Analysis of the relation between the price of fodder mixture ingredients and the price of chicken meat

Analýza vztahu mezi cenou složek krmné směsi a cenou kuřecího masa

V. PEZLAROVÁ

Mendel University of Agriculture and Forestry, Faculty of Economics, Brno, Czech Republic

Abstract: This paper aims at finding a suitable model describing the relation between the price of fodder mixture ingredients (wheat, maize) and the price of chicken meat. The procedure of searching for the right model will be demonstrated here on the available agricultural data. The models will trace the development of the price of chicken meat (agricultural producer price – APP) as related to time, the price of feed in the current and previous periods, and the previous prices of chicken meat. It designates five different models for estimating the price of chicken meat. For producers, the best is the Model 5 ($\hat{y}_t = 0.003 \cdot x_{t-2} + 0.6054 \cdot y_{t-2}$), which predicts the price two months ahead. These models represent one of the ways to deal with the problem in question. The price of chicken meat is influenced by a lot of other variables.

Key words: chicken meat, maize, wheat, price, regression, correlation, residual analysis

Abstrakt: Cílem článku je nalézt vhodný model, který popisuje vztah mezi cenou složek krmné směsi (pšenice, kukuřice) a cenou kuřecího masa. Na dostupných zemědělských datech předvedu postup nalezení vhodného modelu. V modelech je sledován vývoj ceny kuřecího masa (cena výrobců – CZV) v závislosti na čase, na ceně krmné směsi v současném a předchozích obdobích a na předchozích cenách kuřecího masa. Bylo sestrojeno 5 různých modelů pro zjištění ceny kuřecího masa. Pro odhad ceny masa pro producenty je nejlepším modelem model 5 ($\hat{y}_t = 0,003 \cdot x_{t-2} + 0,6054 \cdot y_{t-2}$), pomocí kterého můžeme odhadnout cenu masa na dva měsíce dopředu. Navržené modely jsou jednou z možností, jak řešit daný problém. Na cenu kuřecího masa má vliv ještě mnoho dalších veličin.

Klíčová slova: kuřecí maso, kukuřice, pšenice, cena, regrese, korelace, analýza reziduí

The economy of a state should be directed towards as great efficiency and stability as possible. Therefore, predicting the future development of economic variables brings a significant benefit. If the economists presuppose stable relations between the variables, they may take various measures in order to avoid the undesirable development.

According to the results of animal production (the Czech Statistical Office) at the end of the first half of 2001, the stocks of poultry decreased by 1.7% compared to the same period in 2000, although there was a constant growth in the APP of broiler chicken. The situation is different to that of the previous year when the stocks of poultry, while the APP stagnated, had increased by 7.7% by the half of 2000, as a result of greater demand for chicken meat. The volume of chicken meat production steps up by approximately 3% (3.7%) in 2001 (2000) compared to 2000 (1999). The most significant increase in chicken meat production – by 13.3% – was in 1999, compared to 1998. Within three quarters of 2001, the overall purchase of poultry went up by 3.5%, compared to the same period in 2001. Similarly, there was an increase in the consumption of chicken meat, which in 2000 amounted to 20.8 kg per capita per year. With this volume of consumption, the Czech Republic, already in 1999, reached the level of consumption per capita per year in the EU.

Chicken fattening represents the most important category of poultry breeding and the biggest production volume of poultry meat in the Czech Republic. The degree of dependence of chicken fattening on natural conditions is, with regard to the composition of fodder (most often a complete fodder mixture is used), minimal. Thanks to high concentration of birds at the fattening stations, high productivity of labour is achieved.

The procedure of searching for a suitable model will now be demonstrated on the available agricultural data (average monthly prices of chicken meat – APP, fodder wheat and maize, regarding the period between June 1998 and August 2001). The most significant cost item is represented by fodder costs, which constitute approximately 65% of the overall costs. The staple fodder ingredient is wheat (about 50%), another important ingredient is maize (about 20%); therefore a change in the price of these commodities, if there exists a relation, should bring about a change in the price of chicken meat as well. Taking into account the fact that chicken fattening takes place in a longer period (about 45 days), the change in the price of cereals will reflect the price of meat with a certain delay.

The term "regress" refers to systematic changes of certain variables when other variables are changed, and to the representation of these changes by means of mathematical (regression) functions. The aim of regression analysis is a deeper understanding of the general properties of inter-variable relations. The mathematical representation of a studied variable value changes may be based on various intentions and used for different purposes. When stress is laid on the normalization of the obtained values using a suitable mathematical function, there is an effort to reach maximum agreement between the actual and the normalized values of the studied variable. The success of the method of parameter prediction is assessed by the degree of agreement between the obtained and modelled values. Most regression models are used for extrapolation – i.e. for predicting the further development of the explained variable.

There is a shift from simple to multiple regression analysis in order to improve the prediction of values of the explained variable. However, experience shows that it is usually not convenient to work with too many explicative variables. It is because there is a risk that unimportant factors get included into the explicative variables together with the important ones, the analysis becomes unnecessarily complicated, and the results are difficult to interpret.

MATERIALS AND METHODS

We often have to face a difficult task of dealing with the problem of measuring the interdependence of an uncertain range of variables with unclear status. There are problems with quantification of some important variables and often also with obtaining the suitable data. The informative value of various measuring methods is not always identical. It is necessary to carefully look for procedures that comply with the particular limitations and respect the particularities of the problem in question.

The design of a regression model is preceded by an analysis of data regarding the observed explicative variables and the relations between the explained (studied) variable and the explicative variables. Relations between pairs of variables are represented by "scatter plots", which can indicate the shape of the regression function. Sometimes, index plots are used, which show the order of the particular dot on the x-axis and the respective value on the y-axis. Such a plot may identify the existence of a trend in the succession. These successions are referred to as temporal because the explained variable is dependent on time (Figure 1 and 2).

Having chosen a suitable regression function, we can now proceed to calculate regression parameters b_j. The parameters will be calculated using the least squares method. This method is based on minimization of the sum of squares of the variation between the actual and the normalized values, i.e.

$$\min \sum_{i=1}^{n} (y_i - \hat{y}_i)^2$$

A regression function that satisfies this criterion satisfies also the equation

$$\sum_{i=1}^{n} (y_i - \hat{y}) = 0 \text{, where } \hat{y} = \sum_{j=0}^{m} b_j \cdot f_j(x)$$

that is, the regression function we have chosen. We substitute the chosen regression function into the least

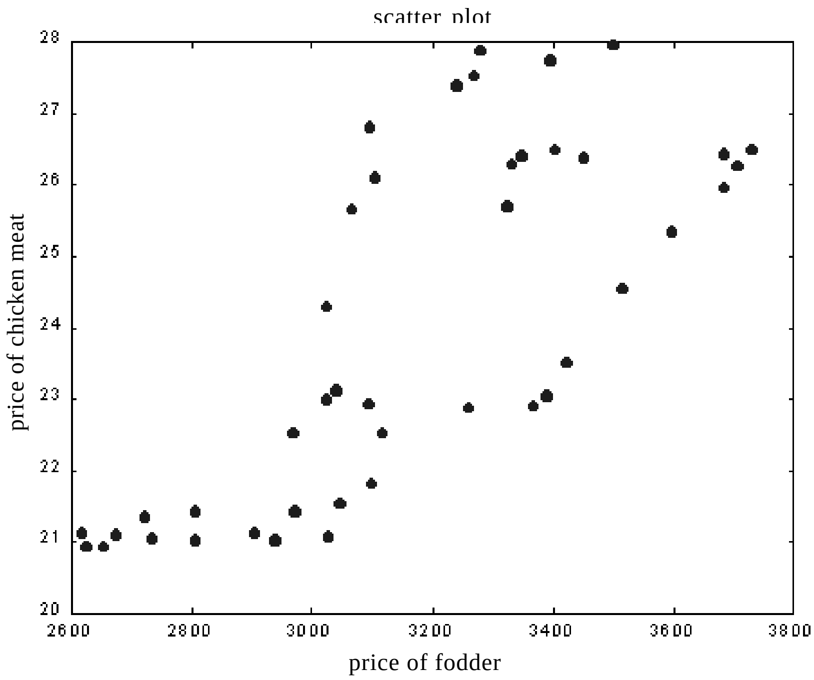

Figure 1. The dependence of chicken meat price on the price of feed

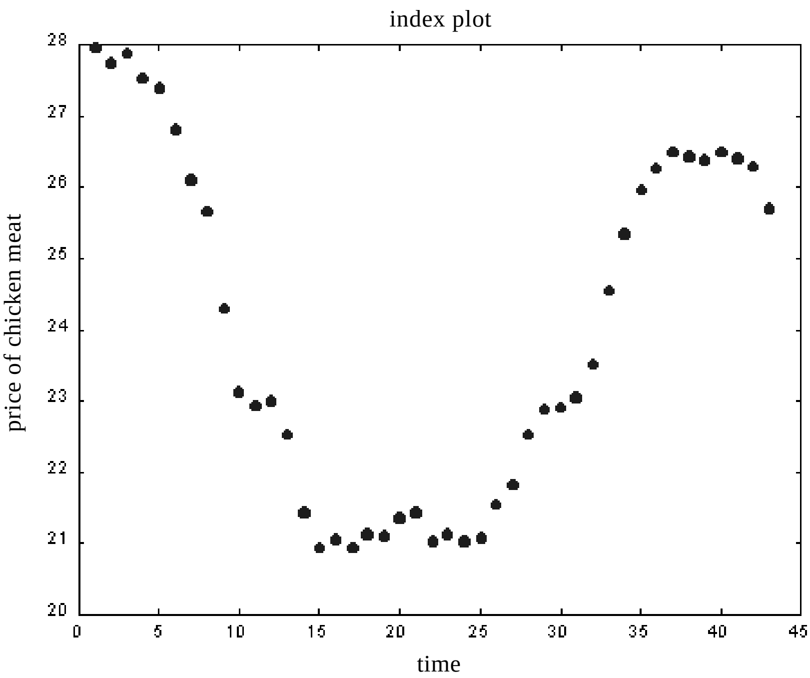

Figure 2. The dependence of chicken meat price on time

squares criterion and differentiate the obtained sum with respect to the individual parameters. We make the obtained first partial derivatives equal to zero and obtain a system of $m + 1$ equations, which are referred to as "normal". The j-th normal equation in its general form looks as follows:

$$\sum_{i=1}^{n} y_i \cdot f_j(x_i) - \sum_{i=1}^{n} \left(\sum_{j=0}^{m} b_j \cdot f_j(x_i) \right) \cdot f_j(x_i) = 0$$

The information about whether we can – having the given selection range – expect reasonably accurate predictions of the regression parameters, is provided by the standard errors $s(b_j)$ of these predictions. As these predictions are not biased, the standard errors are the square roots of dispersions of these predictions.

Using partial t-tests, we shall now exclude all insignificant regression parameters. Parameters are considered insignificant if the value of the test criterion

$T = \frac{b_j}{s(b_j)}$ lies within the range of $\left\langle t_{\frac{\alpha}{2}} ; t_{1-\frac{\alpha}{2}} \right\rangle$,

where α stands for risk.

The correlation index will now be used in order to make sure about the suitability of the chosen regression function. This suitability can also be assessed using residual analysis. A residual is the difference between the original (actual) and the predicted values $e = y - \hat{y}$. The basic properties we are going to calculate for the residual are: average, variation range (the difference between the minimum and the maximum value), dispersion and standard deviation.

RESULTS AND DISCUSSION

The individual models will trace the development of the price on chicken meat as related to time, the price of fodder in the current and previous periods, and the previous prices of chicken meat. The price of fodder will be calculated as a weighted average of wheat and maize prices. According to the index plot, a quadratic dependence on time seems to be suitable.

Model 1:

Explained variable – the price of chicken meat in time t (y_t)

Explicative variables – the price of feed in time t to $t - 4$ ($x_t, \ldots x_{t-4}$)
– time (t, t^2)

After excluding all unimportant parameters (for $\alpha = 0.01$), we have obtained a model in which the price of chicken meat depends solely on the current price of fodder, i.e. the price in time t, and on time t, t^2. The regression function has, therefore, the following form (see Figure 3):

$$\hat{y}_t = 15.788 + 0.0039 \cdot x_t - 0.538 \cdot t + 0.012 \cdot t^2$$

The correlation index for Model 1 is $I = 0.9736$, which means that this regression function explains 94.79% of the dispersion of the original values ($I^2 = 0.94789$).

Model 2:

Explained variable – the price of chicken meat in time t (y_t)

Explicative variables – the price of feed in time t to $t - 4$ ($x_t, \ldots x_{t-4}$)
– time (t, t^2)

– the price of chicken meat in time $t-1$ and $t-2$ (y_{t-1}, y_{t-2})

After excluding all unimportant parameters (for $\alpha = 0.01$), we have obtained a model in which the price of chicken meat depends solely on the current price of fodder, i.e. the price in time t, and on the price of chicken meat in time $t-1$ and in time $t-2$. The regression function has, therefore, the following form (see Figure 4):

$$\hat{y}_t = 0.0008 \cdot x_t + 1.336 \cdot y_{t-1} - 0.44478 \cdot y_{t-2}$$

The correlation index for Model 2 is $I = 0.9905$, which means that this regression function explains 98.11% of the dispersion of the original values.

As in both Model 1 and Model 2 the current price of fodder remains one of the explicative variables, these models are not suitable for future prediction. If we know the current price of fodder, we know the price of chicken meat as well, so it is not necessary to predict it. Therefore, I shall design the two models anew and exclude the current price of fodder (i.e. the price in time t).

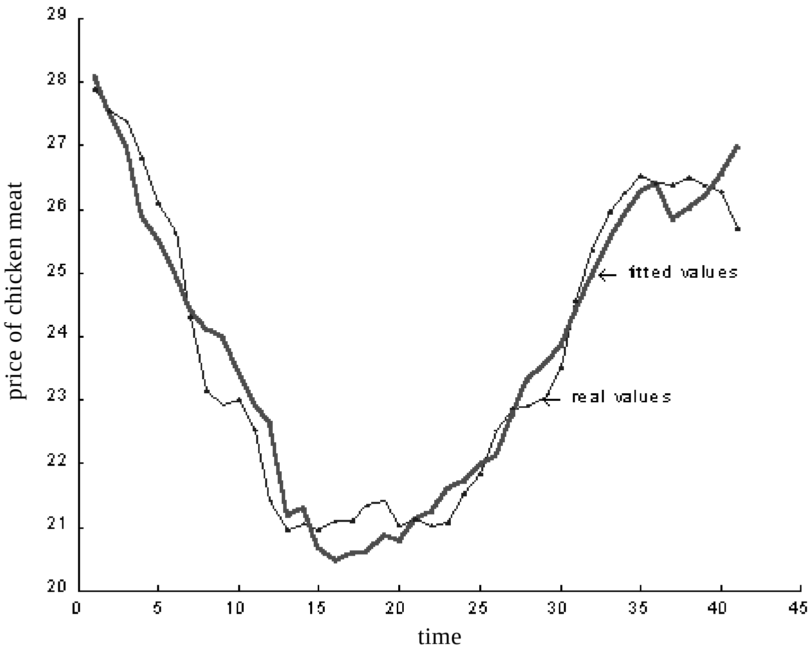

Figure 3. The dependence of chicken meat price on time and on the price of feed

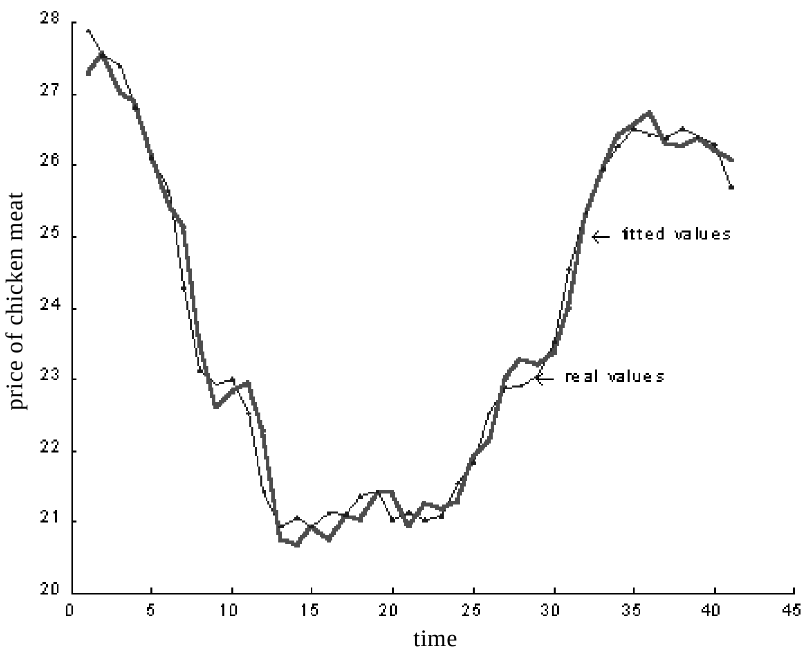

Figure 4. The dependence of chicken meat price on the price of feed and on the previous prices of chicken meat

Model 3:

Explained variable – the price of chicken meat in time t (y_t)

Explicative variables – the price of feed in time $t - 1$ to $t - 4$ ($x_{t-1}, \dots x_{t-4}$)

– time (t, t^2)

After excluding all unimportant parameters (for $\alpha = 0.01$), we have obtained a model in which the price of chicken meat depends solely on the price of fodder in time $t - 1$, and on time t, t^2. The regression function has, therefore, the following form (see Figure 5):

$$\hat{y}_t = 14.5865 + 0.004 \cdot x_{t-1} - 0.4652 \cdot t + 0.0109 \cdot t^2$$

The correlation index for this model is $I = 0.9653$, which means that this regression function explains 93.18% of the dispersion of the original values.

The comparison of values for Model 1 and Model 3 shows that the elimination of a significant parameter and its substitution by another parameter has led to the decrease in correlation, in other words, the model has become to be less appropriate.

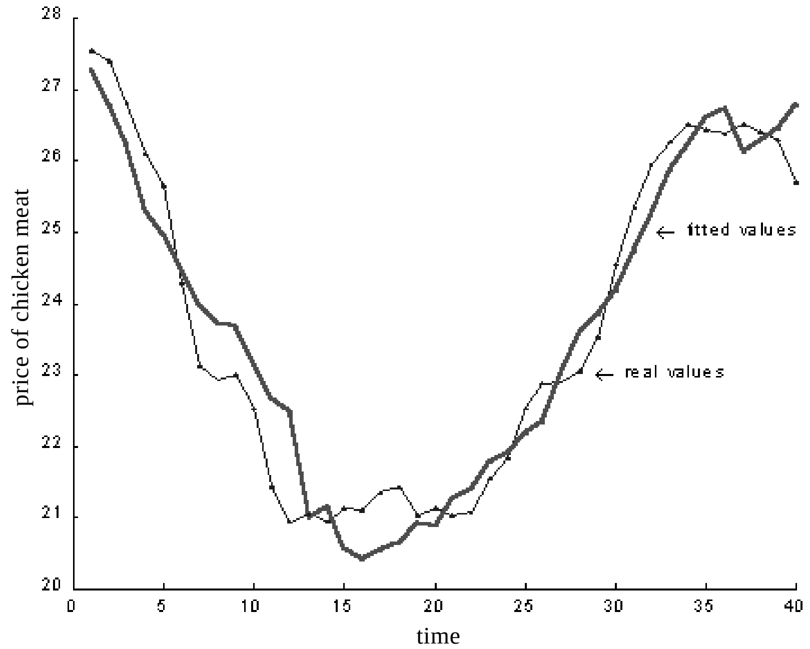

Figure 5. The dependence of chicken meat price on time and the price of fodder

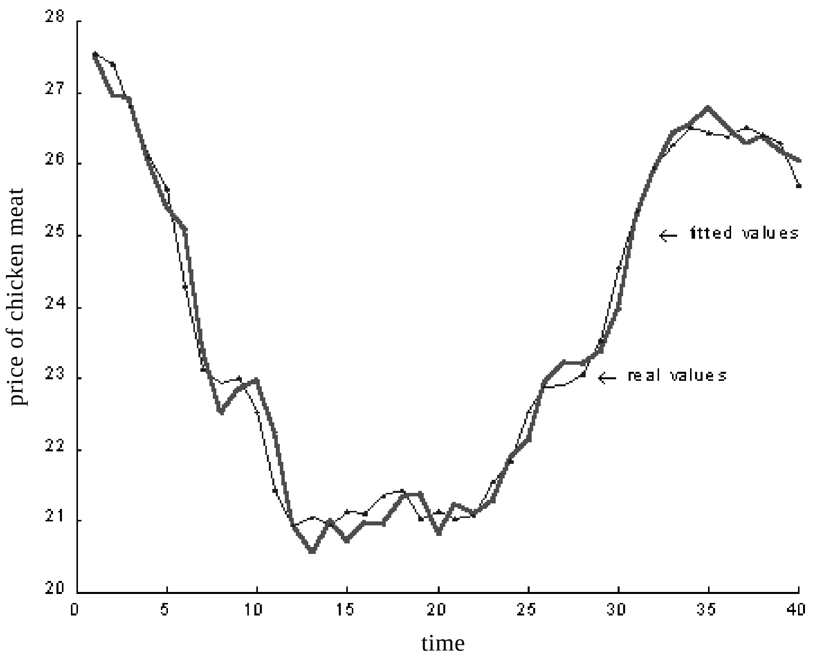

Figure 6. The dependence of chicken meat price on the price of feed and on the previous prices of chicken meat

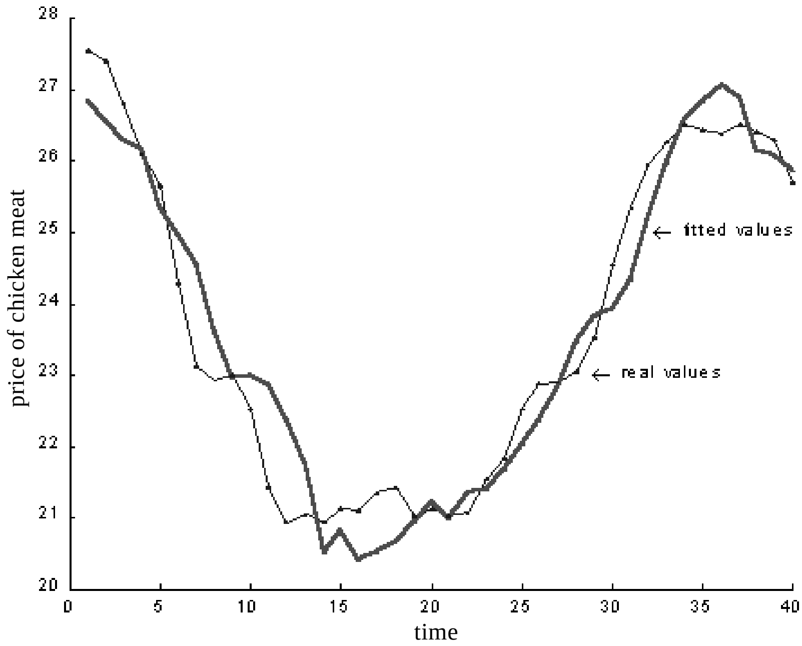

Figure 7. The dependence of chicken meat price on the previous price of feed and on the previous price of chicken meat

Model 4:

Explained variable – the price of chicken meat in time t (y_t)

Explicative variables – the price of feed in time t – 1 to t – 4 (x_{t-1}, … x_{t-4})
– time (t, t^2)
– the price of chicken meat in time t – 1 and t – 2 (y_{t-1}, y_{t-2})

After excluding all unimportant parameters (for $\alpha = 0.01$), the following model has been obtained (see Figure 6):

$$\hat{y}_t = 0.0009 \cdot x_{t-1} + 1.3556 \cdot y_{t-1} - 0.48 \cdot y_{t-2}$$

The correlation index for Model 4 is $I = 0.9904$.

Models 1–4 are rather theoretical models. Chicken fattening takes about a month and a half, i.e. practical reasons make it necessary to consider a two-month delay.

Model 5:

Explained variable – the price of chicken meat in time t (y_t)

Explicative variables – the price of feed in time t – 2 to t – 4 (x_{t-2}, …x_{t-4})
– the price of chicken meat in time t – 2 (y_{t-2})

After excluding all unimportant parameters (for $\alpha = 0.01$), the following model has been obtained (see Figure 7):

$$\hat{y}_t = 0.003 \cdot x_{t-2} + 0.6054 \cdot y_{t-2}$$

The correlation index for Model 5 is $I = 0.9619$.

The price of chicken meat is best explained using Model 2 and Model 4 (see Table 1). Model 4 has the least standard deviation of residuals s_e = 0.3289 CZK. These rather theoretical models explain 98% of the variability in the price of chicken meat ($I^2 \doteq 0.98$). Using this model, prospective customers can predict the price of chicken meat a month ahead.

Producers will more likely follow Model 5, which predicts the price two months ahead. This means that they can decide, according to the prediction obtained from this

Table 1. Model properties

	Model 1	Model 2	Model 3	Model 4	Model 5
$\bar{e}$	1.35×10^{-11} CZK	0.0015 CZK	4.5×10^{13} CZK	0.0048 CZK	0.0038 CZK
min (e)	–1.266 CZK	–0.874 CZK	–1.52 CZK	–0.836 CZK	–1.4545 CZK
max (e)	0.879 CZK	0.573 CZK	0.8 CZK	0.57 CZK	1.0202 CZK
Variation range	2.145 CZK	1.447 CZK	2.32 CZK	1.406 CZK	2.4747 CZK
s_e^2	0.311 CZK	0.11 CZK	0.387 CZK	0.1082 CZK	0.4037 CZK
s_e	0.558 CZK	0.332 CZK	0.6221 CZK	0.3289 CZK	0.6354 CZK
I	0.9736	0.9905	0.9653	0.9904	0.9619
I^2	0.94789	0.98109	0.9318	0.9809	0.92525

model, whether they should alter the number of fattened broiler chickens or not.

The suggested models represent one of the ways to deal with the problem in question. The price of chicken meat is influenced by a lot of other variables.

A significant cost item is constituted by labour costs. The proportion of these costs in the overall costs amounted to 9.4% in 2000. Direct wages per 1 000 days of fattening were, with regard to the increase in the productivity of labour, lower by 10%, although in the given year there was a wage increase that affected monthly wages (also contributed to by increasing farm prices of broiler chickens, compared to the low farm price of broiler chickens at the end of 1998 and in the first half of 1999). In 2000, there was a significant decrease in indirect labour because of better utilization of the capacity of fattening halls and thanks to the increased (by 41%) stock turnover.

As far as the other cost items are concerned, a relatively significant proportion (6.1%) is constituted by overhead costs, which decreased by 41.3% during 2001. There was an enormous increase (117%) in the production overheads in 1999, compared to 1998 (there remained farms with greater concentration of production, which implies greater power consumption) and administrative costs decreased by 1.7% (there was an increase in the concentration of production). Overall overhead costs went up by 25.6% in 1999 (Novák at al. 2001).

REFERENCES

Hebák P. (1998): Regrese – I. část, p. 88; ISBN 80-7079-909-9.

Hindls R., Hronová S., Novák I. (1999): Analýza dat v manažerském rozhodování. Grada, s. 358; ISBN 80-7169-255-7.

Novák J. et al. (2001): Analýza nákladů v českém zemědělství v roce 2000. VÚZE Praha.

Mládek Z., Nohel F. (2002): Ekonomické souvislosti výkrmu. Náš chov, (3): 45–49.

Arrived on 23rd May 2002

Contact address:

Mgr. Veronika Pezlarová, Mendelova lesnická a zemědělská univerzita v Brně, PEF, Ústav statistiky a operačního výzkumu, Zemědělská 1, 61300 Brno, Česká republika
tel: +420 5 4513 2036, e-mail: vpezlar@mendelu.cz