The price transmission in pork meat agri-food chain

Cenová transmise v zemědělsko-potravinářské vertikále vepřového masa

L. Čechura, L. Šobrová

Czech University of Life Sciences, Prague, Czech Republic

Abstract: The paper deals with the analysis of price transmission in pork meat agri-food chain. The analysis is aimed at the determination of the type of market structure in the chain based on the derived theoretical model and fitted reduced model of price transmission in the form of VECM. Then, impulse-response analysis and decomposition of variance of fitted VECM show the system's reaction to innovations and the interaction between variables for longer forecast horizons. The results imply that processing stage may exercise oligopsonic power, i.e. the market structure has the type of oligopsony. Impulse-response analysis shows that the system approaches relatively fast the equilibrium and all responses are positive. Moreover, decomposition of variance informs about the increasing role of the wholesale price in the explanation of forecast error variance of agricultural price. Then, it follows from the obtained results (among other) that the pork meat agri-food chain may be characterised as demand-driven. The type of market structure implies that the agricultural support is in this case shared within the vertically related markets and thus is less efficient.

Key words: price transmission, pork meat, agri-food chain, market structure, farmer, processing industry

Abstrakt: Článek se zabývá analýzou cenové transmise v zemědělsko-potravinářské vertikále vepřového masa. Analýza se zaměřuje na určení typu tržní struktury ve vertikále s využitím odvozeného teoretického modelu a odhadnutého redukovaného modelu cenové transmise ve formě VECM. Impulse-response analýza a dekompozice rozptylu odhadnutého VECM dále ukazuje reakci systému na inovace a interakci mezi proměnnými v delším prognostickém horizontu. Výsledky analýzy naznačují, že zpracovatelé ve vztahu k zemědělcům využívají své síly, tj. tržní strukturu lze v této části vertikály označit jako oligopson. Impulse-response analýza ukazuje, že systém se vrací poměrně rychle do rovnovážného stavu a reakce na inovace jsou pozitivní. Dekompozice rozptylu dále informuje, že s rostoucím prognostickým horizontem roste role ceny potravinářských výrobců ve vysvětlení chyby prognózy cen zemědělských výrobců. Z obdržených výsledků plyne, že zemědělsko-potravinářská vertikála vepřového masa má charakter poptávkově řízené vertikály. Typ tržní struktury dále implikuje, že podpora zemědělců je v tomto případě sdílena ostatními články vertikály, což snižuje její efektivnost.

Klíčová slova: cenová transmise, vepřové maso, zemědělsko-potravinářská vertikála, tržní struktura, zemědělec, potravinářský průmysl

The situation on agricultural market is determined by several factors. One of them is the type of market structure not only on the agricultural market but also on other vertically related markets in the particular agri-food chain. Whereas agricultural producers are represented by numerous farmers and enterprises, the processing industry is concentrated and the retail market is significantly influenced by multiple large, national retail chains. Thus, the market structure in agri-food chain is frequently characterized by oligopoly and/or oligopsony. The question is whether market power is abused with respect to upstream suppliers and/or downstream consumers in the Czech agri-food chain.

It is well known that in the presence of oligopoly, prices may adjust differentially to changes in costs due to the curvature of the demand function. The concept of oligopoly is very well illustrated in the

Supported by the Ministry of Education, Youth and Sports of the Czech Republic (Grant No. MSM 6046070906).

industrial organization literature. On the other hand, its related concept of oligopsony, i.e. competition among few buyers, is described very briefly, if ever, in the theoretical literature. Rogers and Sexton (1994) introduce two reasons why industrial organization economists pay little attention to the buyer's market power: (i) they do not think it is very important, and (ii) they do not believe it presents any unique modeling issues relative to the seller's market power.

Oligopsony may not be important on the industrial markets but it can have a very significant impact on the agricultural market or on the agri-food chain. This significance arises from the characteristics and specifics of agricultural production and agricultural and food markets. Thus, modeling oligopsony can supply unique results about the nature of relations in agri-food chains that help to understand, among other issues, how the markets are pushed into equilibrium states, what is the position of single elements in the chain, what is the competitiveness of farmers, what is the effect of agricultural policy and how is this effect in the chain distributed.

This paper analyses price transmission in one of the most important sectors of the Czech agriculture – pork meat agri-food chain. VAR (Vector autoregressive model) and VECM (Vector error correction model) models are used as the appropriate tools for price transmission analysis.

AIMS AND METHODOLOGY

The aim of the paper is to analyze the nature of price transmission in pork meat agri-food chain based on the derived theoretical framework.

The paper follows a hypothesis that assumes simultaneous relations in price transmission with an excess of demand power over supply power. More precisely, the hypothesis says that the chain is demand-driven and oligopsony power is exercised.

The data set is gathered from the Czech Statistical Office and covers the period January 1995 to December 2006. The analysis of pork meat vertical chain uses the time series of agricultural price and the wholesale price. The agricultural price represents the farm price of pork in Czech Crown per kilogram. The wholesale price is a weighted average of wholesale prices of the processed pig products. The weights stem from the slaughter yields. The RATS software version 6 and the package CATS in RATS (Hansen, Juselius 2002) are used to fit and to test the models.

The Augmented Dickey-Fuller test (ADF) and Phillips-Perron test (PP) are used to test the stationarity of time series. VAR modeling or VECM respectively are used in the part of empirical analysis. The employment of the particular econometric model depends on the relation between the economic time series (Labys 2006). The VECM can be written as:

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

where $C_S = 0$ for $s > p$, X_t is $k \times 1$ vector of variables, which are integrated of order 1, i.e. $I(1)$, $u_1, \dots, u_t$ are nid $(0, \Sigma)$ and Π is a matrix of long-run relationship. If the variables are not cointegrated, the VECM reduces to VAR model, i.e.:

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

The impulse-response analysis is used to analyze the impact of innovations in price transmission. The decomposition of variance is employed to show the interaction between variables especially for longer forecast horizons.

The structure of the contribution is as follows. Firstly, the theoretical model is derived. The model enables the analysis of market structure based on the estimation of price transmission elasticity. Secondly, the specified model is estimated and analyzed. Finally, the theoretical-empirical consequences are drawn.

RESULTS AND DISCUSSION

Theoretical model

The theoretical framework is defined to enable the analysis of the market structure in the agri-food chain. The idea of the theoretical framework follows Lloyd et al. (2004). The characteristics of producers on the agricultural and processing markets can be defined by including the necessary assumptions as follows.

Agricultural market

The agricultural market consists of n producers (farmers or agricultural enterprises) that supply the quantity of agricultural product Q_A depending on the price level P_A and specific supply shifts S_A. This can be expressed in the form of inverse supply function (1).

$$P_A = f(Q_A, S_A | x_1, \dots, x_n) \quad (1)$$

The characteristics of the supply side on the agricultural market can be supposed to be close to the competitive market. Thus, the first order condition for profit maximization of all agricultural producers is equal to:

$MR = P_A = MC$

Assuming the competitive market structure on the supply side of the agricultural market implies not taking into account the substitution matrix (i.e. the Hessian matrix of second-order partials of the profit function) of prices of agricultural products supplied by different agricultural producers in the profit maximization of i^{th} processing firm.

Processing market

The demand function for the processed product can be expressed in the form of an inverse demand function (2)

$$P_P = f(Q_P, D) \tag{2}$$

where: D stands for demand shifts.

The profit function of i^{th} processing firm, which determines output supply and input demand of i^{th} processing firm, can be expressed as follows:

$$\pi_i = P_P\,(Q_P) \times Q_{Pi} - P_A\,(Q_A) \times Q_{Ai} - C_i \tag{3}$$

where:

$Q_{Pi} = \frac{Q_{Ai}}{k}$

k = the input-output coefficient

C_i = other costs

Assuming that other costs C_i do not depend on the Q_{Pi}, i.e. are constant for each level of production in the production space R, then the profit function depends only on the input price from the agricultural market (i.e., on the price of the agricultural raw material) and on the output price, i.e. the price on the processing market. Consequently, the profit function can be defined as the maximum value function:

$$\pi_i(P_P, P_A) = \max\left[P_P(Q_P)\cdot Q_{Pi} - P_A(Q_A)\cdot Q_{Ai} - C_i\right] \tag{4}$$

The first order condition for profit maximization of firm i can be written as:

$$\frac{\partial \pi_i(P_P, P_A)}{\partial Q_{Pi}} = 0 \quad i.e.$$

$$P_p + Q_{Pi} \times \frac{\partial P_p}{\partial Q_P} \times \frac{\partial Q_P}{\partial Q_{Pi}} - kP_A - kQ_{Ai} \times \frac{\partial P_A}{\partial Q_A} \times \frac{\partial Q_A}{\partial Q_{Ai}} = 0 \tag{5}$$

Condition (5) can be reordered into (6).

$$P_P + Q_{Pi} \times \frac{\partial P_p}{\partial Q_P} \times \frac{\partial Q_P}{\partial Q_{Pi}} = kP_A + kQ_{Ai} \times \frac{\partial P_A}{\partial Q_A} \times \frac{\partial Q_A}{\partial Q_{Ai}} \tag{6}$$

For better orientation below, it is useful to express relation (6) in elasticity notation

$$P_p \times (1 + \frac{\chi_i}{e_{PP}}) = kP_A \times (1 + \frac{\delta_i}{e_{PA}}) \tag{7}$$

where:

χ_i = the conjectural elasticity of firm i in the processing market

e_{PP} = the price elasticity of demand for the processing market of given product

δ_i = the conjectural elasticity of firm i in the agricultural market

e_{PA} = the price elasticity of an agricultural product's supply

Expressing (7) for the whole market, i.e. summing all firms on the market by using firms' market shares as weights, results in (8).

$$P_p \times (1 + \frac{\chi}{e_{PP}}) = kP_A \times (1 + \frac{\delta}{e_{PA}}) \tag{8}$$

In relation (8), χ and δ stand for industry level market parameters.

Assuming the following situations or values of χ and δ, respectively:

(i) $\chi = \delta = 0$: if both χ and δ are equal to zero then the market structure is competitive, i.e. there is no market power, and the above-stated relation (8) simplifies to (9).

$$P_P = kP_A \tag{9}$$

where: kP_A = the industry level of marginal cost.

(ii) $\chi > 0$ and $\delta = 0$: if χ is higher than zero and δ is equal to zero, then there is oligopoly power and no oligopsony power on the market. In this situation, the first order condition for profit maximization can be rewritten into (10).

$$P_p \times (1 + \frac{\chi}{e_{PP}}) = kP_A \tag{10}$$

(iii) $\chi = 0$ and $\delta > 0$: if χ is equal to zero and δ is higher than zero, there is oligopsony power and no oligopoly power on the market. Then, the relation (8) can be rewritten into (11).

$$P_p = kP_A \times (1 + \frac{\delta}{e_{PA}}) \tag{11}$$

(iv) $\chi > 0$ and $\delta > 0$: if both parameters are higher than zero, both oligopoly and oligopsony power can be found on the market. The first order condition for profit maximization is in the form of (8).

Assuming that demand shifts on the processing market play a major role in changes in the price transmission of the agri-food chain and cost shifts are not significant, then according to Lloyd et al. (2004) the market structure is competitive if and only if the price transmission elasticity is equal to 1. Oligopoly power is exercised if the price transmission elasticity is higher than 1 and oligopsony power is present if the price transmission elasticity is less than 1. There could also be the possibility of both oligopoly and oligopsony power. In such a case, price elasticity is higher than one but lower than the elasticity of oligopoly power only. The precise numbers of the price transmission elasticises for determining the type of market power depend on the height of parameters in the relation (8). In this paper, the calculation of price transmission elasticises for a given market structure is not done. The above-stated information is sufficient for determining if market power (oligopsony power) is exercised or not, and this is sufficient for the purposes of the following analysis.

Empirical analysis

Unit root tests

First of all, Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC) tests were used to determine maximum lag for each of the variables for testing the stationarity of variables. On the basis of this examination, lag 4 for AP (agricultural price) variable and lag 1 for PP (processing price) variable were chosen as the most suitable forms for the unit root tests.

The unit root tests are used to determine the order of integration in modelling employed variables. The results of unit root tests are presented in Table 1, which contains results of Augmented Dickey-Fuller test (ADF) and Phillips-Perron test (PP). ADF test shows that AP and PP variables are non-stationary at the 1% significance level nearly in all cases. At the 5% significance level, both variables seem to be stationary in several cases. Generally, in context we can conclude that they are non-stationary. DiffAP and diffPP variables are stationary at both 1 and 5% significance level in all cases. According to the results of ADF test, both variables are integrated of order 1 (i.e., I(1)). PP unit root test also suggests that both variables are integrated of order 1 at the 1 and 5% significance level. To sum up, the results of ADF and PP unit root tests suggest that all variables are non-stationary and integrated of order 1.

VECM

Since the variables are integrated of order 1, the analysis starts with the cointegration analysis or with the estimation of VECM, respectively. Thus, it is analyzed if the variables have long-run relationship, i.e. tend to the equilibrium relationship in the long-run.

Table 1. ADF test and PP test

Variable	ADF test			PP test		
	A	B	C	A	B	C
AP	−0.4885	−3.1162	−3.1730	x	−3.5116	−3.5214
diffAP	−6.0945	−6.0719	−6.0784	x	−6.7658	−6.7431
PP	−0.4584	−3.1826	−3.6203	x	−2.8987	−3.1637
diffPP	−7.1622	−7.1378	−7.1057	x	−9.7107	−9.6704

A = without intercept and trend; B = with intercept and without trend; C = with intercept and trend. Italics = significance on level 5 %; Bold = significance level 1 %. Length of lag in ADF test and PP test equals to 4 in case of AP and diffAP; and 1 in case of PP and diffPP

Source: Own calculation

Table 2. Results of cointegration analysis

Eigenvector	L-max	Trace	H0:r	p-r	L-max90	Trace90
0.1176	17.52	24.30	0	2	10.29	17.79
0.0473	6.78	6.78	1	1	7.50	7.50

Source: Own calculation

The VECM consists of two endogenous variables (logAP and logPP). LogAP is the logarithm of agricultural (farm) price and logPP is the logarithm of wholesale price of processed pig products. The VECM has 4 lags in the VAR space, with the length of lag being chosen based on AIC and SIC. Furthermore, the model contains constant in the co-integration space.

The L-max test and Trace test (see Table 2) suggest that the model contains one co-integrating vector at the 10% significance level. That is, the results show that the variables are co-integrated, i.e. they tend to the equilibrium relationship, and the model contains unique information about the long-run relationship between variables.

The co-integrating vector is obtained by normalization of eigenvector by the coefficient of logAP (see Table 3). The co-integrating vector (1.000, –0.668, –0.659) for logAP, logPP and constant represents the equilibrium relationship between these variables. The equilibrium relationship implies that the agricultural price is positively determined by the wholesale price, however, the coefficient at logPP (–0.668) suggests that the market structure is not competitive. More precisely, the coefficient –0.668 in co-integrating vector represents price transmission elasticity (see logarithmic transformation) assuming that there are no strong knock-on and feedback effects, which could make interpreting the coefficient difficult (see Lloyd et al. 2004).

The 'pass-back' price transmission elasticity is equal to 0.668. Elasticity is smaller than 1, which implies, according to the theoretical framework, that the processing stage may exercise oligopsonistic power.

The co-integrating vector is significant in the equation for logAP at the 5% significance level. In the second equation for logPP, it is not the case. The parameter α in the first equation implies that the model reaches relatively fast the equilibrium relationship. The parameters of the lagged variables in the VAR space are presented in Table 3. The residual analysis showed that the model has satisfactory properties.

Impulse-response analysis

The impulse-response analysis of the VECM shows the system's reaction to innovations (shocks). Thus, it illustrates the dynamic of the system and informs

Table 3. VECM

Beta (transposed)			Alpha			T-values for Alpha
logAP	logPP	constant		logAP	–0.218	–3.685
1.000	–0.668	–0.659		logPP	0.015	0.459
PI	logAP	logPP	constant	T-values for PI		
				logAP	logPP	constant
logAP	–0.218	0.146	0.144	–3.685	3.685	3.685
logPP	0.015	–0.010	–0.010	0.459	–0.459	–0.459
Usable observations: 140; Degrees of freedom: 132						
Variable	Dependent variable – logAP			Dependent variable – logPP		
	coefficient	std. error	signif.	coefficient	std. error	signif.
logAP(1)	0.6905	0.0954	0.0000	0.3094	0.0539	0.0000
logAP(2)	–0.3074	0.1045	0.0039	–0.0782	0.0590	0.1873
logAP(3)	0.2675	0.1041	0.0113	0.1394	0.0588	0.0192
logPP(1)	–0.0869	0.1655	0.6004	–0.1028	0.0935	0.2733
logPP(2)	0.0112	0.1644	0.9459	0.0053	0.0929	0.9548
logPP(3)	–0.2511	0.1575	0.1132	–0.1630	0.0889	0.0691
constant	–0.0006	0.0052	0.9096	–0.0004	0.0029	0.8889
EC1{1}	–0.2180	0.0610	0.0005	0.0156	0.0345	0.6533
R^2		0.3478			0.2634	

Source: Own calculation

about the speed and the way of establishing equilibrium. Figure 1 and 2 demonstrate responses of the system to the unitary orthogonal innovation (shock) in logAP. The response of a series is normalized by dividing by its innovation variance.

Figure 1 shows responses of logAP and logPP to the unitary innovation in the logAP. The results of impulse-response function show that the responses of logAP and logPP are positive in all periods. The response of logAP is higher than of logPP till the 3rd month. The system equilibrates approximately after 10 months.

Figure 2 shows responses of logAP and logPP to the unitary innovation in the logPP. The responses of logAP and logPP are again positive in all periods. The response of logPP is higher than of logAP. The system reaches the equilibrium approximately after 10 months. Compared to the first Figure, the margin is slightly higher.

Decomposition of variance

Tables 4 and 5 present the results of variance decomposition for variables logAP and logPP. The variance decomposition shows in detail the interaction between variables especially for longer forecast horizons. The prognostic period in this paper is 36 steps. One step is equal to one month, that is 36 steps correspond with 3 years. Standard Errors in Tables 4 and 5 represent the prognostic error of the given period. The forecast error in the first step is equal to standard deviation of logAP innovation in Table 4 or logPP innovation in Table 5, respectively. The forecast errors in the next steps are larger because of respecting the uncertainty of the development, forecast respectively, of the variables – logAP or logPP, respectively.

The variance decomposition of logAP is presented in the last two columns of Table 4. The variable logAP explains all of its first step ahead forecast error variance. However, the explanatory ability is decreasing with longer forecast horizons. For example, logAP explains 91.095 percent of its twelfth step ahead forecast error variance, whereas logPP explain 8.905 percent of the twelfth step ahead forecast error variance in logAP. Then, with longer forecast horizons, there is a further increase of explanatory ability of the variable logPP. At the end of our forecast horizons, the variable logAP explains 70.733 percent of its 36-step ahead forecast error variance, whereas logPP explains 29.267 percent of the 36-step ahead forecast error variance in logAP. However, it is worth noting that in the forecast horizons of 5 years, logPP explains nearly 40 percent of forecast error variance and the explanatory ability of logPP is still increasing.

Table 5 presents the variance decomposition of logPP. The variable logPP explains 81.649 percent of its first step forecast error variance. This explanatory ability of logPP is decreasing till the sixth step in favour of explanatory ability of the variable logAP. The explanatory ability of logPP is increasing from the sixth step. At the end of our forecast horizons, logPP

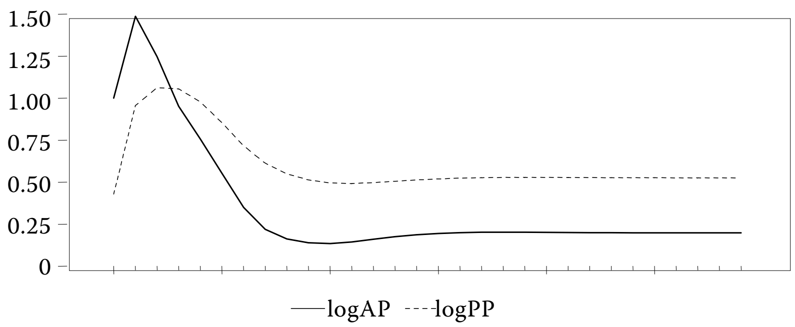

Figure 1. Plot of responses to logAP

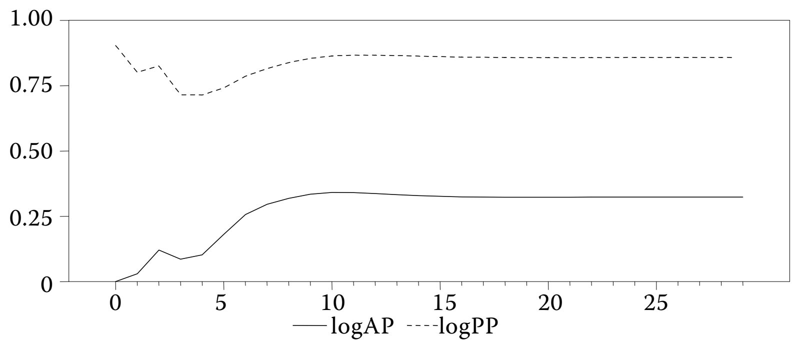

Figure 2. Plot of responses to logPP

Table 4. Decomposition of variance – logAP

Step	StdError	logAP	logPP
1	0.060079122	100.000	0.000
2	0.107657995	99.972	0.028
…			
6	0.154532385	99.003	0.997
…			
12	0.164209671	91.095	8.905
…			
18	0.173391256	84.224	15.776
…			
24	0.182203756	78.902	21.098
…			
30	0.190583185	74.466	25.534
…			
36	0.198611675	70.733	29.267

Source: Own calculation

Table 5. Decomposition of variance – logPP

Step	StdError	logAP	logPP
1	0.033930144	18.351	81.649
2	0.054229326	42.899	57.101
…			
6	0.100284606	57.504	42.496
…			
12	0.130936145	46.776	53.224
…			
18	0.155279847	40.841	59.159
…			
24	0.176408628	37.829	62.171
…			
30	0.195248792	35.903	64.097
…			
36	0.212425203	34.574	65.426

Source: Own calculation

explains 65.426 percent of its 36-step ahead forecast error variance and logAP explains 34.574 percent of the 36-step ahead forecast error variance in logPP. If we had longer forecast horizons, the explanatory ability of variables would change only slightly.

According to the obtained results, we may conclude that the variable logPP has an important explanatory ability especially in longer forecast horizons of logAP. The variable logAP is important especially in forecast horizons till 12 months in both equations. Since the explanatory ability of variable logPP is increasing in both cases, it may suggest that information carried by variable logPP has a significant impact on the value of logAP. In other words, downstream consumers may have a significant impact on the situation on agricultural market or creation of agricultural market equilibrium, respectively. That is, this conclusion is consistent with the hypothesis of demand driven nature of the chain and with the above identified type of the market structure.

Theoretical-empirical consequences

The estimated model showed that long-term relationship between analysed variables does exist. Cointegrating vector (1.000, –0.668, –0.659) expresses that 1% increase in wholesale price (PP) in long-term period causes 0.668% increase in agricultural price (AP). This price transmission elasticity expresses the type of the market structure on the assumptions set, oligopsony in this case. In other words, it means that processors have a stronger position in the agricultural market, more precisely, they abuse their market power. However, the result does not confirm the oligopoly market structure. It means that processors may not have such strong position in the food market, even more they may have a worse position than demand. This would mean a distinctively demand-driven character. An analysis of other chain elements will be done in the consequent research. Demand role in the analyzed relation appeared significant, i.e. price movements according to the estimated relationship have the origin in demand. The formulated hypothesis, which assumes that the chain is demand-driven and oligopsony power is exercised, was accepted. The model also shows that in case of oligopsony market structure, the agricultural policy's effects are shared within the agri-food chain. Hence, agricultural subsidies do not remain just with farmers, they are shared with the other market chain elements (it depends on their relationships). Agrarian policy is then less efficient.

CONCLUSION

The aim of this paper was fulfilled based on the theoretical-empirical procedure. On the basis of the designed theoretical model, the empirical analysis was carried out, and then theoretical-empirical consequences were deduced. The pork agri-food chain in the Czech Republic and its price transmission were analysed, namely logarithm of agricultural price and logarithm of processing price were used. AIC and SIC tests were used for maximum lag detection of each of the chosen variables. The ADF and PP tests were employed for unit root testing. These tests identified that time series of agricultural price (AP) and wholesale (processing) price (PP) are nonstationary, integrated of order 1. The cointegration analysis and VECM were applied to define the market structure of the selected agri-food chain. Impulse-response analysis was used for examination of variables' responses to innovations (shocks). Finally, decomposition of variance was employed to analyze the interaction between variables for longer forecast horizons.

The long-term simultaneous relationship between agricultural price and wholesale price of processed pig products was confirmed. Price transmission elasticity implies that the processing stage may exercise oligopsonic power. The impulse-response analysis of the VECM shows a relatively fast return to equilibrium after any innovation in both logAP and logPP. The results of impulse-response function show that responses in logAP and logPP are positive in all periods. Moreover, decomposition of variance suggests that downstream consumers may have a significant impact on the situation on agricultural market or creation of agricultural market equilibrium, respectively. To sum up, the analysis shows that the chosen agri-food market is characterized by demand-driven behaviour. The model also suggests that in case of oligopsony market structure, the agricultural policy's effects are shared within the agri-food chain.

REFERENCES

Hansen H., Juselius K. (2002): CATS in RATS: Cointegration Analysis of Time Series. Estima, Evanston, USA.

Labys W.C. (2006): Modeling Forecasting Primary Commodity Prices. Ashgate, Hampshire, UK; ISBN 0-7546-4629-7.

Lloyd T., McCorriston S., Morgan W., Rayner T. (2004): Price Transmission in Imperfectly Competitive Vertical Markets. Discussion Papers in Economics No. 04/09, University of Nottingham. Available at http://www.nottingham.ac.uk/economics/research/dp/school_dp/DP.04.09.pdf

Rogers,R.T., Sexton R.J. (1994): Assessing the importance of oligopsony power in agricultural markets. American Journal of Agricultural Economics, *76* (5): 1143–1150.

Arrived on 9th January 2008

Contact address:

Lukáš Čechura, Lenka Šobrová, Czech University of Life Sciences, Kamýcká 129, 165 21 Prague 6-Suchdol, Czech Republic
e-mail: cechura@pef.czu.cz, sobrova@pef.czu.cz