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Examination of existence of the law of one price at Czech meat markets

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Abstract

This paper deals with the problem of the law of one price. The topic is examined on wholesaler level of pig meat and beef meat agri-food chains in the Czech Republic. The aim of the paper is to examine whether the law of one price holds at these markets. To fulfill the aim the multivariate time series analysis is employed, concretely co-integration analysis and Vector error correction model (VECM). The analysis is based on time series of wholesale price in individual regions of the Czech Republic which contain bi-weekly data in period from May 2004 to June 2011. The analysis shows that the law of one price does not hold at both markets. However, if the transaction costs are omitted there might be found some regions where it works. Finally, some dominant as well as submissive regions were detected at both pig meat as well as beef meat market.

Key words

Price transmission, law of one price, agri-food market, pig meat, beef meat, co-integration analysis, VECM.

Anotace

Tento článek se zabývá problematikou existence zákona jedné ceny. Téma je zkoumáno na zpracovatelské úrovni vertikály vepřového a hovězího masa v České republice. Cílem článku je ověřit, zda zákon jedné ceny na zvolených trzích platí. Pro naplnění cíle je použita analýza vícerozměrných časových řad, konkrétně kointegrační analýza a Vector error correction model (VECM). Analýza je založena na časových řadách cen potravinářských výrobců vepřového a hovězího masa v jednotlivých regionech České republiky, které obsahují čtrnáctidenní data v období květen 2004 – červen 2011. Provedená analýza ukazuje, že zákon jedné ceny na trhu vepřového ani hovězího masa neplatí. Nicméně při zanedbání transakčních nákladů byla platnost zákona jedné ceny prokázána mezi některými dílčími regiony. Dále byly detekovány regiony, které lze považovat na daném trhu za dominantní, popř. submisivní.

Klíčová slova

Cenová transmise, zákon jedné ceny, zemědělsko-potravinářský trh, vepřové maso, hovězí maso, kointegrační analýza, VECM.

Introduction

Pig meat and beef meat belong among the most important sectors of livestock production. Pork meat is the most popular meat in the Czech Republic. Its consumption reaches level of 40 kg/year/capita even its long-term tendency is decreasing; it decreased from level of 50 kg/year/capita in year 1990 to 41 kg/year/capita in year 2010. Then, the consumption of poultry meat reaches level of 25 kg/year/capita, however, its tendency is increasing. The consumption of poultry meat increased from 13.5 kg/year/capita in year 1990 to 25 kg/year/capita in year 2010. Poultry meat is favorite especially due to its price, taste and cooking features. Finally, the third place in meat consumption belongs to beef meat. The consumption of beef meat reaches level of 10 kg/year/capita, however, its long-term tendency is decreasing. The consumption of beef meat decreased from almost 30 kg/year/capita in year 1990 to 10 kg/year/capita in year 2010. The decreasing tendency of beef meat consumption is connected especially with relatively high price compared to other meats. The consumption at domestic market as well as foreign demand is fundamental for the farmers as well as

processors. The production of meat is driven by its consumption. Moreover, the supply of meat is affected by the price level as the main factor of economic relationships. Thus, the level of farm-gate price, wholesale price and consumer price and their transmission in both vertical and horizontal direction are crucial.

Due to the data availability the paper is focused just on pig meat market and beef meat market. Pig meat and beef meat markets in the Czech Republic were already analyzed e.g. in Lechanová (2006), Čechura et al (2010), Mach et al (2010), Malý et al (2011a) or Malý et al (2011b).

The price transmission can be analyzed in both vertical and horizontal direction as it was already mentioned. At horizontal level the analysis might be connected with the question of the law of one price. The law of one price is usually examined in connection with foreign trade at world level. It means that usually the price transmission among different countries all around the world is examined. Then, transaction costs play an important role as well as foreign policies. However, the law of one price may be applied also in the case of one economy and its partial markets. Thus, an inter-regional existence of the law of one price might be examined.

Spatial price transmission at selected agri-food chains and the law of one price were analyzed e.g. in Ardeni (1989), Baffes (1991), Goodwin et al (1990), Asche (1999), Goodwin (2006), Serra et al (2006), Bakucs, Fertö (2007), Hockman, Vöneki (2007), Pippenger, Phillips (2008), Šobrová, Čechura (2008), Babiker, Abdalla (2009), Goodwin et al (2011) or Graubner et al (2011).

Material and methods

The aim of this paper is to examine whether the law of one price does hold at selected meat agri-food markets in the Czech Republic, concretely pig meat and beef meat markets. To fulfill the aim the following hypotheses were defined.

H1: The law of one price does not hold among all regions at wholesaler level at pig meat as well as beef meat market in the Czech Republic.

H2: The position and the strength of analyzed regions are not equal. Among these regions there may be found dominant regions that influence the prices in other regions.

To verify the hypotheses the multivariate time series analysis is employed, concretely co-integration analysis and Vector error correction model are used in the following steps:

i) detection of time series stationarity using Augmented Dickey-Fuller test (ADF) and Phillips-Perron test (PP);

ii) detection of long-run relationship between analyzed variables using co-integration analysis;

iii) estimation of Vector Error Correction Model (VECM) to describe the relationship between prices in selected regions. VECM model is estimated in the following form:

$$\Delta X_t = \eta + \Pi X_{t-1} + \sum_{s=1}^{p} C_s \Delta X_{t-s} + U_t ,$$

where C_s for $s>p$, X_t is a k x 1 vector of variables which are supposed to be integrated of order 1, (I(1)), $u_1, \ldots, u_t$ are nid $(0,\sum)$ and $\prod$ is a matrix of the long-run relationship;

iv) examination of the law of one price based on the estimated models, price transmission elasticity and test of weak exogeneity.

The time series of wholesale price of pig meat and beef meat in individual regions of the Czech Republic contain bi-weekly data in period from May 2004 to June 2011. The time series contain 172 observations except the time series in North-west region and Moravia Silesia region where several missing values are included due to not available data. The data set was provided by State Agricultural Interventional Fund. The law of one price is examined at pig meat and beef meat market in the Czech Republic, i.e. it is analyzed the price transmission of the wholesale price among the following regions: Middle Bohemia region (MB), North-east region (NE), North-west region (NW), South-east region (SE) and Moravia-Silesia region (MS). The calculations were done using an econometric software RATS 6.35 and CATS 2.0.

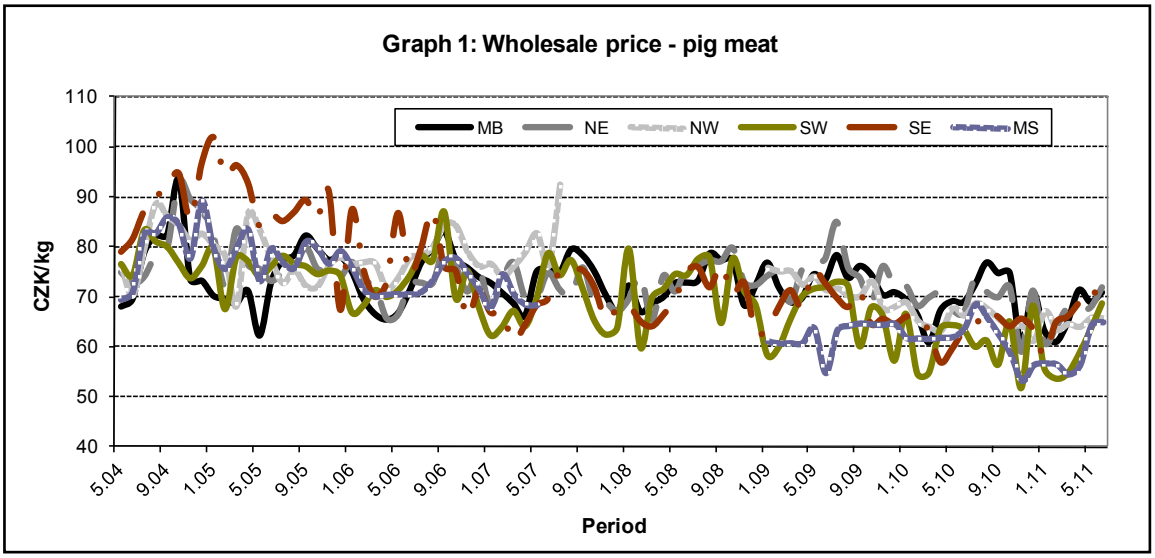
Results and discussion

The following text consists of two parts. First of all, the main statistic characteristics of analyzed time series, i.e. the wholesale price of pig meat and beef meat in individual regions of the Czech Republic, are introduced and their main properties described. Subsequently, the law of one price is examined based on price transmission analysis among individual regions at selected agri-food markets.

I. Description of analyzed time series

Pig meat

Graph 1 shows the development of the wholesale price of pig meat in individual regions of the Czech



Source: author's processing.

Graph 1: Wholesale price - pig meat.

Region	MB	NE	NW	SW	SE	MS
Mean (CZK/kg)	72.52	73.20	73.63	69.90	73.32	69.07
Std. deviation	5.34	5.49	6.64	6.88	10.70	8.75
Variation coefficient (%)	7.37	7.50	9.02	9.84	14.60	12.67
Index number (%)	106.66	94.84	85.44	80.58	86.64	93.73

Source: author's calculations.

Table 1: Main characteristics of pig meat time series.

Republic in period from May 2004 to July 2011. The graph shows decreasing tendency of all time series in analyzed period except the time series in Middle Bohemia region where the wholesale price increased by 6.66 % between May 2004 and June 2011. The other time series decreased by approximately 5.0 – 19.5 % in the same period (see table 1). The highest decrease of the wholesale price was detected in South-west region.

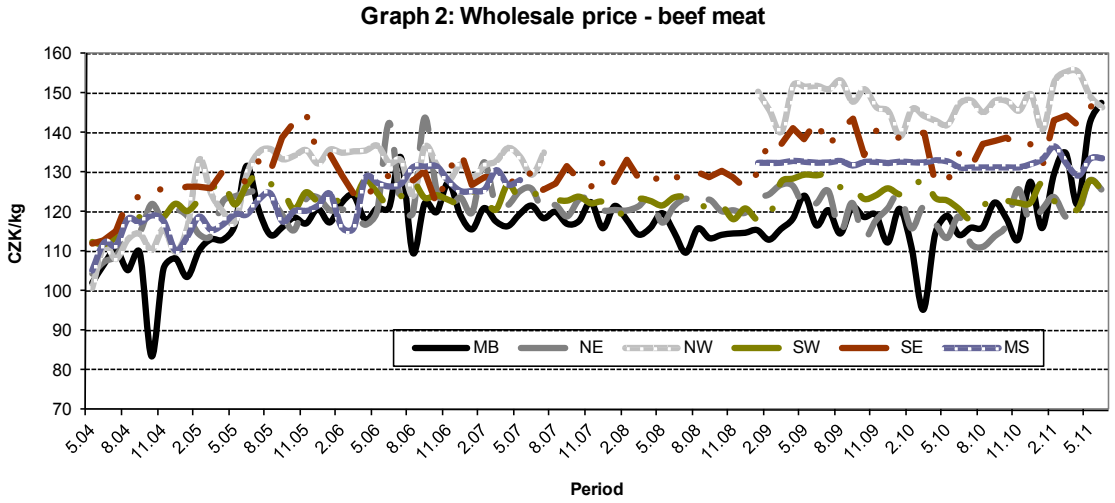
The decreasing tendency of the wholesale price of pig meat is connected with the situation in pig meat agri-food chain after the EU accession. The Czech Republic is former competitive producer of pig meat; however, EU conditions and requirements have affected the extent of pig meat production in the Czech Republic. The production is not efficient anymore and many of the Czech farmers had to finish their production due to profit-loss reasons. Decreasing tendency of the wholesale price of pig meat in the Czech Republic is connected with cheap import of pork meat that has devastated Czech pig producers. Anyway, the development of the consumer price of pork meat does not really correspond with the development of the wholesale price.

Table 1 shows average level of wholesale price of pig meat in individual regions of the Czech Republic, their standard deviations and coefficients of variation. Average value of wholesale price reach values between 69.07 CZK/kg and 73.69 CZK/kg. Then, North-west region might be considered as the region with the highest price level while Moravia-Silesia region might be considered as the region with the lowest price level.

The variation of examined time series in analyzed period is quite high. The values of coefficient of variation equals from 7.37 % to 14.60 %. The highest fluctuation was detected in the time series of wholesale price in South-east region while the lowest fluctuation was detected in Middle Bohemia region and North-east region.

Beef meat

Graph 2 shows the development of the wholesale price of beef meat in individual regions of the Czech Republic in period from May 2004 to July 2011. The graph shows increasing tendency of all time series in analyzed period. The wholesale price in individual regions of the Czech Republic increased by approximately 9.5 – 54.5 % between May 2004 and June 2011 (see table 2). The highest increase of the wholesale price was detected in North-west region. Thus, the level of wholesale price in this region became the highest of all regions of the



Source: author's processing.

Graph 2: Wholesale price - beef meat.

Region	MB	NE	NW	SW	SE	MS
Mean (CZK/kg)	117.22	120.59	136.06	123.01	132.01	126.26
Std. deviation	7.75	5.00	13.30	3.38	7.18	7.40
Variation coefficient (%)	6.61	4.14	9.77	2.75	5.44	5.86
Index number (%)	140.67	120.30	154.37	109.63	133.09	125.92

Source: author's calculations.

Table 2: Main characteristics of beef meat time series.

Czech Republic.

Table 2 contains mean values of the wholesale price time series of beef meat in individual regions of the Czech Republic in period from May 2004 to June 2011, their standard deviations and coefficients of variation. Average values of beef meat reach the values from 117.22 CZK/kg to 136.06 CZK/kg. Based on these values North-west region might be considered as the region with the highest price level while Middle Bohemian region might be considered as the region with the lowest price level.

The variation of examined time series in analyzed period is not as extreme as in case of the wholesale price of pig meat. The coefficient of variation reaches the values between 2.75 % and 9.77 %. The lowest fluctuation was detected in South-west region while the highest fluctuation was detected in North-west region.

II. Examination of existence of the law of one price at selected markets

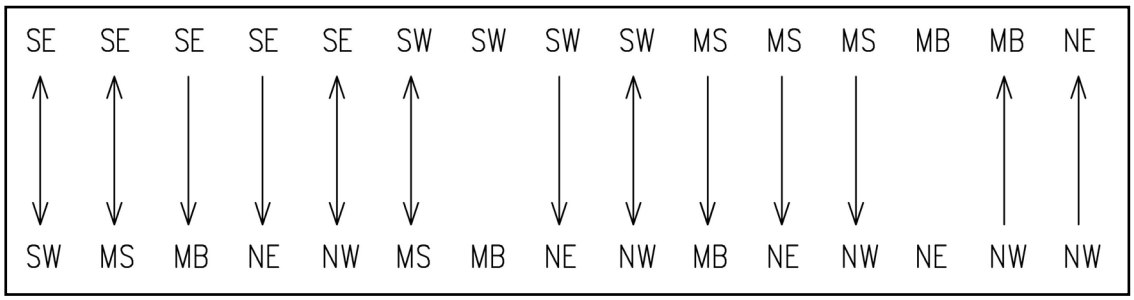
To examine the existence of the law of one price and to verify the hypotheses defined the co-integration analysis was employed and Vector error correction model (VECM) was estimated. Finally, the results are discussed and the conclusions stated.

Pig meat

First of all, the stationarity of the time series of the wholesale price of pig meat in individual regions was examined using Augmented Dickey-Fuller test and Phillips-Perron test. Based on these tests all time series might be considered as non-stationary and integrated of order one, i.e. I(1). Thus, the long-run relationship might be examined.

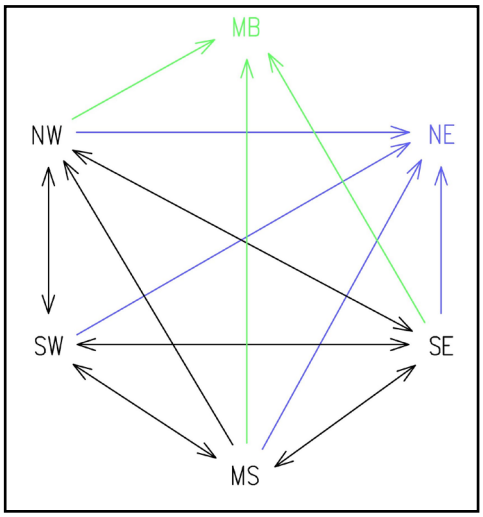
The co-integration analysis and the test of weak exogeneity proved the long-run relationship between each two regions of the Czech Republic except the regions South-west – Middle Bohemia and Middle Bohemia – North-east. Subsequently, the VECM model was estimated for each two regions to find whether the relationship between the wholesale prices is one-way or simultaneous. Estimated models proved simultaneous relationship between some regions and one-way relationships between another (see Scheme 1).

Then, complex relationships among all analyzed regions were examined. The final result is shown in Scheme 2. According to the results of estimated models several regions with specific position were



Source: author's calculations.

Scheme 1: Price transmission between regions – pig meat.



Source: author's calculations.

Scheme 2: Complex price transmission – pig meat.

	SW	MS	MB	NE	NW
SE	0.5	0.9	0.2	0.4	0.5
SW		0.9	x	0.8	**1.0**
MS			0.4	0.5	**1.0**
MB				0.4	0.5
NE					0.7

Source: author's calculations.

Table 3: Price transmission elasticity – pig meat (%).

detected. First of all, two regions were detected in submissive position in relation to other regions, concretely Middle Bohemia and North-east region. These regions are connected just with one-way relationship with other regions of the Czech Republic. Thus, Middle Bohemia and North-east regions seem to be the price takers. On the other hand region Moravia-Silesia might be assumed as the region in mainly dominant position. The region is connected with other regions with both simultaneous and one-way relations. However, the other regions take its price changes. Moreover, among the analyzed regions partial circle of simultaneous relationships was detected. The regions South-west – South-east – Moravia-Bohemia are connected with partial simultaneous relationships with almost perfect price transmission.

Finally, the price transmission elasticity was quantified to examine whether the law of one price hold at pig meat market. The coefficients of elasticity reach the values between 0.2 % and 1.0 % (see table 3). Then, it might be concluded that the law of one price does not hold at analyzed market. However, some of the partial relations might be characterized by its existence . The law of one price does hold among regions South-west – North-west and Moravia-Silesia – North-west. Among these regions perfect price transmission does exist; even in case of Moravia-Silesia – North-west regions the relationship is just one-way. Moreover, among the

regions South-east – Moravia-Silesia and South-west – Moravia-Silesia the price transmission might be considered as almost perfect (the price transmission elasticity equals approximately 0.9%).

Beef meat

First of all, the stationarity of the time series of wholesale price of beef meat in individual regions of the Czech Republic was examined using Augmented Dickey-Fuller test and Phillips-Perron test. The tests showed that all analyzed time series are non-stationary and integrated of order one, i.e. I(1). Thus, the long-run relationship between individual regions might be examined.

The co-integration analysis and the test of weak exogeneity proved the long-run relations between each two analyzed regions except the relationship between South-west – North-east regions. Among the regions several cases of simultaneous relationships were proved as well as several one-way relationships (see scheme 3). In case of beef meat market more one-way relations were detected compared to pig meat market.

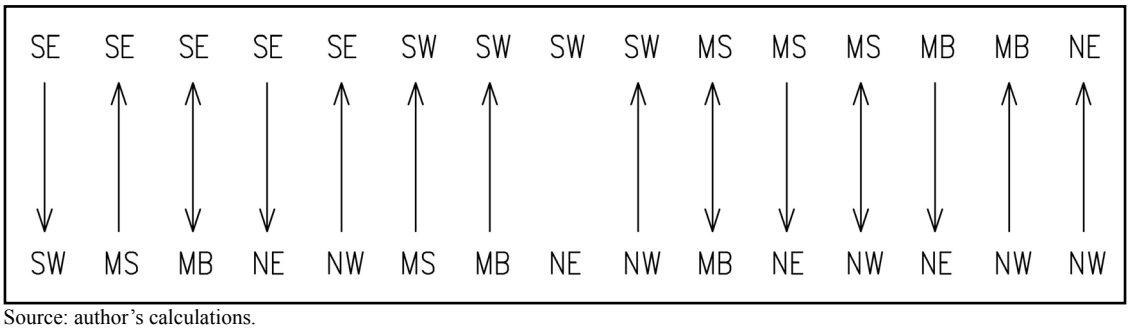
Then, complex relationships among all analyzed regions were examined. The final result is shown in scheme 4. Also in case of beef meat market some regions in dominant position as well as the regions in submissive position were found. Two regions were detected to be in submissive position, concretely North-east region and South-west region. These two regions might be assumed as the price takers. The level of their wholesale price and its changes do not influence the level of the wholesale price in other regions. On the other hand North-west region and Moravia-Silesia region were detected as mainly dominant regions. Thus, the price in these regions influences the price level in other regions.

Finally, the law of one price was examined based on the price transmission elasticity. The values of coefficient of elasticity equal 0.1 – 0.8 % (see table 4). Based on this examination it might be concluded that the law of one price does not hold at beef meat market in the Czech Republic. Moreover, at this market even partial perfect price transmission was not proven. Generally, the relations at beef meat market are less elastic compared to the relations at pig meat market.

Conclusions

The aim of the paper was to examine whether the law of one price holds at wholesaler level of pig meat and beef meat markets in the Czech Republic. The aim was fulfilled using co-integration analysis and Vector error correction model. The analysis was processed based on the time series of wholesale price of pig meat and beef meat in individual regions of the Czech Republic. The time series contained bi-weekly data in period from May 2004 to June 2011.

The analysis was connected with two hypotheses to verify. The first hypothesis which says that the law of one price does not hold among all regions at wholesaler level at pig meat as well as beef meat market in the Czech Republic was accepted (except of some partial relations). It means that



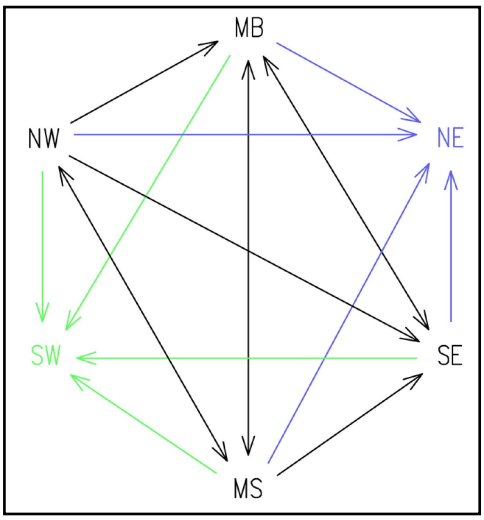
Source: author's calculations.

Scheme 3: Price transmission between regions – beef meat.

	SW	MS	MB	NE	NW
SE	0.2	0.3	0.8	0.1	0.5
SW		0.3	0.2	x	0.1
MS			0.6	0.1	0.5
MB				0.3	0.4
NE					0.1

Source: author's calculations.

Table 4: Price transmission elasticity – beef meat (%).



Source: author's calculations.

Scheme 4: Complex price transmission – beef meat.

even the transaction costs are omitted the price transmission is not perfect. It might be caused e.g. by an asymmetric information that influences the smoothness of the price transmission as well as other reasons. Even the law of one price does not hold the long-run relationship between the wholesale prices in individual regions was proven (in almost all cases).

The second hypothesis which says that the position and the strength of analyzed regions are not equal and that among these regions there may be found dominant regions that influence the prices in other regions was accepted, too. The analysis showed that some regions are connected with mutual relationships while the other regions are connected just with one-way relations. Also the price transmission elasticity showed differences in price transmission between individual regions. Thus, some regions with the specific position were detected. For example North-east region might be considered as submissive at both pig meat and beef meat market and Moravia-Silesia might be considered as region with dominant position at both markets.

To conclude, it may be said that the wholesale prices are transmitted among the regions; however, they are not transmitted perfectly. Moreover, some relations are just one-way relations. Thus, some of the regions might be considered as dominant while other regions might be considered as submissive in this transmission.

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References

[1] Ardeni, P.G. (1989): Does the Law of One Price Really Hold for Commodity Prices? American Journal of Agricultural Economics, Vol. 71, No. 3. ISSN 00029092.

[2] Asche, F., Bremnes, H., Wessells, C.R. (1999): Product Aggregation, Market Integration, and Relationships between Prices: An Application to World Salmon Markets. American Journal of Agricultural Economics, Vol. 81, No. 3. ISSN 0002-9092.

[3] Babiker, B.I., Abdalla, A.G.M. (2009): Spatial price transmission: a study of sheep markets in Sudan. African Journal of Agricultural and Resource Economics, Vol. 3, No. 1. ISSN 1993-3738.

[4] Baffes, J. (1991): Some Further Evidence on the Law of One Price. American Journal of Agricultural Economics, Vol. 73, No. 4. ISSN 0002-9092.

[5] Bakucs, L. Z., Fertö, I. (2007): Spatial Integration on the Hungarian Milk Market. 104th (joint) EAAE – IAAE Seminar Agricultural Economics and Transition.

[6] Čechura, L. et al. (2010): Production functions in livestock production. Key Publishing, Ostrava. ISBN 978-80-7418-090-3. [in Czech]

[7] Goodwin, B.K., Grennes, T.J., Wohlgenant, M.K. (1990): A Revised Test of Law of one Price Using Rational Price Expectations. American Journal of Agricultural Economics, Vol. 72, No. 3. ISSN 0002-9092.

[8] Goodwin, B.K., Holt, M.T., Prestemon, J.P. (2011): North American oriented strand board markets, arbitrage activity, and market price dynamics: a smooth transition approach. American Journal of Agricultural Economics, Vol. 93, No. 4. ISSN 0002-9092.

[9] Goodwin, B.K. (2006): Spatial and Vertical Price Transmission in Meat Markets. Market Integration and Vertical and Spatial Price Transmission in Agricultural Markets Workshop.

[10] Graubner, M., Balmann, A., Sexton, J.R. (2011): Spatial Price Discrimination in Agricultural Product Procurement Markets: A Computational Economics Approach. American Journal of Agricultural Economics, Vol. 93, No. 4. ISSN 0002-9092.

[11] Hockmann, H., Vöneki, É. (2007): Assessing Market Functioning: The Case of the Hungarian Milk Chain. In 104th (joint) EAAE – IAAE Seminar Agricultural Economics and Transition.

[12] Lechanová, I. (2006): The transmission process of supply and demand shocks in Czech meat commodity chain. Agricultural Economics, 52 (2006). ISSN 0139-570X.

[13] Mach, J., Křístková, Z., Čechura, L., Šobrová, L., Žídková, D., Peterová, J., Kroupová, Z., Malý, M., Gallová, L., Maier, T., Hučko, J. (2010): Modelling the cattle breeding production in the Czech Republic. Agris on-line Papers in Economics and Informatics, Vol. II, No. 3/2010. ISSN 1804-1930.

[14] Malý, M., Kroupová, Z., Žídková, D., Peterová, J., Šobrová, L., Čechura, L., Pánková, L., Mach, J., Křístková, Z., Maier, T., Hučko, J. (2011a): Potential for pork production in the Czech Republic. Agricultural Economics, 57 (2011). ISSN 0139-570X.

[15] Malý, M., Malá, Z., Šobrová, L., Hálová P. (2011b): Partial Equilibrium Model of Czech Beef Trade. Agris on-line papers in Economics and Informatics, Vol. III, No. 2, 2011. ISSN 1804-1930.

[16] Pippenger, J., Phillips, L. (2008): The Law of One Price: an Interpretation of the Literature and Some New Evidence. Journal of Academy of Business and Economics, Vol. April 1.

[17] Serra, T., Gil, J.M., Goodwin, B.K. (2006): Local polynomial fitting and spatial price relationships: price transmission in EU pork markets. European Review of Agricultural Economics, Vol. 33, No. 3. ISSN 0165-1587.

[18] Šobrová, L., Čechura, L. (2008): Interregional Comparison of Price Transmissions in Pork Agri-food Chain. Collection of papers of international conference: Countryside – Our World. CULS, Prague. ISBN 978-80-213-1851-9.

[19] Ministry of Agriculture: http://www.mze.cz

[20] State Agricultural Interventional Fund: http://www.szif.cz