PRODUKČNÍ CHARAKTERISTIKY VELKÝCH ZEMĚDĚLSKÝCH PODNIKŮ

PRODUCTION CHARACTERISTICS OF BIG AGRICULTURAL ENTERPRISES

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Anotace:
Příspěvek se zabývá analýzou produkčních charakteristik (vztahů) velkých zemědělských podniků. Kointegrační analýza je použita k odhadu Cobb-Douglasovy produkční funkce. Analýza vztahů mezi produktem a faktory využívá odhadnutého Vector Error-Correction modelu. Výsledky analýzy ukazují, že podniky se 100 a více zaměstnanci mají rostoucí výnosy z rozsahu. Proměnné přidaná hodnota, kapitál a půda/pracovníci jsou kointegrovány, tj. směřují v dlouhém období k rovnovážnému stavu. Strukturální šoky jsou absorbovány velmi rychle, avšak systém dosahuje rovnováhy až po pěti čtvrtletích. Výsledky impulse-response analýzy a dekompozice rozptylu potvrzují, že ekonomické charakteristiky podniků se 100 a více zaměstnanci jsou velmi dobré. Příspěvek vznikl v rámci řešení grantového projektu 402/06/P364 GAČR.

Klíčová slova:
zemědělské podniky, produkční funkce, Vector Error-Correction model, impulse-response analýza, dekompozice rozptylu.

Abstract:
The contribution is concerned with the analysis of production characteristics of big agricultural enterprises. The co-integration analysis is used to estimate the Cobb-Douglas production function and the Vector Error-Correction model is developed to analyse the relationships between output and production factors. The results show that the enterprises with 100 and more workers have increasing returns to scale. The variables, i.e. Value Added, Capital and Land/Workers are co-integrated, that is, they tend to equilibrium relationship in long period. Moreover, the short-run deviations are reduced very fast, however, the system seems to reach equilibrium as lately as 5 quarters after the unitary orthogonal innovation. The impulse-response analysis and variance decomposition also show that the group of enterprises with 100 and more employees has very good economic features. The contribution arose in frame of the solution of grant project 402/06/P364 from the Czech Science Foundation (GAČR).

Key words:
agricultural enterprises, production function, Vector Error-Correction model, impulse-response analysis, variance decomposition.

1. INTRODUCTION

The big agricultural enterprises, i.e. the group of enterprises with 100 and more workers may play an important social-economic role in both agricultural sector and economy of rural areas. As far as the agricultural sector is concerned, the big agricultural enterprises may contribute to the higher stability of the agricultural markets and may increase the competitiveness of Czech agricultural sector on the common EU market. However, the big agricultural enterprises do not only make a business in agricultural sector but their product portfolio is larger. It means that their activities are more diversified and the enterprises are less sensitive to the arising risk factors. That is, these enterprises with respect to their production characteristics and horizontal diversification are able to employ more people and such a way play an important social-economic role in regional development especially in rural areas. The analysis of production characteristics is just the objective of this paper. Thus, the analysis enables to uncover consequences of the existence of big agricultural enterprises in Czech agricultural sector.

2. AIMS AND METHODOLOGY

The aim of the paper is to analyse quantitatively production characteristics of the big agricultural enterprises (with 100 and more workers) and based on obtained results to deduct and to discuss their consequences.

The co-integration analysis is used to estimate a production function of the type of Cobb-Douglass. The estimation of Cobb-Douglass production function with output of value added (VA) and inputs of capital and land/workers stands on quarter data set in the period of 1997 – 2002. The variables are seasonally adjusted in statistical software Statgraphics, expressed in real values and logarithmic transformed. The RATS software version 6 is employed in the estimation of production function, tests of unit roots, estimation of VECM (Vector Error-Correction Model), impulse-response analysis and decomposition of variance.

There are several reasons for using co-integration analysis. The most important ones are the problem with spurious regression and the possibility of definition and analysis of long-run relationship between variables. The co-integration analysis helps to avoid of analysing spurious relationship between variables. Furthermore, the co-integration analysis offers to derive and analyse the long-run equilibrium of time series. The information about the long-run relationship, i.e. the estimated co-integrating vector, can be utilised in the estimation of the error correction model. The Vector Error-Correction model (VECM) contains on the one hand co-integrating vector (i.e. the long-run relationship between variables) and on the other hand differenced and lag variables in VAR space (i.e. the short-run dynamic). All variables (i.e. output and production factors) are endogenous in VECM. The variance decomposition and impulse-response analysis of VECM show important production and economic qualities and characteristics of variables used in Cobb-Douglas production function.

The analysed Cobb-Douglas production function has following form.

$$VA_t = a * Capital_t^{\,b} * (Land/Workers)_t^{\,c} * u_t^{\,k}$$

and in linear form (after logarithmic transformation)

$$lnVA_t = lna + blnCapital_t + c(Land/Workers)_t + klnu_t$$

where t = 1,2, ..., n.

VA = value added (in thousand CZK), Capital (in million CZK), Land/Workers (hectares/workers) and u = residuals.

3. RESULTS AND DISCUSSION

The fitted Cobb-Douglas production function is illustrated in point (i). The statistical characteristics of fitted model are presented below the equation (i). The R-Squared statistic indicates that the model as fitted explains 62.22%, 58.44% (adjusted R-Squared) respectively, of the variability in value added. The model appears to fit the data well especially with respect to the other in this production function not included variables that have an effect on output. The Durbin Watson test statistic does not imply that autocorrelation exists. Tests of significance for the included variables report that H_0 may be rejected for all structural parameters (including intercept) at 5% significance level. That is all variables are significant regressors (see standard errors (SE) situated below relevant structural parameters).

$$(i) \quad lnVA_t' = 4.84486 + 0.47536 lnCapital_{t-1} + 0.68122 lnLand/Employees_{t-1}$$
$$(SE) \quad (0.7587) \quad (0.1921) \quad (0.2879)$$
$$R^2/R^2(\text{Adj.}) = 62.22/58.44 \qquad \text{D-W test} = 2.1572$$

$$(ii) \quad VA^* = 4.84486 + 0.47536 Capital^* + 0.68122 Land/Employees^*$$

$$(iii) \quad \varepsilon_t = VA_t - 4.84486 - 0.47536 Capital_t - 0.68122 Land/Employees_t$$

The structural parameters of fitted production function represents the elasticity (see the logarithmic transformation), thus the efficiency of given production factor. The sum of these structural parameters informs about the stage of homogeneity of production function. The elasticity of value added with respect to capital is estimated as 0.47536. The sign is positive and consistent with economic theory. The magnitude suggests that for each 1% change in the level of capital, we expect the volume of value added on average to change by about 0.475%. The magnitude also follows the economic theory. The elasticity of value added with respect to land/workers is fitted as 0.68122. The sign and magnitude satisfy the economic criteria. The magnitude informs that for each 1% change in the level of land/workers it is expected the rise in value added by about 0.68%. The result suggests that the land/workers is more productive than capital. The land/workers determines the value added by about 1/5 more than capital. The sum of structural parameters is higher than unit (exactly 1.15658). That is the stage of homogeneity of estimated production function expresses increasing returns to scale.

The test of co-integration demands for expressing the fitted model in long-run relationship. The model has the form of DL model (2,1). That is, there are two exogenous variables that are lag by one period. With respect to the transformation of ADL or DL model respectively on the equation expressing the long-run relation we may conclude that the long-run relationship has the same value of structural parameters like estimated DL model (2,1). It means the Cobb-Douglas production function can be written in form of (ii).

The equation of long-run relationship (ii) can be exploited for testing of co-integration. Testing for unit root is used to determine the existence of the long-run equilibrium relationship, co-integration of time series respectively. Testing for unit root is employed on residuals of relation (ii), which can be rewritten as (iii). There are used Dickey-Fuller test, Augmented Dickey-Fuller test respectively and Philips-Perron test for determination of order of integration.

The results of testing for unit root suggests that residuals (ε) are integrated of order zero (we may write I(0)) at 5% significance level. The residuals (ε) have the form of stationary time series. Regarding to the order of integration I(1) of variables used in Cobb-Douglas function we may conclude that the time series are co-integrated. That is, the long-run equilibrium relationship among the variables exists.

The co-integration analysis suggests that the variables of Cobb-Douglas function of big agricultural enterprises (that is with 100 and more employees) are co-integrated. These results enable to estimate the Vector Error-Correction Model (VECM). VECM allows the analysis of both the long-run relationship and short-run relationship among the variables.

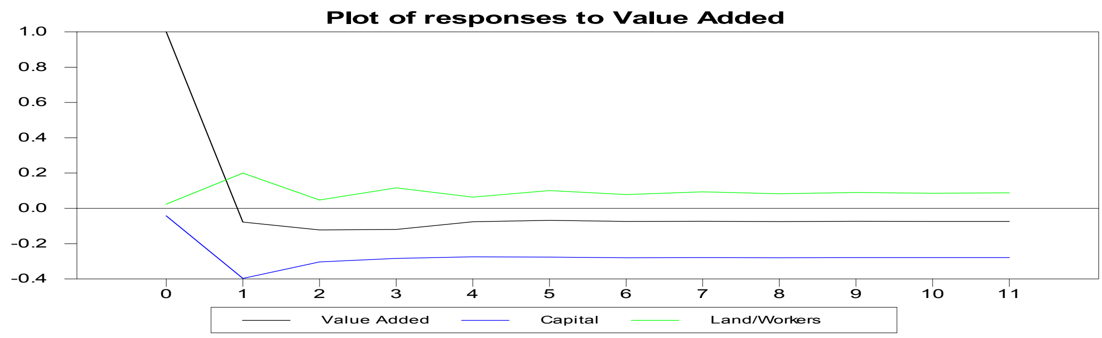
VECM is fitted with 2 lags in VAR space. The length of lag was derived on the basis of statistical criterion AIC (Akaikes's Information Criterion), SIC (Schwarz Information Criterion), Durbin-Watson value, degrees of freedom and with respect to the autocorrelation structure of residuals. There was used the co-integrating vector [1.000;-4.845;-0.475;-0.681] to estimate the VECM (see the point (iv)). The fitted VECM is presented in this paper only for the value added that is endogenous variable in Cobb-Douglas function. However, in VAR model or VECM respectively, all variables are endogenous. The choice for paying attention just to value added in VECM follows the main objective of the paper.

$$\text{(iv)}\quad dVA_t' = 0.012918 + 0.19789 dVA_{t-1} - 0.68565 dCapital_{t-1} - 0.40656 dLand/Empl_{t-1} -$$
$$\text{(SE)}\quad (0.018) \quad (0.215) \quad (0.344) \quad (0.278)$$

$$1.28549 * (VA_{t-1} - 4.845 - 0.47536 Capital_{t-1} - 0.68122 Land/Empl_{t-1})$$
$$(0.286)$$
$$R^2/R^2(Adj.) = 0.6336 / 0.5474 \quad D\text{-}W\ test = 2.2318$$

The VECM of big agricultural enterprises for variable value added (iv) suggests that short-run dynamic of fitted equation is finite. The system returns very fast to equilibrium relationship. This remarkable characteristic of equation (iv) satisfies economic assumption that we may accept for well functional enterprise. The long-run instability in basic economic characteristics has significant negative influence on the performance, i.e. it has negative impact on the output. This instability may cause, in extreme case, the bankruptcy. The detail analysis of fitted VECM is better to process with help of impulse-response analysis and variance decomposition. The impulse-response analysis of the VECM shows the system's reaction to innovations (shocks). Thus, it illustrates the dynamic of the system and informs about the speed and the way of establishing equilibrium. The variance decomposition offers very valuable and detailed information about relations between analysed variables (in this case between production factors and output).

Figure 1 – Impulse-Response analysis



The figure 1 demonstrates responses of the system to the unitary orthogonal innovation (shock) in value added. A series' response is normalized by dividing by its innovation variance. The graph shows responses of value added (black line), capital (blue line) and land/workers (green line) to the unitary innovation in value added. The responses of value added are after one period slightly negative, the responses of capital are negative with the decrease of value added and the responses of land/workers are positive in all period.

All together, it can be said that the short-run deviations are reduced very fast, however, the system seems to reach equilibrium as lately as 5 quarters after the unitary orthogonal innovation.

Table 1 presents the results of variance decomposition for variables value added that represents the agricultural output of enterprises with 100 and more workers. The variance decomposition shows in detail the interaction between variables especially for longer forecast horizons. The prognostic period in this paper is 12 steps. One step is equal to one quarter that is 12 steps correspond with 4 years. Standard Errors in table 1 represent the prognostic error of given period. The forecast error in the first step is equal to standard deviation of value added innovation.

Table 1 –Variance Decomposition of value added (VA)

Step	Std. Error	VA	Capital	Land/Employees
1	0.068941663	100.000	0.000	0.000
2	0.072579512	90.771	0.508	8.722
3	0.082119388	71.957	13.108	14.935
4	0.089113447	61.956	21.087	16.957
5	0.095650429	54.079	26.748	19.174
6	0.100875519	48.834	30.603	20.562
7	0.106194748	44.295	33.672	22.033
8	0.111095815	40.679	36.274	23.047
9	0.115931734	37.557	38.438	24.005
10	0.120490163	34.947	40.303	24.749
11	0.124931196	32.676	41.891	25.433
12	0.129186832	30.715	43.283	26.002

The forecast errors in the next steps are larger because of respecting the uncertainty of the development, forecast respectively, of the variables – capital and land/workers. The variance decomposition of value added is presented in the last three columns of table 1. The value added explains all of its first step ahead forecast error variance. However, the explanatory ability is decreasing with longer forecast horizons. For example, the value added explains 61,956 percent of its forth step ahead forecast error variance, whereas the capital and land/workers explain 21 percent and 16,957 percent of the forth step ahead forecast error variance in value added, respectively. By comparing of the first, second, third and forth steps it is evident that there is an increase of the impact of the capital in relation to the land/workers. With longer forecast horizons there is a further increase of explanatory ability of the capital and land/workers. At the end of our forecast horizons the value added explains 30,715 percent of its 12-step ahead forecast error variance, whereas the capital and land/employees explain 43,283 percent and 26 percent of the 12-step ahead forecast error variance in value added, respectively. According to the obtained results we may conclude that the value added has a decreasing influence with longer forecast horizons. That is there may not be find any "important" causality in its own development because of the significant impact of other factors. Such a conclusion fully corresponds with the economic assumptions. The value added is created by transformation of inputs into outputs. The total value added depends on the type of transformation and the transformation efficiency. Theoretically, the value added does not depend at all of its past values but primarily on the transformation process. The conclusion (i.e. the increasing importance of capital and land/workers) seems to be correct. There is an increase of the impact of production factors, which primary determines the nature and efficiency of the transformation. Furthermore, the important conclusion of variance decomposition is a structure of factors' influence. The capital explains more of ahead forecast error variance in value added (starting in 4-step) than the land/workers explains despite the lower capital elasticity than land/workers elasticity in production function. The increase of capital importance corresponds with the economic assumptions, which respect technical and technological innovations. The conclusion also relates to possible substitution of production factors. It suggests that the substitution is finite. However, we may assume that the substitution is in restrictive scale possible in the short- and middle-run. In the long-run the transformation process will be changed by larger capital exploitation, thus changes in the proportion of production function can be expected.

4. DISCUSSION

The results of fitted Cobb-Douglas production function are close to the Pánková (2003). Her cross-section analysis contains 370 agricultural enterprises. As far as the fitted Cobb-Douglass production function is concerned, the parameters are approximately consistent with parameters in this paper. Thus, the estimation of Cobb-Douglass production function based on the time series may meet the reality.

5. CONCLUSIONS

To sum up, the results of 2-factors production function suggests that the enterprises with 100 and more workers have increasing returns to scale. This feature should be exploited and also supported with respect to the competitiveness of Czech agriculture in the frame of the multifunctional agriculture. The variables, i.e. Value Added, Capital and Land/Workers are co-integrated, that is, they tend to equilibrium relationship in long period. Moreover, the short-run deviations are reduced very fast, however, the system seems to reach equilibrium as lately as 5 quarters after the unitary orthogonal innovation.

The analysis of production characteristics of big agricultural enterprises suggests that this group may have (under some assumptions) good possibility to be competitive on the common EU market.

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