

## **Economic appraisal of the commodity vertical of pork market and its input prices in the Czech Republic**

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### **Abstract**

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The aim of the article is to evaluate economic aspects of commodity verticals of pork market, including pigs for slaughter and pork meat taking into account input prices in the Czech Republic. In the Czech Republic, pig breeding and pork production had a traditional and significant position, which has been hampered by foreign competition in recent years. Czech producers can hardly compete with large enterprises from Germany or the Netherlands with modern infrastructure, concentrated production and are thus able to benefit from the economies of scale. Lower competitiveness of the Czech Republic in the production of pork reflects also in its high focus on imports. A result of several years of decline in the total number of pigs is high non-self-sufficiency of the Czech Republic in the production of pork and a high focus on imports. This is also evident from the calculated models of development trends in pork production in the Czech Republic. Correlations of pig breeding and other indicators were determined on the basis of selected indicators and create a basis for further analyses. A multidimensional regression analysis was performed using the backward stepwise regression method to evaluate pork production and selected economic indicators in the Czech Republic and confirmed an assumption that input prices have a significant impact on pork production in the Czech Republic.

*Keywords:* market; pork; commodity vertical; input price; multidimensional regression; correlation

### **Introduction**

The period when the Czech Republic and other countries of Central and Eastern Europe became members of the European Union was difficult not only because the EU integrated with the most states in its history, but also because Europe needed to find its future direction to create conditions for its long-term competitiveness in a global context and at the same time to guarantee and maintain the social level within the present social model. Past issues of competitiveness of agriculture in the Czech Republic have been dealt by for instance by Bečvářová (2008). The aim of the article is to evaluate economic aspects of commodity verticals of pork market, including pigs for

slaughter and pork meat taking into account input prices in the Czech Republic. The expected scientific contribution of the article is to be seen in a novel calculation of development models of pork meat in the Czech Republic where a starting point for it is an introductory analysis of the development of the pork market in the Czech Republic. Further findings have been provided by calculated correlations for selected indicators of pig breeding and finally by a multi-dimensional regression analysis of pork meat production and other economic indicators that can render evidence on the role of input prices in production in the Czech Republic using stepwise regression. The current knowledge base and state-of-the-art issues of this topic are described in next paragraphs.

Increased market integration and its growth has been a major stimulus to the development of regional and intra-regional trade within Europe. The result of it was a significant shift in geographic and commodity distribution. Rodríguez et al. (2014) identifies new opportunities in operations research to improve pork supply chain efficiency. From the point of view of the supply-oriented commodity chain, its individual elements should be interconnected enabling a mutual cooperation. The market structure in selected livestock agri-food chains in the Czech Republic has been evaluated by Rumánková (2012). Current commodity verticals are typically grouped into hybrid forms of control structure to take advantage of centralized coordination and control as well as the information benefits of decentralized business, see for instance Flanigan & Sutherland (2016) or Stock et al. (2014). Partners in such relationships cooperate in some areas, but they also compete with each other to the extent that can be set out in different agreements that they signed together. For this reason, the networks keep constantly changing.

Organizations that are part of the hybrid forms of networks are experiencing significant development in commodity verticals. A greater emphasis has been put on the control of processes and products in connection with the gradual development of the demand and supply side of the market and the interpretation of quality control. Moschini & Meilke (1989) dealt with modeling of the patterns of structural changes in U.S. demand for meat. Fraser & Moosa (2002) presented meat demand estimation in the presence of stochastic trend and seasonality in the United Kingdom. Tamáš and Bečvářová (2013) dealt with the issue of pigs and pork market in agribusiness. Agricultural producers of pigs for slaughter are undergoing a very demanding production period. Low purchase prices and missing state support in recent years has resulted in termination of activity of many farms and in further fall in the self-sufficiency of pork production. According to some studies, per capita pork consumption may also decline (Windhorst, 2018). According to Chovancová (2009), conditions for the creation of cooperatives, which play an increasingly important role in balancing economic, social and environmental interests, should be supported by the government. Spatial Dimension of Czech Enterprise Support Policy was dealt by Novosák et al. (2018). The increasing importance of cooperation has been also emphasized by Dvořáková & Palát (2014).

Klein (2018) draws attention to the fragile links within the transnational networks between Germany and Central and Eastern Europe. Another issue is that regional food has steadily grown in popularity, see for instance Moog & Gebhardt (2018). They focussed on German-speaking countries and show that perceptions among consumers and sponsor-

ing organisations differ especially considering the size and definition of a region and despite the fact that consumers associate types of animal husbandry with regional origins of pork, the correlation results are only weak. Therefore the international competition is very high and Czech primary producers have to compete with large enterprises from Germany or the Netherlands, which have modern infrastructure, concentrated production and are thus able to benefit from the economies of scale. Technological advances have been a key reason for productivity growth in pork and also beef industries that were studied and compared by Maples et al. (2019) and this perspective allows for the consideration of what the future might hold for each industry, and how technological innovation influences product quality, trade, and market structure.

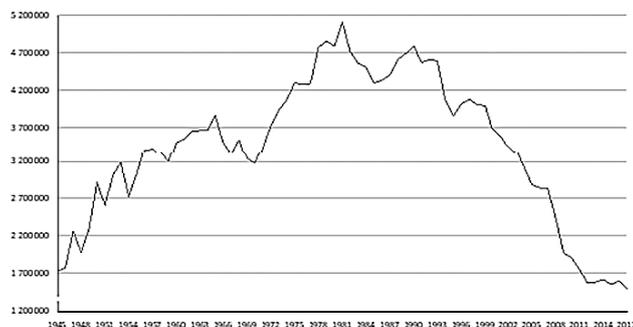
## Material and Methods

The main research aim is to evaluate economic aspects of commodity verticals of pork market, including pigs for slaughter and pork meat taking into account input prices in the Czech Republic. The starting point of the research is an analysis of the development of the pork market in the Czech Republic, which is a prerequisite for calculation of development models of pork meat. Furthermore, a correlation matrix for selected indicators of pig breeding is calculated. Final multi-dimensional regression analyses of pork meat production and other economic indicators examine the role of input prices in production. To carry out correlation and multidimensional regression we use available annual data published in the Czech Republic and in the European Union. The sources of data are CZSO (2019), eAGRI (2019) and EUROSTAT (2019). For the models of multidimensional analyses we use a method of stepwise regression. The analytical type of models has been chosen in a form of the dependence of interpreted and explicatory variables linear in parameters. It refers to the additive model type when there are only operations of addition and subtraction between particular variables. Statistical software UNISTAT has been used for the statistical computation of following models.

## Results and Discussion

The first part of the article deals with the evaluation of the development of the pork market in the Czech Republic. The situation on the pork market has been determined by many factors, including the pork market worldwide. Soare & Chiurciu (2017) analyzed the evolution of the pork market worldwide in the 2010-2016 periods. Among the indicators analyzed in their study, the most significant were: number of

pigs worldwide, global pork production, the total consumption of pork in the world, average prices for live pigs, imports and exports of pork etc. The market situation is a result of changes in supply and demand, including their main determinants. Figure 1 shows the development of the number of pigs in the Czech Republic in 1945–2017.



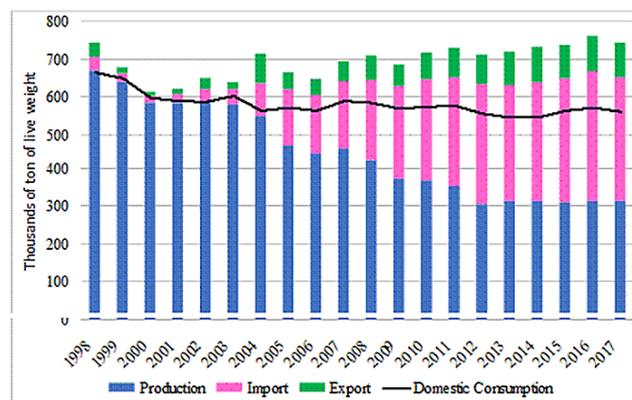
**Fig. 1. Number of pigs in the Czech Republic in 1945–2017 (pcs)**

Source: Own processing of data from Historical Statistical Yearbook of the CSSR (1985) and CZSO (2019)

From Figure 1 it is obvious that the number of pigs was steeply rising during the post-war reconstruction of agriculture, at the time of collectivization (1949–1960), but also at the time of the centrally organized agriculture (1967–1989). In 1981, the number of pigs reached a maximum of 5 106 thousand. In the following years, there has been a gradual decline in the numbers of pigs. After 1989, sweeping economic reforms in the agrarian sector were realized, when ownership relations to land and agricultural property were restored, state-owned agricultural cooperatives were transformed and privatized, and price liberalization was a key measure (Bečvářová, 2014). The issues of the economic transition and the agricultural economics have been elaborated for instance by Csaki et al. (2008). Businesses breeding pigs, which were originally created by a co-operative association of several entities, were privatized without farming land and if they did not manage to acquire farmland, they experienced a significant shock due to a neglected risk diversification in business (Pavlů, 2012). The next economic depression in this sector emerged around the year 2000, when the Czech Republic was preparing to join the European Union, and pig breeders had to prepare for the implementation of international trade liberalization agreements. After joining the European Union in 2004, the pig farming sector started to face increased competition from many EU Member States. Pig breeders and meat processing companies were forced to spend money on investment in breeding and technological

equipment to be able to comply with applicable standards, hygiene and health regulations.

Increasing legislative requirements have resulted in growing breeding costs and reducing profitability. Other important factors that can be mentioned at this point are following: the sharp rise in cereal prices in 2007 that makes a substantial proportion of pig feed mixture, increasing pressures from other EU countries importers and considerable fluctuations in agricultural producer prices. Nevertheless, the pork production worldwide was increasing in this period and some growth tendencies have been observed even in some of the EU countries (Pavlů, 2012). A result of a continuous several years lasting decline in the total number of pigs is that the Czech Republic is no longer self-sufficient in pig meat production and has to rely heavily on imports (Figure 2). Similarly, for beef production compare with Palát et al. (2012).

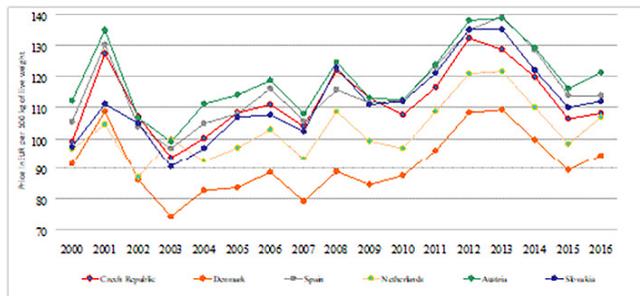


**Fig. 2. Balance of production and consumption of pork in the Czech Republic in the period 1998–2017**

Source: Own processing of data from eAGRI (2019)

As already mentioned, since 2003 there has been a decrease in production and an increase in imports of pork in the Czech Republic. This leads to a negative balance of foreign trade and according to the Ministry of Agriculture this trend can be also expected in the following period. In 2000, 583.9 thousand tons of live weight of pork was produced in the Czech Republic, in 2016 it was only 310.5 thousand tons of live weight. Imports increased from 19.3 thousand tons to 355 thousand tons of live weight in 2016, while the consumption of pork stagnates between 41–42 kg per person per year and is not expected to increase. However, it will be necessary to take into account also other commodities with a higher added value than live pigs or pork meat for the overall picture of commodity development. These goods have been

growing in exports from the Czech Republic in recent years and a positive balance of foreign trade has been achieved for some goods. Figure 3 shows the development of prices of pigs for slaughter in selected EU countries.



**Fig. 3. The development of prices of pigs for slaughter in selected EU countries in the period 2000–2016 (Czech Republic, Denmark, Spain, Netherlands, Austria and Slovakia)**

Source: Own processing of data from EUROSTAT (2019)

Lower prices for pigs for slaughter than in other countries under review were recorded in Denmark and the Netherlands. These countries are characterized by a high level of specialization in pig production and a concentration of farms in large-capacity farms that bring economies of scale. Higher prices of pigs for slaughter than in the Czech Republic were recorded in Austria and Spain, while prices in Slovakia oscillate at the Czech Republic's price level. Price developments in Germany or Poland are not available. The development of pigs' livestock and pork production in other countries has been partly described by Rotaru (2018). A deep evaluation of the sustainability of contrasted pig farming systems with a development of a market conformity tool for pork products based on technological quality traits was carried out by Gonzales et al. (2014), Bonneau et al. (2014a, 2014b). It is obvious that Czech producers can hardly compete with large enterprises from Germany or the Netherlands, which have modern infrastructure using newest technology, have concentrated production and are thus able to benefit from the economies of scale. And for instance Klein (2018) argues also that the added-value potentials offered by the Central and Eastern European countries have become increasingly lucrative for the German pork industry, particularly as the domestic market is showing a certain degree of saturation in terms of consumption.

### Models of development trends and correlation matrix of pork production in Czech Republic

Following models of developmental trends in pork production in Czech Republic were calculated. Linear, quadratic

and cubic functions were used in the models and correlation indices were calculated where the variables  $a_{yt}$ ,  $b_{yt}$ ,  $c_{yt}$ ,  $d_{yt}$  are model parameters and  $t$  is time variable. Table 1 shows models of these development trends in the reference period 2005–2016.

**Table 1. Model of development trends of pork production in the reference period 2005–2016 in the Czech Republic**

Model	$a_{y y t t}$	$b_{y y t t}$	$c_{y y t t}$	$d_{y y t t}$	$I_{y y t t}$
1	36.7658789	-1.4861608	–	–	0.9595**
2	40.024181	-2.8825764	0.10741658	–	0.9826**
3	37.967171	-1.2927261	-0.18644200	0.015	0.9865**

Source: own calculations of data from CZSO (2019)

Notes: type of function: 1 – linear, 2 – quadratic, 3 – cubic; model parameters:

$a_{y|y|t|t}$ ,  $b_{y|y|t|t}$ ,  $c_{y|y|t|t}$ ,  $d_{y|y|t|t}$ ; correlation index  $I_{y|y|t|t}$ ;

\* – significance level  $\alpha = 0.05$ ; \*\* – significance level  $\alpha = 0.01$

The equation for the linear model is:

$$y_t = a_{yt} + b_{yt} t.$$

The equation for the quadratic model is:

$$y_t = a_{yt} + b_{yt} t + c_{yt} t^2.$$

The equation for the cubic model is:

$$y_t = a_{yt} + b_{yt} t + c_{yt} t^2 + d_{yt} t^3.$$

Parameters of models of developmental trends of pork production were calculated in the reference period 2005–2016 and correlation indices  $I_{yt}$  are statistically significant at the significance level  $\alpha = 0.01$ . Linear trends in pork production are decreasing in the Czech Republic, see negative regression coefficient  $b_{yt}$ . The development of the monitored indicator is better expressed by the use of non-linear models.

Furthermore, the attention has been paid to possible correlations of several indicators of pig breeding in the Czech Republic. The factual material used for the following calculations comes from the data available on EUROSTAT (2019). Development trends and methods of regression and correlation analysis were used. Following indicators were selected: pork production, price index of agricultural products: pigs and number of pigs. Table 2 shows the correlation matrix for selected indicators of pig breeding in the Czech Republic.

One asterisk indicates the results statistically significant at the significance level  $\alpha = 0.05$  and two asterisks then statistically highly significant results at the significance level  $\alpha = 0.01$ . A positive correlation between the number of pigs and the production of pork meat is statistically highly significant at the significance level  $\alpha = 0.01$  in the Czech Republic. There is also a negative correlation between the number of pigs and the price index of agricultural products: pigs, although not statistically significant.

**Table 2. Correlation matrix for selected indicators of pig breeding in the Czech Republic**

	M	P	N
M	1.0000	X	X
P	-0.4470	1.0000	X
N	0.9439**	-0.3817	1.0000

Source: own calculations of data from EUROSTAT (2019)

Notes: M – pork production; P – agricultural product price index: pigs; N – number of pigs;

\* – significance level  $\alpha = 0.05$ ; \*\* – significance level  $\alpha = 0.01$

### Multidimensional regression analysis of pork production and other economic indicators

It can be assumed that input prices have a significant impact on pork production in the Czech Republic. In this part, a multidimensional regression analysis is performed to evaluate the pork production and following economic indicators in the Czech Republic in the period 2001–2016: MP – pork production (1000 tons) (dependent variable), CT – pork consumption total (in 1000 tons of live weight), CP – consumption of pork (in kg per capita), P – price for 100 kg of live weight (pigs), N – number of pigs (in 1000 pcs), E – electricity (price for 100 kwh), D – price of diesel (price per 100 l), FR – complete feed for pigs at breeding (price per 100 kg), FF – complete feed for pigs for fattening (price per 100 kg). The method is so-called backward stepwise regression using the least squares method without constant. Different models are constructed using different available variables. The dependent variable is always pork production (MP).

Model 1 explains pork production (MP) with five variables: cost per 100 kg live weight (pigs) (P), number of pigs (N), electricity (cost per 100 kwh) (E), diesel price (price per 100 l) (D), complete feed for fattening pigs (price per 100 kg) (FF). Calculated Model 1 is:

$MP = -1.049001288836 P + 0.126690332377 N + 8.985 E + 0.360158899981 D + 1.409300586909 FF$ . The results of the multi-dimensional regression analysis of pork production and the above-mentioned economic indicators in the Czech Republic in Model 1 are shown in Table 3.

In model 2, variable N (number of pigs) was not included in the stepwise regression calculation and four explanatory variables were selected using multidimensional regression analysis: total pork consumption (in 1000 tons of live weight) (CT), electricity (price per 100 kwh) (E), complete feed for breeding pigs (100 kg) (FR), complete feed for fattening pigs (100 kg) (FF). Model 2 is expressed by the equation:  $MP = 1.122152444264 CT - 14.185549461 E - 62.13058183692 FR + 53.94465846026 FF$ . The results of the multidimensional regression analysis of pork production and the above-mentioned economic indicators in the Czech Republic in Model 2 are shown in Table 4.

In terms of statistical significance, Models 1 and 2 are highly statistically significant ( $P = 0.01$ ). Therefore, based on statistical evaluation using multidimensional regression analysis by the backward step regression, both models seem to be suitable for explaining the pork production indicator in the Czech Republic with the introduction of input prices as variables.

### Conclusions

In the Czech Republic, pig breeding and pork production had a traditional and significant position, which has been hampered by foreign competition in recent years. Moreover, pork is one of the most consumed meats in the Czech Republic. The situation on the pork market in the Czech Republic has been determined by many factors, including the number of pigs. After joining the European Union in 2004, the pig farming sector faced competition from many Member States,

**Table 3. Multidimensional regression analysis of pork production and selected economic indicators in the Czech Republic: Model No. 1**

	Coefficient	Std. Error	t-Statistic	Significance
P	-1.049001288836	0.496331765835	-2.113508264116	0.0582
N	0.126690332377	0.00812178733339	15.59882414745	0.0000
E	8.985887679274	4.193507610247	2.1428094365	0.0553
D	0.360158899981	0.465783673062	0.773232126436	0.4557
F <sub>F</sub>	1.409300586909	1.858946968425	0.758117692891	0.4643
Residual Sum of Squares		2376.829542541	Adjusted R-squared	0.997924603461
Standard Error		14.69950383374	F (5,11)	1539.674017496
Mean of Y		314.713125	Significance of F	0.0000
Stand Dev of Y		73.52809374371	Durbin-Watson Statistic	1.888722594758
R-squared		0.998573164879	log of likelihood	-63.20803640654

Source: own calculations of data from EUROSTAT (2019)

**Table 4. Multidimensional regression analysis of pork production and selected economic indicators in the Czech Republic: Model 2**

	Coefficient	Std. Error	t-Statistic	Significance
C <sub>T</sub>	1.122152444264	0.0755082505864	14.8613222469	0.0000
E	-14.185549461	4.740466873764	-2.992437208983	0.0112
F <sub>R</sub>	-62.13058183692	18.16069511315	-3,421156593941	0.0051
F <sub>F</sub>	53.94465846026	17.816821329	3.027737521982	0.0105
Residual Sum of Squares		10079.89966777	Adjusted R-squared	0.991931910638
Standard Error		28.98260925073	F (4,12)	492.780329231
Mean of Y		314.713125	Significance of F	0.0000
Stand Dev of Y		73.52809374371	Durbin-Watson Statistic	2.032570277048
R-squared		0.993948932979	log of likelihood	-74.57015206555

Source: own calculations of data from EUROSTAT (2019)

reducing production and increasing imports of pork. From a geographical point of view, an intra-EU pig production is concentrated in a number of countries, where Denmark, Germany, Spain, France, the Netherlands and Poland account for more than two thirds of pigs. Pig production is highly specialized across countries, such as Denmark for piglet rearing and Spain for pig fattening. A result of several years of decline in the total number of pigs is high non-self-sufficiency and lower competitiveness of the Czech Republic in the production of pork and a high focus on imports. This is also evident from the calculated models of development trends in pork production in the Czech Republic. Through correlation analysis, correlations of pig breeding and other indicators were determined on the basis of three selected indicators and created a basis for further analyses. In addition, a multidimensional regression analysis was performed using the backward stepwise regression method to evaluate pork production and selected economic indicators in the Czech Republic and tested whether input prices significantly affect pork production. While both models are highly statistically significant, they seem to be useful for explaining the pork production indicator in the Czech Republic introducing input prices as variables. This confirms an assumption that input prices have a significant impact on pork production in the Czech Republic.

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