# Are there any differences in efficiency between Czech agricultural holdings managed by male or female farmers?

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**Annotation**: There are differences in the management style of both genders which might lead to different performance of the companies. Therefore, the aim of the paper is to examine the efficiency of holdings controlled by females in comparison with males with focus on agricultural firms. On one hand, the farms managed by females can be less efficient as women may be using traditional technologies either due to lack of knowledge, lack of access to modern inputs associated with new technologies or higher costs to adopt the new technologies. Also discrimination against women in the allocation of credit might weaken their bargaining position. On the other hand, this is truer for developing countries than for developed ones. The most estimates of male-female differences in technical efficiency from production function studies show that male and female farmers are equally efficient farm managers, controlling for levels of inputs and human capital.

In this article we apply Stochastic Frontier Analysis on the Czech farms' accounting data from Albertina database and business register. An unbalanced panel contains information about 117 agricultural holdings for years 2007 to 2012. Altogether there are 526 observations. Traditional inputs (material, services and capital – adjusted for price changes, labour, and land – adjusted for soil quality) are used as explanatory variables in production function in Cobb-Douglas form. A "true" fixed effect model with truncated normal distribution of inefficiency term is estimated. The results are statistically tested and discussed in the context of previous researches. On average, the agricultural holdings are efficient from 57.29 %, which shows that there is a space for improvement. The sample is then divided on males and females and the differences in technical efficiency of their farms are tested. We may conclude that there are no statistically significant differences between efficiency of agricultural holdings managed by males and females.

**Key words:** farms, gender, technical efficiency, Stochastic Frontier Analysis

**JEL classification:** J16, C10

## 1 Introduction

Czech society has experienced a boom in the number of university-educated females in the last 10 to 15 years (Šimpach, 2015). Consequently the business reflects those changes and the positions in the management (or even top management) are now more often taken by females. "The democratization of Central and Eastern Europe brought with it a new economic force – the female entrepreneur – and has enable her to start, own, and manage a significant number of small business" (Lituchy and Reavley, 2004).

The Velvet revolution in Czechoslovakia brought the changes to many sectors and especially to agriculture where the possibility of having private business emerged (Machonin, 1994). "After 1989 and the onset of privatisation, small farms began re-emerging in large numbers

(though many big farms still exist) and the average area of a farm's land decreased again" (Grešlová Kušková, 2013). Also the technical efficiency of farms developed.

The efficiency of agricultural holdings has been examined since Farrel came with the concept in 1950s. First approaches towards the technical efficiency calculations were non-parametric. The parametric approach – stochastic frontier analysis – originated with work of Messen and van den Broeck (1977) and Aigner et al. (1977). They were the first who divided the error term into two parts – noise $v_i$ and inefficiency $u_i$. This later enabled to derive the firm specific inefficiency $u_i$ from the composed error term $\varepsilon_i = v_i - u_i$. Based on this finding it is possible to assess the technical efficiency of particular farms and compare it. The technical efficiency can differ among farms according to their size (see Čechura, 2014), allocation in the less favoured areas, type of land management (see e.g. Malá, 2011 or Kroupová, 2010), age of the farmer etc. Also the gender differences are examined, although mostly in developing countries. "Female farmers, for example, may be using traditional technologies either due to lack of knowledge, lack of access to modern inputs associated with new technologies, or higher costs to adopting the new technologies" (Quisumbing, 1996). Similarly the discrimination against women in the allocation of credit might weaken the bargaining position of women (and thus lower their welfare), but any credit that reaches any member of a household will be allocated efficiently across the productive activities of all of the members of the household (Udry et al., 1995). "The asymmetric distribution of rights, resources, and responsibilities by gender may have more serious implications for allocative efficiency than sex differences do for technical efficiency" (Quisumbing, 1996).

Therefore, the aim of the paper is to assess whether the technical efficiency of the farms depends on the gender of the main manager. First, the used methods and data are described, than the technical efficiency of the farms is estimated and they are divided according to the gender of the main managers. Second, it is statistically tested whether they are differences in technical efficiency and the results are discussed. Last section concludes.

## 2 Methodology and Data

A parametric Stochastic Frontier Analysis is applied on the Czech farms' accounting data. Those were gathered from Albertina database of the Bisnode ltd. company and from business register. An unbalanced panel contained information about 117 agricultural holdings for years 2007 to 2012. Altogether there are 526 observations, ranging from 2 to 6 for each farm with 4.5 on average. To each company, the gender of the main manager was assigned. As there were only legal companies in a sample, we consider the farm to be managed by female, when she was a chairmen of the board in joint-stock company or executive director in limited liability company. There were 18 farms (82 observations) for female managed farms.

The technical efficiency of farms is derived from the production function in Cobb-Douglas form which was formulated as follows (1).

$$y_{it} = \beta_0 \, x_{1,it}^{\beta_1} \, x_{2,it}^{\beta_2} \, .... \, x_{m,it}^{\beta_m}, \qquad (1)$$

where $\beta_0$ represents the constant, $\beta_j$ ($j$ = 1, 2, ..., $m$) are parameters of the variables $x_j$ ($j$ marks the number of included explanatory variables). The function (1) can be linearized by natural logarithms as (2):

$$\ln(y_{it}) = \ln(\beta_0) + \beta_1 \ln(x_{1,it}) + \beta_2 \ln(x_{2,it}) + ... \beta_m \ln(x_{m,it}), \qquad (2)$$

The volume of production ($y_{it}$, where $i$ marks the particular farm in time $t$) was explained by the amount of consumed production factors: $x_{1,it}$ – material and services, $x_{2,it}$ – capital (long term assets), $x_{3,it}$ – number of employees calculated as the personal costs divided by the average salary in agriculture in particular region and year and $x_{4,it}$ – land calculated as the division of SAPS subsidies by the SAPS rate.

A "true" fixed effect model for panel data as elaborated by Greene (2002) was estimated. The composed error term is divided on inefficiency term ($u_i$) and stochastic term ($v_i$). We supposed truncated normal distribution of inefficiency term $u_i \sim N^{+}(\mu;\sigma^2)$. Nor the heterogeneity, nor the heteroscedasticity among farms were explained. The function of the mean of inefficiency ($\mu_u$) contained only constant as same as the function of the variance of inefficiency ($\sigma^2_u$). The stochastic term had normal distribution $v_i \sim N\ (\mu;\sigma^2)$ and its variance ($\sigma^2_v$) was explained again only by a constant.

The efficiency was estimated as suggested by Jondrow et al., (1982). They estimated (technical or cost) efficiency as (3)

$$\exp\left[-E(u|e)\right]. \qquad (3)$$

Null value of $u_{it}$ implies that the farm is efficient from 100%. If the $|u_{it}| > 0$, the farm is producing under its possibilities. There is a production gap which provides the space for improvement.

Consequently it was found by Shapiro Wilk test that the technical efficiency of the farms is not normally distributed. Therefore, non-parametric version of t-test for the differences between two means was used. Particularly the null hypothesis ($H_0$: Farms managed by males and females are equally efficient) was tested by Wilcoxon rank-sum test. If the hypothesis is rejected, we are able to conclude that the technical efficiency of farms depends on whether the main farmer is female or male.

## 3 Results and Discussion

First, the technical efficiency was assessed. According to Wald $\chi^{2[4]} = 9.13e^7$ with p-value 0.00 the model as a whole was statistically significant. Log likelihood was -504.17. All frontier coefficients were statistically significant from 0 at level of significance $\alpha = 0.01$. They had expected signs according to the economic theory – the production is increasing with higher amount of production factors employed. When the consumed material and services or capital increases by 1% the production increases by 0.08%. The highest elasticity is the case of labour, when its 1% increase causes 0.20% increase of production. Increase of land by 1% indicates an increase in production by 0.10%. The heterogeneity and heteroscedasticity were explained only by constants which were in both cases statistically significant. Coefficient lambda is also statistically significant. It provides an indication of the relative contribution of inefficiency and random error term to the whole error component ($v_i$ - $u_i$). The divergence from the frontier is in our case to a great extent explained by heterogeneous inefficiency. The sum of frontier coefficients is lower than 1 which means that farms achieve decreasing returns to scale.

**Table 1.** TFE model estimation results

| **Frontier** | | **Mean of inefficiency** ($\mu_u$) | |
|---|---|---|---|
| Variable | Coefficient | $\delta_0$ [const.] | -51.4676** |
| $\beta_1$ [ln($x_1$)] | 0.0774*** | **Variance of inefficiency** ($\sigma^2_u$) | |
| $\beta_2$ [ln($x_2$)] | 0.0780*** | $\omega_0$ [const.] | 3.9338*** |
| $\beta_3$ [ln($x_3$)] | 0.1985*** | **Variance of stochastic term** ($\sigma^2_v$) | |
| $\beta_4$ [ln($x_4$)] | 0.0972*** | $\gamma_0$ [const.] | -29.3994 |
| $e^{(\sigma^2 u/2)}$ | 7.14860*** | | |
| $e^{(\sigma^2 v/2)}$ | $4.13e^{-7}$ | | |
| $\lambda$ | $1.73e^{7***}$ | | |

Note: asterisks mark the significance level: * statistically significant at $\alpha$ = 0.10, ** $\alpha$ = 0.05, *** $\alpha$ = 0.01

**Source: own elaboration (2015)**

On average, the agricultural holdings were efficient from 57.29%, which implies that there is a space for improvement. Half of farms were less or more efficient than 58.08% which shows that there were quite a lot of them highly efficient (75% of them even from more than 95.48%. The majority of farms was managed by male leaders. There were only 82 observations (16% of all) for women (18 farms – 15% from all). The characteristics of farms managed by males and females are described in Table 2.

**Table 2.** Characteristics of farms managed by males and females

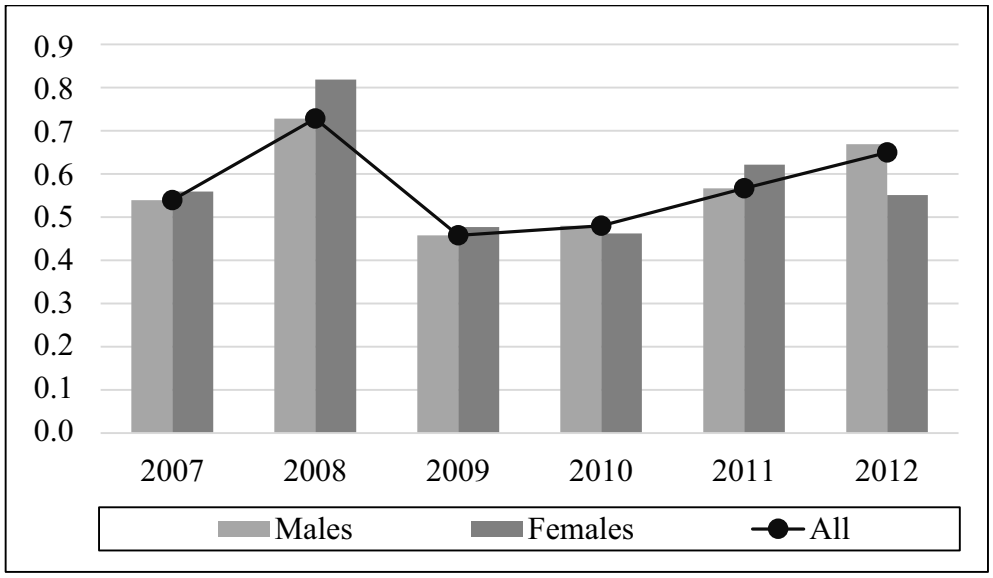
| All | 526 | | Male | 444 | Female | 82 |
|---|---|---|---|---|---|---|
| **Variable** | **Mean** | **Std. dev.** | **Mean** | **Std. dev.** | **Mean** | **Std. dev.** |
| Production | 994 191 | 2 701 502 | 864 015 | 2 563 502 | 1 699 050 | 3 281 169 |
| Mater., serv. | 1 836 332 | 3 346 575 | 1 773 725 | 3 259 334 | 2 175 327 | 3 788 389 |
| Capital | 10 000 000 | 12 300 000 | 9 479 948 | 9 800 102 | 12 900 000 | 21 100 000 |
| Employees | 83 | 93 | 79 | 70 | 104 | 171 |
| Soil quality | 2 618 | 5 506 | 2 505 | 4 541 | 3 231 | 9 125 |
| Efficiency | 0.5729 | 0.3428 | 0.5702 | 0.3469 | 0.5873 | 0.3209 |

**Source: own elaboration (2015)**

It can be seen that average farm managed by female uses 1.3 times more resources (material, services, capital, employees and soil) than agricultural holdings managed by male. As a result, they produce twice as more as farms managed by males. Contrary to that, the average efficiency is almost equal. Females' farms were efficient from 58.73%, but males' from 57.02%. The distribution of efficiency was tested whether it is normal. However, it was found that it does not follow the normal distribution. Therefore, a non-parametric Wilcoxon rank-sum test was used to test the differences between technical efficiency of males and females managed farms. The results ($z$ = -0.463 with p-value = 0.643) did not enable to reject null hypothesis which implies that there are no statistically significant differences in technical efficiency of farms managed by males and females in the period of 2007 to 2012.

We also looked on the development of technical efficiency over years. As it can be observed from Figure 1 it was almost equal in years 2007, 2009 and 2010, but differs in year 2008 and 2012. Interestingly in the crisis year 2008, the farms where the females were leading are more efficient.

**Fig. 1.** Average technical efficiency of farms managed by males and females.




**Source: own elaboration (2015)**

However, when we tested the statistical significance of the results, we found that there were none. As presented in Table 3, the p-values for test criteria of Wilcoxon rank-sum tests are always higher than level of significance $\alpha$ = 0.05. The null hypotheses of equality of the technical efficiency were not rejected in any year. This shows the consistency of the results throughout the examined period.

**Table 3.** Wilcoxon rank-sum test for the differences in technical efficiency between farms managed by males and females

| Year | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| Technical efficiency - males | 0.539 | 0.728 | 0.457 | 0.480 | 0.566 | 0.669 |
| Technical efficiency - females | 0.559 | 0.819 | 0.477 | 0.462 | 0.621 | 0.551 |
| Test criterion | -0.181 | -0.278 | -0.515 | 0.173 | -0.433 | 0.844 |
| P-value | 0.857 | 0.201 | 0.606 | 0.863 | 0.665 | 0.399 |

**Source: own elaboration (2015)**

Our conclusions are consistent with other researches of foreign authors. According to the results of Alene et al. (2008) women are as technically and allocative efficient as men in Western Kenya. Similarly Quisumbing (1996) states that "most estimates of male-female differences in technical efficiency from production function studies show that male and female farmers are equally efficient farm managers, controlling for levels of inputs and human capital." The situation in Northern Ghana is similar in terms that the "enterprises with male spousal influence were less efficient than their counterparts that were independently managed by the women" (Akpalu et al., 2012).

However, other characteristics should be examined further. The situation in Northern Ghana is different according to whether the woman operates only one or more businesses. According to the findings of Akpalu et al. (2012) "enterprises owned by women who managed more than one business operated at relatively lower efficiency levels". Whereas Kazianga and Wahhaj (2013) using a survey of agricultural households in Burkina Faso show how important is the position of the head of family in the results of land management of a family farm. They concluded that "plots owned by the head of the household are farmed more intensively

and achieve higher yields than plots with similar characteristics owned by other household members. Male and female family members who do not head the household achieve similar yields" (Kazianga and Wahhaj, 2013). Therefore, the challenge for the future research is to examine the further other factors which may influence the differences between farms managed by males and females than the technical efficiency.

## 4 Conclusion

The aim of the paper was to assess the technical efficiency of agricultural holdings in the Czech Republic in years 2007 to 2012 and to find out whether it differs between farms managed by males and females. A Stochastic Frontier Analysis was employed. A "True Fixed Effects model" with Cobb-Douglas production function was estimated using maximum likelihood method.

In accordance with the results of many studies of foreign authors, also our research found out that there are no statistically significant differences in technical efficiency between Czech agricultural holding managed by males and females in the period of 2007 to 2012. They have probably equal changes on the market as males and their holdings are equally efficient. Also the examination of each year separately, despite that there was a production gap between males' and females' farms in efficiency in the height of 0.91 percentage point in year 2008, showed that the differences were not statistically significantly different. The challenge for future research on the topic is to identify other determinants of differences between farms managed by males and females than the technical efficiency which proved to be similar.

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