Sectoral Production Function of Chicken Broiler Fattening

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Abstract

The function was formed on the basis of sectional data from seven Czech businesses using data from seven to eight annual observations. The Least Square Dummy Variable Model was used to estimate the power function. The information presented in the article is the product of working on the Institutional Research Plan MSM 6046070906, "The Economics of Czech agriculture resources and their efficient use within a multifunctional agri-food systems framework".

Key words

Production Function, Broiler Chicken, Model.

Anotace

Funkce byla vytvořena na základě panelových dat z celkem sedmi českých podniků při sedmi až osmi ročních pozorováních. Tvar analytické funkce je mocninný a byla použita metoda nejmenších čtverců fixních efektů. Poznatky prezentované v článku jsou výsledkem řešení výzkumného záměru MŠM 6046070906 „Ekonomika zdrojů českého zemědělství a jejich efektivní využívání v rámci multifunkčních zemědělskopotravinářských systémů".

Klíčová slova

Produkční funkce, kuřecí brojler, model.

Introduction

The rearing of broiler chickens counts itself among the most important agri-food sectors in the Czech Republic and of all three main types of meat (pork, beef, poultry) it is this sector which is the only one to have displayed a trend of increasing consumption and related indicators over the last 20 years. In 1990, poultry had a mere 14 % share of total meat consumption in the CR and by 2007 it had already reached a full 30 % share. The highest poultry consumption per person was reached in 2005 (26.1 kg), with stagnation or slight decline recorded since this period [2]. This fact can mainly be ascribed to avian flu and the related global hysteria over the problem. In the same year, the lowest historical beef consumption was reached (9.9 kg). This is because there was a substitution effect between beef and poultry in consumption patterns – in 1990 beef had a 29 % share of total meat consumption, which had reached a mere 13 % by 2007. Nevertheless, the above described situation does not fully correspond to the level of national production, or specifically to levels of Czech poultry. In 1993 (earlier data is not available) there were 28.2 millions poultry in the CR while in 20078 there were 27.3 millions heads of poultry. These details make it clear that increased consumption has been covered by imports and thus that Czech produces are losing their position in relative terms.

Aim

The aim of this article is to estimate the industry's production function in the broiler chicken rearing sector and to apply it to the average business; this will focus particularly on:

- the production efficiency of separate production factors (feed mixes),
- deriving the average and marginal product functions,
- simulation calculations.

[8] *Until 2002 the state was monitored to 1.3., from 2003 to 1.4.*

Methods

The data base used for estimating the parameters was obtained from our own research from selected Czech businesses in the poultry rearing sector. The underlying data is in the form of panel data and was subject to critical analysis; extreme observations were eliminated in order to reduce distortions to the results to a minimum. The selected set of panel data examined contains a total of 112 observations which were obtained from seven businesses in the years 2006 and 2007. The average period between two removals from feedlot was 45 days including sanitation. Most of the businesses house their fowls in large sheds using various kinds of litter.

In terms of size (number of animals kept) the businesses cannot be considered a homogenous group, as the number of heads kept varies from 20 613 heads to 131 706 heads in one cycle. The average number of animals kept for all businesses and cycles comes to 59 520. The average starting weight of one animal is 0.04 kg for almost all cycles, with the exception of a number of cycles in two businesses in 2007, where the weight was given as 0.05 kg/animal. The underlying data also suggests that average slaughter weight is somewhere between 1.8 – 2.05 kg/head, with an average for the whole selected set of 1.9 kg/head.

In terms of number of animals kept, individual cycles (businesses) in the selected set can be divided into three groups - small (19 740 – 61 911 heads), medium (61 912 – 104 083 heads) and large (104 084 - 146 255 heads).

The duration of feeding in each business did not fall below 33 days and is not higher than 42 days, while the same duration of feeding did not lead to the same slaughter weight for all businesses, which also varies according to individual cycle. Equally, the duration of sanitation for each cycle displays a marked variability with values within the range of 7 – 30 days. However, it should be noted that a sanitation duration of greater than 20 days is really an exception (occurred for seven cycles), displaying an average of around 15 sanitation days.

The consumption of feed mixtures is divided among three kinds of feed mixture during the whole feeding period, these being BR1, BR2 and BR3. The use of each mixture as a percentage of total feed within the cycle also differs to some extent between separate businesses and cycles.

The feed mixture with the lowest represented percentage, BR1, is at around a level of 7.8 %, maximum 12.6 %. BR2 is represented in the feed at between 50.5 – 64.3 % and for BR3 its consumption interval as a percentage share of total feed mixture consumption is 29.1 – 37.2 %. The general production model was further broken down into the following form9:

$$YP_{nt} = \gamma_0 \times BR_{1nt}^{\gamma_1} \times BR_{2nt}^{\gamma_2} \times BR_{3nt}^{\gamma_3} \times e^{I_{nt}} \times e^{u_t}$$

where: BR1 – feed mixture BR1 consumption (kg/cycle),

BR2 – feed mixture BR2 consumption (kg/cycle),

BR3 – feed mixture BR3 consumption (kg/cycle),

YP – weight gain in kg/animal/cycle,

γ0, γ 1,…, γm – “m-th” structural parameter,

Int – dummy variable for “n-th” business,

e – Euler number

unt – stochastic variable for n-th business at time t.

The above detailed model is based on these basic suppositions:

- businesses focused on feeding broilers use their technological know-how and are thus stable producers of chicken meat, meaning that they had produced chicken meat for a sufficient length of time before the period the underlying data was obtained, making them established in their sector;
- the feed used is always made up of three kinds of feed mixture, these being BR1, BR2, BR3 and these mixtures are identical for all cycles in terms of nutritional content and conversion
- feeding lengths for separate mixtures BR1, BR2 and BR3 vary because the ingredients of these feeds substantially differ;

[9] *The reasons – see e.g. Tung and Rasmussen, 2005*

- feed mixture BR2 makes up the highest share of consumption within one cycle;
- consumption of feed mixture BR3 lasts for at least 5 days before animals are sent for slaughter, as this requirement arises from zoo-veterinary regulations (anticoccidial);
- all seven businesses monitored apply the same or similar rearing technology, this being floor or deep litter husbandry.

After undertaking a partial analysis and on accepting the above detailed suppositions the following hypotheses were stipulated:

H1: Consumption of BR1 feed mixture positively affects the weight gain of broilers fed on it.

H2: Consumption of BR2 feed mixture positively affects the weight gain of broilers fed on it.

H3: Consumption of BR3 feed mixture positively affects the weight gain of broilers fed on it.

H4: All elasticity values (production efficiencies for each feed mixture) are within the range (0;1), which characterises the rational stage.

Results and discussion

The specified model was first estimated using an ordinary least squares method (OLSM); however this estimation did not have the required agreement between theoretical and empirical values of endogenous variables and therefore it was decided to do the estimation using a fixed effects least squares model (LSDVM). The resulting estimates now had the required properties and are presented in the results[10]. Because the estimated function was a power function, it was necessary to linearise it (see method, eg Hušek, 2003).

Model analytical form:

ln(YP) = -0.117*ln(BR1) + 0.192*ln(BR2) + 0.073*ln(BR3) – 1.426 + 0.268*ln(I1) +

(SE)[11] (0.058) (0.027) (0.014) (0.386) (0.054)

0.073*ln(I2) + 0.323*ln(I3) + 0.159*ln(I4) + 0.272*ln(I5) + 0.546*ln(I6)

(0.023) (0.05) (0.021) (0.083) (0.106)

The interpretation of the results of the estimated production function will be focused on a number of points. Firstly, the estimate as a whole and its full range of elemental descriptive characters will be assessed. Subsequently, an analysis and interpretation of the estimated parameters will be undertaken from a statistical and practical viewpoint. Finally, a test of the estimate will be carried out.

The R^2 value = 0.54 % (explanatory capability of the model) can be considered rather poor. However, account should be taken of the fact that apart from the dummy variables, the model includes only three variables, representing the consumption of the three types of feed mixtures, and the resultant production is doubtlessly influenced by other variables unavailable to us. The estimate was also calculated using an unbalanced set of panel data. Of the seven businesses used, the smallest number of observations was 12 for two businesses, with the largest being 15 observations for one business. The average business provided 13 observations. The estimate was created on the basis of a total of 94 observations. In this way, using the above detailed LSDVM a total of 10 parameters were estimated, three of which characterise the relationship between the consumption of specific feed mixtures and the remaining 7 quantifying the relationship between the dummy variables and the endogenous variable (production). The dummy variables are symbolised ‘I1...I7’. The effect of time, specifically any seasonality, was insignificant; livestock farming and especially livestock farming in enclosed spaces is not subject to these influences.

Although at first glance a power function estimate may appear more complicated than the estimate of a linear function, because all empirical values must be transformed into their logarithmic forms, the resultant parameters can be interpreted as elasticity. The validity of the above detailed hypotheses was tested with the following results. The first hypothesis was rejected due to negative signs, the second and third hypotheses could not be rejected on the basis of the production surface created. The final hypothesis was then rejected for a similar reason to the first. The second variable, consumption of the BR2 feed mixture, has the

[10] *The OxMetrics5 software was used for our estimate (PCGive12)*
[11] *SE means standard error for the structural parameter estimate*

greatest effect on production. The efficiency of variable production factors can thus be interpreted in the following way:

i. Increasing consumption of feed mixture BR1 (in kg/cycle) by 1 % results in a reduction in weight gain (in kg/head/cycle) of 0.117 %. This at first sight illogical relation has its origin in higher death rates of chickens during the first phase of feeding. BR1 feed mixture makes up only 7.8 % to 12.6 % of total consumption in the selected set monitored. The p-value of this parameter is 0.045, meaning the parameter is significant at significance level of 0.05.

ii. Increasing the amount of feed mixture BR2 (in kg/cycle) by 1 % results in an increase in weight gain (in kg/head/cycle) of 0.192 %, which can be considered as the conversion of feed mixture BR2. If the price of feed mixture BR2 is calculated at 6 CZK/kg, then the cost for a weight gain of one gram of chicken is 3.1 hellers and the production effect is 2.3 hellers for a realisation price for farmers of 22.82 CZK/kg, which is the average value valid for 2008. This would then imply that the marginal product point is slightly below the point of marginal costs (price of BR2 production factor) and the chickens are unnecessarily overfed without it bringing the sought economic effect. The p-value was generated as 0.000, meaning the parameter is statistically significant even for the strictest criteria.

iii. Increasing the consumption of feed mixture BR3 (in kg/cycle) by 1 % results in an increase in weight gain (in kg/animal/cycle) of 0.073 %. Because feed mixture BR3 is only slightly cheaper than BR2, the distance between the price of BR3 and the point of marginal income will be even worse. The p-value was generated as 0.000, meaning the parameter is statistically significant even for the strictest criteria.

The partial production functions for each business are displayed in Table 1.

The next part will be focused on the average business, or more specifically the business whose constant lies on the median. This is the second business with company specification parameter 0.314, as the estimated parameter could be called. For this business, the behaviour of the BR2 average production factor is:

$APP2BR2 = 0.105 \times BR2^{-0.808} \times BR3^{0.073}$,

BR2 marginal production factor:

$MPP2BR2 = 0.020 \times BR2^{-0.808} \times BR3^{0.073}$,

BR3 average production factor:

$APP2BR3 = 0.105 \times BR2^{0.192} \times BR3^{-0.927}$,

Identification	Function
Business P1 function	$YP_{P1} = 0.240 \times BR1^{-0.117} \times BR2^{0.192} \times BR3^{0.073}$
Business P2 function	$YP_{P2} = 0.314 \times BR1^{-0.117} \times BR2^{0.192} \times BR3^{0.073}$
Business P3 function	$YP_{P3} = 0.258 \times BR1^{-0.117} \times BR2^{0.192} \times BR3^{0.073}$
Business P4 function	$YP_{P4} = 0.331 \times BR1^{-0.117} \times BR2^{0.192} \times BR3^{0.073}$
Business P5 function	$YP_{P5} = 0.281 \times BR1^{-0.117} \times BR2^{0.192} \times BR3^{0.073}$
Business P6 function	$YP_{P6} = 0.315 \times BR1^{-0.117} \times BR2^{0.192} \times BR3^{0.073}$
Business P7 function	$YP_{P7} = 0.414 \times BR1^{-0.117} \times BR2^{0.192} \times BR3^{0.073}$

Source: Own investigation and calculations

Table 1: Production function for each business.

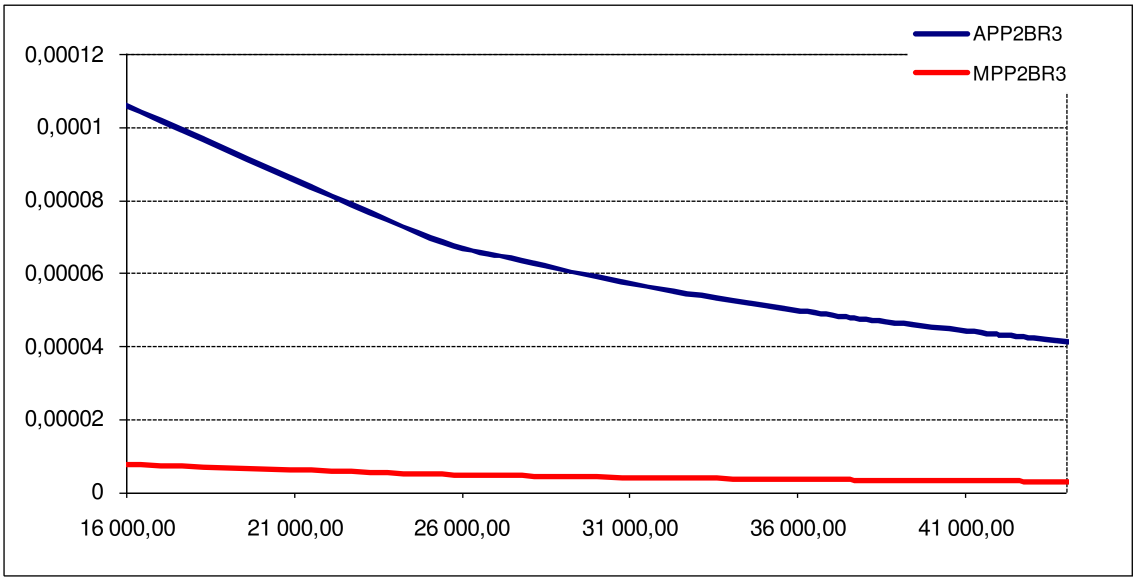
And finally the BR3 marginal production factor:

MPP2BR3 = 0.008 x $BR2^{0.192}$ x $BR3^{-0.927}$.

Graph 1 summarises the behaviour of feed mixture BR3's marginal and average production for the average business.

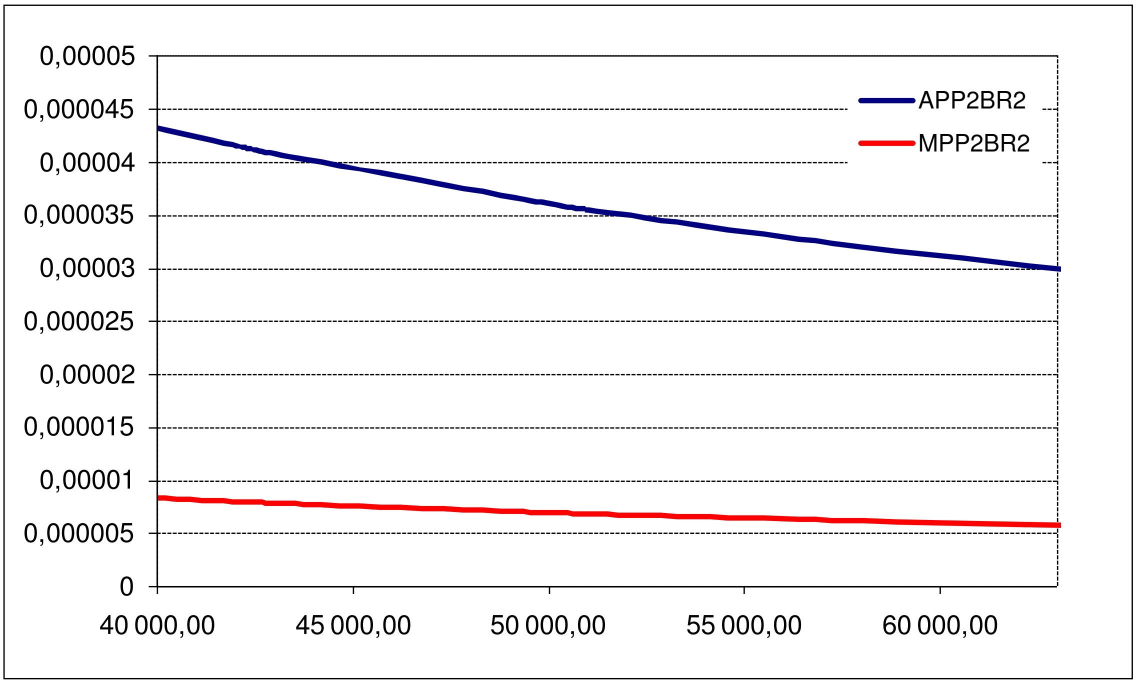
The average production for feed mixture BR3 falls over the whole range of use of the detailed production factor considered. This fact suggests a falling conversion for this feed mixture, which clearly corresponds to the observed facts.

The marginal production function behaviour is similar (Graph 2), which according to the laws of economics should also fall. In practice, this means that a constant consumption of feed mixture BR2 and increasing consumption of mixture BR3 leads to falling chicken meat production growth.



Source: Own investigation and calculations

Graph 1: BR3 marginal and average production factor for business ϕ AVE.



Source: Own investigation and calculations

Graph 2: BR2 marginal and average production factor for business ϕ AVE.

Where the amount of BR3 feed mixture is fixed to an average with BR2 feed mixture varied, the behaviour of the marginal and average production functions are very similar to the previous case, except that both functions do not drop so steeply.

Conclusion

The efficiency of feed mixture BR2 is more or less in agreement with the zootechnical and economic reality. The efficiency of feed mixture BR2 is the highest of all feed mixtures because it is used for the longest, 'supportive' part of feeding and is also within the range (1;0), which just demonstrates that optional production occurs in the rational part of the range. Were it to be greater than one, the factor's production efficiency would be unnecessarily strong, i.e. production would stop while there was still a very large marginal growth of production. The same kind of dependence is displayed by feed mixture BR3's production efficiency, except that the factor efficiency here is significantly lower. This is because this feed mixture is not as efficient as feed mixture BR2 in economic terms, although it must nevertheless be included for zoo-veterinary reasons. It is probably most difficult to explain the negative impact of feed mixture BR1. To a certain extent, this will probably be caused by two antagonistic and related factors: as feed mixture BR1 is only fed for a short period, this results in higher mortality and thus to a negative impact on production; if it is fed for a sufficiently long period then there is less time to feed mixture BR2 in particular, which has the highest (conversion) efficiency. The decision when exactly to transfer from BR1 to BR2 is determined by many other factors and in addition this moment needs to be determined with relatively high precision. Another big problem is the fact that chickens are to some extent heterogenous in their growth and weight over the whole cycle, but in terms of transaction costs, it is not possible to choose an individual approach, even to the most minimal extent. The statistical significance of the effect of BR1 is lowest for all variables monitored, but nevertheless its significance level comes to 0.045. The other parameters are statistically significant even under the strictest of conditions.

Because of the method used, the model also contains dummy variables I1 to I6 and a constant, a total of 7 dummy variables; this number thus represents the number of businesses in the selected set. Their structural parameter values can thus be interpreted as a quantification of each business's specific characteristics. The quantified specific characteristics of the first business is mathematically the anti-logarithm of the constant, the quantified special characteristics of the second business is then the anti-logarithm of the difference between the constant and the I1 dummy variable parameter, the quantified specific characteristics of the third business is then the anti-logarithm of the difference between the constant and the I2 dummy variable parameter, and so on. It seems then that one of the model suppositions can be said to be fulfilled, that being that there are no significant differences between businesses.

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