ECONOMETRIC ANALYSIS OF THE CROPS’ PRODUCTION PRIME COST IN STEPPE ZONE

Alla Zhorova¹, Svetlana Tischenko²

¹ Mykolayiv National Agrarian University. Paryzka Komuna Str., Mykolayiv, 54020, Ukraine. Tel. +38 0512 709302. E-mail AZhorova@mail.ru
² Mykolayiv National Agrarian University. E-mail swetlana1506@rambler.ru

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Efficiency of agrarian production depends on the characteristics of the natural complex in specific territory. Managing costs on crop production in steppe zone is largely determined by correctly chosen strategy of development and tools of its implementation, taking into account cost and innovative technologies. The purpose of this paper is to identify possible ways to reduce the cost of crop production by constructing an econometric model. Searching of the most efficient ways of working agrarian enterprise is grounded by the intense technological progress, with considerable attention which is paid to the econometric modelling. It provides the opportunity not only to see the relationship between the studied quantitative factors, but also to predict the results of activities in an analytical form. The paper proposes an econometric model of the crops’ yield formation and identifies ways to reduce the cost of crop production. The hypothesis of a linear relation between the prime cost, expenditures and yield is proved. As a result of the analysis, the dependence of production costs on crop yields and prime costs, the opportunity to use the survey data to predict future economic factors in agriculture is given.

Keywords: crop production, expenditures, index analysis, prime costs, productivity.
JEL codes: C00, C02, C15, Q10.

1. Introduction

Planning in a modern agrarian business in the conditions of market economy and world globalization with a view to ensuring food security, actualizes the problem of the resources’ rational use and leads to a significant improvement of cost management. The main task in the management of production costs is to determine the feasibility of their arising in daily activities, achieving the required profitability in a competitive environment, and in the development of enterprises.

Various aspects of econometric models’ construction in the Ukrainian economy have been already included since the sixties and seventies of the XX th century. It is necessary to highlight the scientific developments of NSU scientists in the USSR Governmental plan, who had constructed the econometric models Ukr1-3 of economic development. Model Ukr-2 consisted of 101 regression equations and had been formed directly on the branches, including agriculture (Emelyanov, 1970).
In this paper (Ermolaev, 2006) the correlative and regressive pricing model for the main agrarian types of agricultural had been constructed. Its applicability to further prediction had been shown.


The purpose of this paper is to identify possible ways to reduce the cost of crop production by constructing an econometric model.

Optimizing the level of production prime costs is an important prerequisite to improve financial performance of the enterprise and ensure its efficiency, in order to increase the amount of agrarian production, reducing labor costs and production resources at its unit. Reduction of the crops’ prime cost is contributed by increase in production volume due to more efficient use of production capacity; reduction of production costs by improving productivity, economical use of raw materials, electricity, fuel, equipment, prevention of non-production expenditures, etc.

2. The main material

Increase in agrarian production and decrease in its prime cost can be achieved by improvement of enterprise’s efficiency and crops’ productivity (Golovanov, 1989).

For management decision-making it is necessary to examine the factors influencing the change in the prime cost of production. The level of crop production’s cost depends on two complex factors: production yield and the expenditures for it. To form effective information base of crops’ production management a methodology that provides a systematic approach to collect economic information, modelling of economic phenomena, analysis and synthesis of the results is used.

To construct an econometric model of influence yields and expenditures on crops’ prime costs in Mykolayiv region (Ukraine), the following algorithm can be used:

1. Determination of indexes of the main types products’ prime cost (1 quintal of cereals, vegetables):

\[ i = z_i / z_0, \quad \Delta = z_i - z_0. \]

Index analyzing of expenditures as a percentage:

\[ I_{zg} = \frac{\sum z_i g_1}{\sum z_0 g_0}. \]

Absolute change of expenditures:

\[ \Delta_{zg} = \sum z_i g_1 - \sum z_0 g_0, \]
2. Calculation of cost changes under the influence of production amount:

\[ Ig = \frac{\sum z_0 g_1}{\sum z_0 g_0}, \]  

Absolute change in costs due to production amount:

\[ \Delta g = \sum z_0 g_1 - \sum z_0 g_0 \]  

3. Calculation of the index change in costs per unit:

\[ Iz = \frac{\sum z_1 g_1}{\sum z_0 g_1} \]  

Absolute change in prime cost:

\[ \Delta z = \sum z_1 g_1 - \sum z_0 g_1 \]  

4. In order to show the relationship of indices and increments, the following formula can be used:

\[ Izg = Iz \times Ig \]  

\[ \Delta zg = \Delta z + \Delta g \]  

The present level of the crop’s production cost in the Steppe zone was analyzed by statistical materials of Mykolayiv region (Ukraine).

Let’s define the prime cost of production of 1 quintal of crop production for agrarian enterprises of Mykolayiv region. To do this, we calculate the table 1. In 2013 the cost of 1 quintal of cereals, compared with 2011, had increased by 16.4%, but in comparison with 2012, it had decreased by 25.4%.

The production prime cost of 1 quintal of spring barley in 2013, compared with 2011, had increased by 22.86%, and in comparison with 2012, had decreased by 21.9%.
Table 1. The prime cost of 1 quintal of crops in agrarian enterprises of Mykolayiv region, UAH

<table>
<thead>
<tr>
<th>Types of products</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2013 (%) up to 2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crops</td>
<td>93.54</td>
<td>145.98</td>
<td>108.88</td>
<td>116.4</td>
<td>74.59</td>
</tr>
<tr>
<td>including</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>wheat</td>
<td>95.89</td>
<td>157.69</td>
<td>118.59</td>
<td>123.67</td>
<td>75.20</td>
</tr>
<tr>
<td>rye</td>
<td>97.69</td>
<td>112.59</td>
<td>112.37</td>
<td>115.03</td>
<td>99.8</td>
</tr>
<tr>
<td>barley</td>
<td>100.87</td>
<td>158.61</td>
<td>123.93</td>
<td>122.86</td>
<td>78.14</td>
</tr>
<tr>
<td>corn</td>
<td>72.09</td>
<td>115.46</td>
<td>79.20</td>
<td>109.86</td>
<td>68.6</td>
</tr>
<tr>
<td>гречка</td>
<td>215.74</td>
<td>363.92</td>
<td>276.19</td>
<td>128.02</td>
<td>75.89</td>
</tr>
<tr>
<td>горох</td>
<td>170.76</td>
<td>191.68</td>
<td>215.07</td>
<td>125.95</td>
<td>112.2</td>
</tr>
<tr>
<td>oats</td>
<td>118.53</td>
<td>116.84</td>
<td>130.64</td>
<td>110.22</td>
<td>111.81</td>
</tr>
<tr>
<td>.sugar beet (factory)</td>
<td>18.70</td>
<td>21.55</td>
<td>34.58</td>
<td>184.92</td>
<td>160.46</td>
</tr>
<tr>
<td>.seeds of sunflower</td>
<td>170.70</td>
<td>228.96</td>
<td>181.07</td>
<td>106.03</td>
<td>79.08</td>
</tr>
<tr>
<td>.rape</td>
<td>240.52</td>
<td>284.36</td>
<td>213.04</td>
<td>88.57</td>
<td>74.92</td>
</tr>
<tr>
<td>.soybeans</td>
<td>174.71</td>
<td>273.35</td>
<td>271.59</td>
<td>155.45</td>
<td>99.36</td>
</tr>
<tr>
<td>.potato</td>
<td>148.57</td>
<td>86.50</td>
<td>219.14</td>
<td>147.5</td>
<td>253.34</td>
</tr>
<tr>
<td>.field vegetables</td>
<td>46.02</td>
<td>44.99</td>
<td>57.14</td>
<td>124.16</td>
<td>127.00</td>
</tr>
</tbody>
</table>

During the reporting period the production prime cost of 1 quintal of peas, compared to 2011 and 2012, had increased by 25.95%, respectively.

To determine the above-mentioned indices we calculate Table 2.

Table 2. Indicators to measure the crops’ prime cost in agrarian enterprises of Mykolayiv region

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Symbols</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain yield quintal / ha</td>
<td>Y</td>
<td>28.4</td>
<td>16.3</td>
<td>29.4</td>
</tr>
<tr>
<td>Prime cost of 1 quintal of grain, UAH</td>
<td>Z</td>
<td>93.54</td>
<td>145.98</td>
<td>108.88</td>
</tr>
<tr>
<td>Expenditures for 1ha of grain, UAH</td>
<td>YZ</td>
<td>2656.54</td>
<td>2379.47</td>
<td>3201.07</td>
</tr>
</tbody>
</table>

To calculate the total change in the prime cost of 1 quintal of grain and leguminous crops the following formulas can be used:

\[
i = \frac{108.88}{145.98} = 0.75 \text{ or } 75\%
\]

\[
\Delta = 108.88 - 145.98 = -37.1 \text{ UAH}
\]

The prime cost price of 1 quintal of grain in 2013, compared with 2012, in Mykolayiv region had decreased by 25% or 37.1 UAH.

In order to perform the index analysis of prime cost of crops’ production in Mykolayiv region, it is necessary to analyze the change in crops’ prime cost during past two years (Table 3).

Expenditures’ index

\[
I_{zg} = \frac{5068546}{3698007} = 1.37 \text{ or } 137\%
\]
Let's calculate the absolute expenditures' change according to the following formula (4): \( \Delta zg = 5068546 - 3698007 = 1370539 UAH \).

Its index characterizes the expenditures' change under the influence of production amount:

\[
I_g = \frac{6483824}{3698007} = 1.75 \text{ or } 175\%.
\]

Absolute expenditures' change due to the production amount:

\[
\Delta g = 6483824 - 3698007 = 2785817 \text{ UAH}
\]

Index of expenditures' change due to the prime cost per unit:

\[
I_z = \frac{5068546}{6483824} = 0.78 \text{ or } 78\%
\]

Absolute expenditures' change due to the prime cost:

\[
\Delta = 5068546 - 6483824 = -1415278 \text{ UAH}
\]

In order to show the relationship of indices and increments, the following formulas are used:

\[
I_{zg} = 0.78 \times 1.75 = 1.37 \text{ or } 137\%
\]

\[
\Delta = -1415278 + 2785817 = 1370539 \text{ UAH}.
\]

The calculated indices and gains show that the overall cost of funds for crop production in Mykolayiv region (Ukraine) in 2013, compared with 2012, had increased by 37\% or by 1370539 UAH. This was due to two factors: the change in the number of products and changes in the cost of production of 1 quintal.

By increasing the amount of products the overall cost of funds for production in the reporting year, compared with the basic index, had increased by 75\%. In absolute terms it is amounted to 2785817 UAH.
Table 3. The production expenditures and crops’ prime cost in Mykolayiv region

<table>
<thead>
<tr>
<th>Types of products</th>
<th>2012</th>
<th>2013</th>
<th>Conventional production’s prime costs UAH (thou)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Croppage, UAH (thou)</td>
<td>Production prime cost</td>
<td>Croppage, UAH (thou)</td>
</tr>
<tr>
<td></td>
<td>Total, UAH (thou)</td>
<td>UAH / quintal</td>
<td>Total, UAH (thou)</td>
</tr>
<tr>
<td>Crops, including:</td>
<td>g₀</td>
<td>z₀g₀</td>
<td>z₀</td>
</tr>
<tr>
<td>Wheat</td>
<td>1278.3</td>
<td>1866062</td>
<td>145.98</td>
</tr>
<tr>
<td>Rye</td>
<td>419.2</td>
<td>661036</td>
<td>157.69</td>
</tr>
<tr>
<td>Barley</td>
<td>1.5</td>
<td>1688</td>
<td>112.59</td>
</tr>
<tr>
<td>Corn</td>
<td>381.5</td>
<td>605097</td>
<td>158.61</td>
</tr>
<tr>
<td>Sugar beet (factory)</td>
<td>59.0</td>
<td>12714</td>
<td>21.55</td>
</tr>
<tr>
<td>Sunflower</td>
<td>692.6</td>
<td>1585776</td>
<td>228.96</td>
</tr>
<tr>
<td>Filed vegetables</td>
<td>518.9</td>
<td>233453</td>
<td>44.99</td>
</tr>
<tr>
<td>Total</td>
<td>3698007</td>
<td>5068546</td>
<td>6483824</td>
</tr>
</tbody>
</table>

Total expenditures for crop production in 2013, compared with 2012, had decreased by 22%. In absolute terms it is amounted to 1415278 UAH.

3. The econometric model’s constructing

To clarify the influence of factors on the cost of grain in Mykolayiv region (Ukraine), we identify the variables of the econometric model: \( Y \) – the cost of crop production vector, \( X_1 \) – the vector of yields, \( X_2 \) – the vector of expenditures, \( u \) – the vector of residuals (Table 4).

Table 4. Initial data for the construction of multiple correlations

<table>
<thead>
<tr>
<th>Years</th>
<th>Yield of crops, quintal / ha</th>
<th>Costs of funds of crops, UAH /ha</th>
<th>Prime cost of crops, UAH / quintal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definitions</td>
<td>( X_1 )</td>
<td>( X_2 )</td>
<td>( Y )</td>
</tr>
<tr>
<td>2008</td>
<td>28.7</td>
<td>1564.15</td>
<td>54.5</td>
</tr>
<tr>
<td>2009</td>
<td>27.6</td>
<td>1771.65</td>
<td>64.19</td>
</tr>
<tr>
<td>2010</td>
<td>25.1</td>
<td>2091.34</td>
<td>83.32</td>
</tr>
<tr>
<td>2011</td>
<td>28.4</td>
<td>2656.54</td>
<td>93.54</td>
</tr>
<tr>
<td>2012</td>
<td>16.3</td>
<td>2379.48</td>
<td>145.98</td>
</tr>
<tr>
<td>2013</td>
<td>29.4</td>
<td>3201.08</td>
<td>108.88</td>
</tr>
</tbody>
</table>
Let’s discuss the specification of econometric model $Y = f(X_1, X_2, u)$ as a linear formula $\hat{Y} = \hat{a}_0 + \hat{a}_1 X_1 + \hat{a}_2 X_2$, where $a_0, a_1, a_2$ – unknown model parameters $\hat{a}_0, \hat{a}_1, \hat{a}_2$ – their evaluations; $\hat{Y}$ – theoretic index of efficient feature; $u = Y - \hat{Y}$ the vector of residuals.

To determine the parameters of the regression equation we use the method of least squares (OLS), i.e. $F = \sum_{i=1}^{n} u_i^2 = \sum_{i=1}^{n} (y_i - \hat{y}_i)^2 \rightarrow \min$.

After identifying the unknown model parameters we have an equation system of:

$$
\begin{align*}
a_0 n + a_1 \sum_{i=1}^{n} x_1 + a_2 \sum_{i=1}^{n} x_2 &= \sum_{i=1}^{n} x_i; \\
a_0 \sum_{i=1}^{n} x_1 + a_1 \sum_{i=1}^{n} x_1^2 + a_2 \sum_{i=1}^{n} x_1 x_2 &= \sum_{i=1}^{n} y x_1; \\
a_0 \sum_{i=1}^{n} x_2 + a_1 \sum_{i=1}^{n} x_1 x_2 + a_2 \sum_{i=1}^{n} x_2^2 &= \sum_{i=1}^{n} y x_2 
\end{align*}
$$

Solving this equation system, we get: $a_0 = 139.1728; a_1 = -5.0706; a_2 = 0.0369$.

Multiple regression equation, which characterizes the dependence of the cost of 1 quintal of grain crops, on yield and cost per 1 ha of cultivated area will have the form: $y = 139.1728 - 5.0706 X_1 + 0.0369 X_2$.

To find out the adequacy of this model we calculate the residues $u = Y - \hat{Y}$, and check the closeness of the overall impact of the independent variables on the dependent using the coefficient of determination $R^2 = 1 - \frac{\sum_{i=1}^{n} u_i^2}{\sum_{i=1}^{n} (y_i - \bar{y})^2} = 0.99$.

Let’s verify the statistical significance of the results.

We calculate F-statistics $F_{\text{man}} = \frac{R^2}{1 - R^2} \frac{n - m - 1}{m} = 77.79$, where $n$ – the volume of original population, $m$ – factors’ amount. Let’s compare the received result with the tabulated value of Fisher’s exact test $F_{\text{табл}} = 76.4$. As $F_{\text{man}} > F_{\text{табл}}$, the econometric model can be considered as adequate to data.

The coefficient of $x_1$ is equal to $-5.0706$. It shows that at average expenditures per 1 ha of crop grain, the yield’s increase per 1 quintal / ha will reduce the prime cost of 1 quintal of grain in 5.0706 UAH. Increasing the expenditures of 1 ha of crop of grain to UAH1, would increase the prime cost to 0.0369 UAH, at a certain average yield.
There is a fairly strong positive relationship between the factor variables. The value of the multiple correlations 0.9915 characterizes sufficiently strong connection between the prime cost, expenditures and yield.

The coefficient of multiple determinations indicates that 99% of the prime cost’s range, 1 quintal of grain is conditioned by the factors included in the model, and the rest – 1% – by unaccounted factors.

For a complete analysis of influence of the above-mentioned factors on the prime cost of grain we had calculated the coefficients of elasticity.

The calculated partial coefficients of elasticity prove the situation when the grain yield is increased by 1%, the cost of 1 quintal of products is decreased by 1.29 UAH on conditions that all other factors are constant. If the cost of 1 hectare of crops is increased by 1%, the cost of 1 quintal of products is also by 1.058 UAH on conditions that all other factors are constant.

4. Conclusions

1. The model is statistically significant and can be used to predict the cost of crop production in the coming years (2014–2016) in the regional economy of agrarian complex.

2. The real value of econometric models for forecasting of prime cost of crop production is not determined by the reflection of the relationship between economic factors, but by the possible analytical prediction of the prime cost of production, taking into account the change in the structure of labour costs, improving the system of management personnel.

References


ŽEMĖS ŪKIO PRODUKCIJOS AUGINIMO STEPĖS ZONOJE SAVIKAINOS EKONOMETRINĖ ANALIZĖ

Alla Zhorova, Svetlana Tischenko
Nikolarevo nacionalinis žemės ūkio universitetas (Ukraina)
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Santrauka


Raktiniai žodžiai: žemės ūkio produkcija, išlaidos, rodiklių tyrimas, pirminiai kaštai, produktyvumas.

JEL kodai: C00, C02, C15, Q10.