there is an interaction of family members through the structure, organization, and distribution of resources and power within households (Browner 1989). Begum and Yasmeen (2011) and Tibbo et al. (2009) explicitly considered the role of women and separated tasks between those performed exclusively by men and those performed exclusively by women. These authors concluded that women's importance in a household emphasizes their potential significance in organized efforts to promote change in health conditions, and also to achieve social change. Furthermore, women's contributions were surprisingly important in the majority of agricultural activities.

Due to incorrect bias caused by the fact that women in an agricultural family not only work but also act as family caretakers, it was considered imperative to determine the effect of women's health in agricultural production efficiency.

There is evidence proving the active role of women in the farm (Begum and Yasmeen 2011; Browner 1989; Ulimwengu et al. 2013; Tibbo et al. 2009). Of the European Union member states, in Greece and Portugal agriculture continues to be the main source of employment for women. Traditionally, a farm in Europe consists of a family where a couple works the farm, with the wife helping her husband with daily tasks (Fermont 2001).

We highlight the role that gender plays in an agricultural household's health and its relation to agricultural production efficiency, and propose solutions for improving women's health. By improving both men and women's health, households expect to increase the stock of available healthy time, which will increase the amount of time available for earning income or for producing consumption goods (Ulimwengu 2009).

Data and Methodology

This study is based on a random sample of 100 farmers in Larissa Prefecture, Greece, from 2012–2013. The data cover households for three villages in rural Larissa. Personal interviews were conducted and data were collected using an anonymous structured questionnaire.

Table 1 Analysis of the Factors (input-output) Used in Data Envelopment Analysis

	Variables	Metric	Definition of variables	Average	Std. Deviation
Inputs	Land	Acres	Total acres either owned or rented	199	146
	Variable costs	Euro	Seeds, fertilizers, pesticides, herbicides, mechanical clearance, mechanical sowing and irrigation	19.181	14.910
	Labor	Hours	Hours of work by family and foreign workers	1.436	1.310
Outputs	Gross output	Euro	Gross output with subsidies	47.044	37.066

Larissa Prefecture was selected because it is the largest county in Greece by cultivated area and the second-largest by land area. The top three cultivated crops by land area and production volume are wheat, cotton, and corn. These crops are also the main crops cultivated by the farmers surveyed.

This article employs Data Envelopment Analysis (DEA) to estimate the technical efficiency of all farms in the sample. The input variables employed are as follows: land (total acres either owned or rented), variable costs (seeds, fertilizers, pesticides, herbicides, mechanical clearance, mechanical sowing and irrigation in Euros), and labor (hours of work by family and foreign workers in hours). The output variable was gross output (in Euros; see table 1).

Based on the work of Farrell (1957), DEA is a non-parametric mathematical programming methodology that measures the efficiency of each decision making unit (DMU) relative to the frontier. This involves the use of linear programming to construct a total efficiency (piece-wise) frontier that provides a means by which all farms can be evaluated in terms of relative effectiveness (Charnes, Cooper, and Rhodes 1978).

Farrell suggested that the efficiency of a firm consists of two components: technical efficiency, which reflects the ability of an enterprise to achieve maximum output from a given set of inputs, and allocative efficiency, which reflects the ability of a business to use the inputs at their optimal proportions, given their respective prices. These two measures are combined to produce a measure of total technical efficiency (Coelli 1996).

Based on the constant returns to scale assumption (CRS) and using duality in linear programming, the mathematical programming problem takes the following form:

$$\begin{gathered} \mathrm{Min}_{\theta,\lambda}\theta, \\ \text{So that } -y_i + Y\lambda \geq 0, \\ \theta x_i - X\lambda \geq 0, \\ \lambda \geq 0 \end{gathered} \tag{1}$$

where θ reflects input-oriented technical efficiency, and λ is a N*1 vector of constants (Coelli 1996).

The variable returns to scale (VRS) model can be estimated by adding the convexity restriction N $1'\lambda=1$, which is expressed as follows:

$$\begin{aligned} &\mathrm{Min}_{\theta,\lambda}\theta, \\ &\text{So that} - y_i + Y\lambda \geq 0, \\ &\theta x_i - X\lambda \geq 0, \\ &N\ 1'\lambda = 1, \\ &\lambda \geq 0. \end{aligned} \tag{2}$$

The scale efficiency can be found from the relationship: $SE_i = TE^{CRS}/TE^{VRS}$, where $SE = 1$ indicates constant returns to scale and $SE_i < 1$ indicates scale inefficiency (Coelli 1996).

It is important to note the impact of the bootstrap in this paper. Bootstrapping is used when there is doubt that the usual distributional assumptions and asymptotic results are valid and accurate. Bootstrapping is a nonparametric, deterministic method that lets us compute estimated standard errors, confidence intervals, and hypothesis testing. In the case of DEA estimators with multiple inputs or outputs, the bootstrap currently offers the only sensible approach to inference and hypothesis testing (Simar and Wilson 2011).

The efficiency results produced by DEA may be influenced by the presence of outliers in the data. Outliers are a typical observation and the results of recording errors must be deleted from the sample (Wilson 1993). We attempted to deal with the standard errors by employing the Outlier Analysis method proposed by Simar and Wilson (2000). No outliers are indicated in the data; thus, no observations were deleted from the data. Since bootstrap results do not differ statistically from the normal DEA results, we proceed with our analysis using the DEA results without bootstrap.

We should note that there is a potential endogeneity due to correlation between variables such as medical expenses, education, experience, and size. Although endogeneity can be dealt with using parametric techniques, nonparametric methods like DEA, which is the most common technique for measuring technical efficiency, can be applied. The effects of endogeneity on efficiency estimates have received little attention in the literature. However, Orme and Smith (1996) have demonstrated using a Monte Carlo simulation that if there is efficient DMUs relative to inefficient DMUs along some parts of the frontier, endogeneity is likely to generate biased efficiency measures, especially with small sample sizes. More recently, Cordero et al. (2013), also using a Monte Carlo simulation, have shown that DEA is robust to negative and low positive endogeneity, but not to a high positive endogeneity level. Since an important part of our research focuses on DEA, we proceed with this caveat.

Multiple regression was used to evaluate the impact of the farmer's health in agricultural production efficiency and to identify the factors that affect their health. All the independent variables employed were based on the literature (Pingali and Agnes 1994; Battese, Malik, and Gill 1996; Croppenstedt and Muller 2000; Asadullah and Rahman 2009; Loureiro 2009; Ulimwengu 2009; Basanta et al. 2004; Egbetokum et al. 2012). Total technical efficiency was employed as the dependent variable and the independent

Table 2 Explanation of Variables Used in the Multiple Regression

Variables	Explanation of variable	Average	Std. Deviation
Edu	Education: Primary School (1), Secondary School (2), High School (3), University(4), other (5)	0.8632	0.43567
Exp	Farmer's experience expressed in years:2-24 years (1),25-48 years (2)	0.7380	0.52852
ME	Medical expenses for the whole family: 0-800 Euro (1), 801-1700 Euro (2)	0.0416	0.16544
F1	Male leader's frequency of illness in the last twelve months: Never (1), 1-2 Times (2), <6Times (3), <12 Times (4), >12 Times (5)	0.4870	0.40163
F2	Female frequency of illness in the last twelve months: Never (1), 1-2 Times (2), <6Times (3), <12 Times (4), >12 Times (5)	0.4634	0.46167
H	Work hours of the head of family part-time (1-4 hours / day), full-time (5-17 hour / day)	0.4921	0.31611
OG	Dummy variable for the existence of a grove on farm No(0), Yes (1)	0,0900	0,28762
S	Farm size: small farms ≤ 149acres, 150-300 medium farms, large farms >300	0.4826	0.46381
D	Risks of working during agricultural tasks: Strongly agree(1), Agree (2), Neither agree nor disagree (3), Disagree (4), Strongly disagree (5)	0.9308	0.55226

variables were as follow: farmer's education; farmer's experience expressed in years; medical expenses for the whole family (Euros); male leader's frequency of illness; and female frequency of illness in the last twelve months. In our data, "female" corresponds to the oldest female in the farm; this is either the wife or the mother of the male head of the farm. In addition, we used employed work hours of the head of family (part and full- time), farm size (small, medium, and large farms), a dummy variable for the existence (or not) of an olive grove on the farm, and finally and a dummy variable indicating whether farmers feel that the work on the farm is risky (table 2). We used the work hours of the head of farm to distinguish between full- and part-time farmers. Several researchers have found that the two groups have chosen different livelihood strategies (Kimhi 2000; Lien et al. 2006), with less time for farm work and less financial dependence on farming income for part-time farmers compared to full-time farmers. These factors may contribute to reduced productivity and technical efficiency (ibid.). Furthermore, the questionnaire included a question for whether or not farmers used technological improvements. Technological improvement refers to innovations in agriculture such as the use of precision agriculture and participation in agri-environmental schemes. However, this variable was not statistically significant in prior analysis and thus was not included in this analysis.

With olive-growing being a major farming activity in Greece (Tzouvelekas, Pantzios, and Fotopoulos 2001), the existence of an olive grove and farm was selected to be used as a dummy variable, since technical efficiency of farms with olive cultivation can be higher than farms without olive cultivation (Lambarraa, Serra, and Gil 2007). Also, variables concerning health were employed, which are detailed in table 2. We consider that the inclusion of farmers' health status is necessary to continue to improve the productivity and efficiency, as are experience, education, and size. The equation used in this analysis was

$$\ln CRS = \beta 0 + \beta 1 \ln Edu_{it} + \beta 2 \ln \exp_{it} + \beta 3 \ln ME_{it} + \beta 4 \ln F1_{it} + \beta 5 \ln F2_{it} + \beta 6 \ln H_{it} + \beta 7 \ln \mathrm{OG}_{it} + \beta 8 \ln \mathrm{S}_{it} + \beta 9 \ln \mathrm{D}_{it} + e. \quad (3)$$

Results

The survey finds that male farmers (53%) are 40–64 years old, while 41% are between 26–39 years old. These results are consistent with the national average, where 49.2% of Greek farmers were 40–64 years old and 30% of Greek farmers were 26–39 years old (Hellenic Statistical Authority, Elstat 2009). In our sample, the average age of the male head of the farm is 49 years old and has an average of 23 years of farm experience. Moreover, 100% of the farm heads are men in the survey, compared with 69.72% for the national average (Hellenic Statistical Authority, Elstat 2009). Thus, we focus on intra-household gender differences and not on the difference between male and female farm heads. It should be noted that the high percentage of male farm heads is typical of the region.

Regarding education levels, 14% of male farm heads have completed primary school, 68% have completed secondary school, and only 16% have completed tertiary education. The farmers in the survey are better educated than the national average, where 56.7% of the male farm heads have completed primary school education, 34.9% have completed secondary school, and 4.1% have completed tertiary education (Hellenic Statistical Authority, Elstat 2009). In addition, 70% of male farm heads are married.

The average farm size of the sample is 49.75 acres, which is larger than the national average of 11.04 acres (Hellenic Statistical Authority, Elstat 2009). This is due to the presence of extensive crop cultivation in the region compared to the national average. The average number of working hours per acre in the sample is approximately 6.4 hours/ acre. With respect to income levels, the average total income of rural households in the sample was calculated at 2,948.70 Euros, while the national farm income average in 2009 was estimated at 11,572 Euros. A large percentage of the farms use fertilizer (92%) and self-report that the quantity used has a significant effect on their health (80.4%).

For this kind of research the DEA methodology has been proposed. The overall technical efficiency of each farm was first estimated for the CRS model. Table 4 shows the number of agricultural farms and the average productivity efficiency for the three types of efficiency (total technical efficiency, pure technical efficiency, and scale efficiency). Farmers exhibit a wide range of production inefficiency varying between 33% and 69% in agricultural farms. The mean technical efficiency is estimated at 0.55 with a standard deviation of 0.17 (table 4), implying that the average farm could decrease production by 45% by optimizing technical efficiency, given the inputs and production technology.

The CRS assumption is appropriate only when farms operate on an optimal scale, which means that they face no problems regarding size

Table 3 Efficiency Results for Variable Returns to Scale

	Total Technical Efficiency		Pure Technical Efficiency		Scale Efficiency	
Scale Efficiency	**Number agricultural farms**	**Average of Efficiency**	**Number of agricultural farms**	**Average of Efficiency**	**Number of agricultural farms**	**Average of Efficiency**
0.10-0.39	15	0.33	12	0.35	2	0.30
0.40-0.59	51	0.55	28	0.49	3	0.50
0.60-0.99	29	0.69	48	0.72	81	0.89
1	5	1.00	12	1.00	14	1.00
Sum	100	**0.55**	100	**0.64**	100	**0.88**

Table 4 Collinearity Statistics (Tolerance, VIF)

	Collinearity Statistics	
Model	**Tolerance**	**VIF**
(Constant)		
Edu	0.693	1,443
Exp	0.734	1,363
ME	0.940	1,063
F1	0.785	1,273
F2	0.807	1,239
HD	0.783	1,278
OG	0.885	1,130
S	0.833	1,200
D	0.898	1,114

inefficiency. But this does not seem to reflect reality; therefore, pure technical efficiency was calculated with the variable returns to scale (VRS) model. The average pure technical efficiency is 0.64 (table 3). Thus, on average, the inefficient farms should reduce their inputs by 36% for the purpose of becoming more effective. This decrease can be achieved without scale adjustments.

The difference in the number of effective agricultural farms between the two embodiments (total and pure technical efficiency), suggests that a part of the overall inefficiency is due to scale inefficiency. Sometimes a farm may be technically efficient but the operating range may not be optimal. In this case, the agricultural farm can become efficient if the operating range is changed, without changing the level and proportion of inputs used. For this reason, scale efficiency was calculated by indicating the degree of deviation of a technically efficient utilization of the optimum size to the scale of production. Scale efficiency is the ratio of overall technical efficiency to pure technical efficiency.

From table 3, the average efficiency is 88%. This result suggests that farms can reduce their inputs by 12% with a given level of production, proceeding in right size adjustment, without changing the technology and the level of output.

Table 5 Results of Multiple Regression Efficiency

	Coefficients				Bootstrap			
	Unstandardized Coefficients				**Unstandardized Coefficients**			
	B	**Std.**			**Error**	**B**		
Model Std. Error			**T**	**Sig.**			**T**	**Sig**
(Constant)	−0.710	0.098	−7.240	0.000	−0.834	0.098	−8.490	0.000
Edu	0.178	0.067	2.653	0.009*	0.165	0.067	2.458	0.016*
Exp	−0.185	0.054	−3.448	0.001*	−0.122	0.054	−2.261	0.026*
F1	0.173	0.068	2.528	0.013*	0.170	0.068	2.477	0.015*
F2	−0.107	0.059	−1.823	0.072**	−0.152	0.059	−2.584	0.011**
S	−0.177	0.057	−3.073	0.003*	0.166	0.057	2.877	0.005*
ME	0.171	0.152	1.128	0.262***	0.233	0.152	1.535	0.128***
D	0.032	0.046	0.694	0.490***	0.005	0.047	0.108	0.915***
H	0.120	0.087	1.379	0.171***	0.098	0.087	1,124	0.264***
OG	0.139	0.090	1.545	0.126***	−0.073	0.090	−0.815	0.417***

Note: *Dependent variable = Final overall effectiveness. Asterisks * and ** indicate significance at the 0.05 and 0.10 levels, respectively, while *** indicates statistically insignificant variables.*

Before employing multiple regressions, it is important to highlight the possibility of multicollinearity. Examining the variance inflation factor (VIF) we see no evidence of multicollinearity in the sample (table 3).

A multiple regression was applied to estimate the determinant factors that affect farm efficiency. Overall technical efficiency is used as the dependent variable. Regression results indicate that education, experience, the farm's size and health factors, such as the male leader's frequency of illness (F1) are statistically significant at the 5% level of significance, and female frequency of illness (F2) is statistically significant at the 10% significant level. These results are summarized in table 5.

Based on table 5, the model takes the long-linear form.

$$\begin{aligned} \ln CRS = & -0.710 + 0.178\ \ln Edu_{it} - 0.185\ \ln \mathrm{Exp}_{it} + 0.173\ \ln F1_{it} \\ & - 0.107\ \ln F2_{it} - 0.177\ \ln S_{it} + 0.171\ \ln ME_{it} + 0.120\ \ln H_{it} \\ & + 0.139\ \ln OG_{it} + 0.032\ \ln D_{it} + e. \end{aligned} \tag{4}$$

We assume that the sampling distribution of the mean is normal. In addition, the observations within a given sample are normally distributed. The normal distribution indicates that, given random and independent samples of N observations each (taken from a normal distribution), the distribution of sample means is normal and unbiased (i.e., centered on the mean of the population), regardless of the size of N (Mordkoff 2011).

Education and male leader's frequency of illness are positively correlated with production efficiency at the 5% significance level, while the other three variables have a negative impact on production efficiency. The most educated person in the household is likely to play the lead role. Among socioeconomic characteristics, only the leader's education is found to be positive and statistically significant. An increase by one unit in education will increase technical efficiency by 17.8%. This result corroborates the findings of Asadullah and Rahman (2009) and Basanta, Nuthall, and Nartea (2004), who highlight the significant role of education in improving technical efficiency.

Moreover, the farmer's experience (independent variable) has an unexpected negative influence on production efficiency, which is contrary to our expectations. In the past, experienced farmers were positively related to higher technical efficiency and this result is consistent with the findings of Battese, Malik, and Gill (1996) but not with the results of Asadullah and Rahman (2009). Older farmers have more experience, but on the other hand their lack of physical strength for dealing with the tasks on the farm may lead to this reduced effectiveness.

Based on the results presented in table 5, the health condition support plays a statistically significant role in explaining the variance of inefficiency in the agricultural sector. More specifically, the parameter estimation for the male leader's frequency of illness is positively significant with production efficiency of the farm. Thus, farmers who said that they become ill more often had presented the most efficient farms, which is contrary to what we expected. This finding may be explained by examining the correlation between the male leader's frequency of illness and work hours of foreign labor. The Pearson factor analysis finds the positive correlation between these two variables, with a value $r = 0.394$. This correlation suggests that farmers are capable of enjoying greater efficiency with the influx of foreign labor.

On the other hand, the results reveal negative correlations between female frequency of illness and agricultural production efficiency. This can be due to the fact that women play a key role in decision making and have a very active role within both the agricultural household and the farm, and thus indirectly influence the production process. Agricultural farms with healthy females enjoy significantly higher efficiency. The contribution of female labor input significantly improves production efficiency. The estimation indicates that a 1% increase of female frequency of illness decreases efficiency by 10.7%. This means that it would be better for women to take business initiatives that will highlight their role in upgrading the agricultural farm, thereby affecting production efficiency. Our findings are consistent with previous work, for example, by Ulimwengu and Badiane (2013) and Tibbo et al. (2009), who specifically highlighted that females are active laborers performing activities that improve agriculture productivity as well as technical efficiency.

Many surveys differentiate between specific tasks performed by men and women in the agricultural sector (Prakash 2003; Tibbo et al. 2009; Begum and Yasmeen 2011). Females in a household are mainly involved with decision making, while they also undertake tasks and participate in activities that improve the farm's economic development. While women are principally occupied in the household, men keep busy on the farms, for example, in heavy and mechanized farming operations. Due to this differentiation of the roles of men and women, we propose that women and men have different efficiency in the farm. In addition, there are differences as it concerns the impact of health on efficiency by gender. This is apparent based on the results since men's work can be replaced by foreign labor, while women's work cannot be readily replaced because of the multiplicity of their roles in the household. Therefore, different health statuses of males and females will have different results in farm efficiency.

It should be noted that the terms "direct" and "indirect" are used due to the different tasks performed in households by men and women. The tasks of the farmer (male) have to do with physical labor such as land preparation and this connects directly with production. In contrast, women work principally in or near the household and are also involved with decision making. These activities have indirect effects on the production and their impacts are mostly shown in the future.

Finally, farm size contributes significantly by improving technical efficiency. Notice an inverse relation between farm size and production efficiency. This means that a 1% increase in farm size will decrease production efficiency by 17.7%. In conclusion, Greek farmers could have more benefits by decreasing their farm size, so, they are scale inefficient.

It should be noted that women's work is very important for the survival and development of the agricultural farm, but in no way can it replace the male head's work on the farm, which is equally important.

Conclusions

The aim of this article was to analyze the role of health in agricultural production efficiency, explicitly taking into account the role of gender. A counterintuitive result arises regarding the effect of health on agricultural production efficiency. The male leader's frequency of illness positively affects production efficiency, which occurs because it is substituted by higher-efficiency foreign labor. On the contrary, for the female the frequency of illness negatively affects production efficiency. We posit that because foreign labor is hired short-term when the male farmer is ill, and is hired to complete specific tasks, their production efficiency is higher. However, it should be noted that our data do not allow this hypothesis to be directly tested.

An innovative aspect of our research is the explicit focus we place on the impact of women's health on production efficiency. Results suggest that women, through their capacity, knowledge and skills, get involved in decision-making and the economic development of the farm. Women's role on the farm seems not to be easily substituted by either male labor or foreign labor. Further, women's work cannot be readily replaced by foreign labor because of their multiple roles in the family and the farm and their active involvement in the rural environment.

Regarding farm size, farmers in Larissa Prefecture should not seek to increase the size of their agricultural farms, but to reduce their inputs to be more effective. In conclusion, smaller farms enjoy higher land productivity.

Finally, policies must be designed to point out the multiple activities that women perform and motivate them to participate not only exclusively on the field but in activities related to the primary sector (e.g., agrotourism) to increase the income of an agricultural household. Investing in the health system will increase the time available for both men and women to devote on the farm, also increasing their income and producing higher-quality products.

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