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ABSTRACT

Vertical price transmission from producer to consumer prices is a key characteristic of the supply chain. This paper examines price transmission mechanism between farm and retail levels in vertical chain of beer. Time series analysis starting with cointegration approach is used to study price linkages between producer prices of malt barley and consumer prices of bottled beer in supermarkets and draught beer in restaurants in Slovakia.

Key words: price transmission, beer, malt barley, market power

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INTRODUCTION

During the last decades numerous studies have been conducted on measurement of market power. Increased concentration and vertical integration of market participants have led to structural changes in the food supply chain and contributed to different levels of bargaining power and economic imbalances between the actors in the chain (EC, 2014). These imbalances have been reflected to the price transmission mechanism in the food supply chain. Price transmission has a significant effect on welfare of consumers, producers as well as on efficiency of agricultural and food markets. Highly integrated markets cause efficient transmission of price signals across markets and assure therefore efficient allocation of resources. Not integrated markets can convey inaccurate price information, leading to misguided policy decisions and a misallocation of scarce resources (Sexton et al. 1991). Price transmission is therefore closely related to market efficiency or market integration (Conforti, 2004). Vertical price transmission from producer to consumer prices is a key characteristic of the supply chain. This paper examines price transmission mechanism between farm and retail levels in vertical chain of beer. Time series analysis starting with cointegration approach is used to study price linkages between producer prices of malt barley, consumer prices of draught beer served in restaurants and retail prices of bottled beer in supermarkets in Slovakia.

In Slovakia barley producers are large corporate farms, which have possibility to change structure of production as well as destination of the products (exports versus domestic market). Beside this, concentration has taken place in the supply chain of beer which led to reduced number of malt barley processors. These facts may cause imperfect and asymmetric price transmission.

Generally, the beer market has been growing from year to year and the latest statistics show that the brewing industry in Europe is not just a stable sector, but the production of beer has increased in the last years. According to Europe Economics (2016), the EU as a whole is the second largest beer producer in the world and it means that in 2016 production represented around 400,1 thousand liters of beer. The European Union countries produce less beer than only China. At present, there exist more than 8 500 breweries operating across the whole EU, from the microbreweries through the brewery producing beer for the local community to the largest regional and national breweries exporting beer across the world. Also, Swinnen (2011) confirms that increasing tends of beer production won't stop in the near future. The number of producers or different brands has been trying to use all the potential niche segments by developing new kinds of beer, new flavors and changes in consumers lifestyles give them new opportunities for growth.

We can find a strong tradition of brewing and malting in Slovakia, dating back to the 5th century and this popularity of beer has been preserved until nowadays (Sladek, 1992). The brewing and malting industry is one of the significant contributors to the economic and cultural environment in Slovakia. Slovak agriculture supplies barley and hops, which are essential raw materials for beer production. The brewing and malting market consists of 68 breweries and 7 malting companies. The malting barley production in Slovakia has been significantly growing since 2014. In 2017, Slovak malt houses exported more than 87% of the production abroad, while the remaining approximately 13% of Slovak malt production was sufficient to meet the needs of Slovak breweries (EY, 2018). In Slovakia, barley producers are mostly large corporate farms which have a possibility to change the structure of production as well as the destination of the products (exports versus domestic market). Also, these facts may cause differences in prices and imperfect and asymmetric transmission of prices from one level of the supply chain to another. Price transmission significantly affects the welfare of consumers, producers as well as on the efficiency of agricultural markets. The aim of this paper is to find out whether there exists an asymmetric price transmission between commodity prices and retail prices on the market of beer. To prove the existence of a non-linear relationship between prices at various levels of the vertical chain, we use threshold autoregressive models. The study is structured as follows. The following part discusses price transmission and its importance in the functioning of the food supply chain. The next section describes the statistical and empirical methodology applied in this study which the results came from. Part 4 shows the results of our analyses and a final part draw out the conclusions.

2 LITERATURE REVIEW

In recent years, price developments have often been analyzed in relation to the ability to transfer prices between markets, referred to in the literature as price transmission. The concept of price transmission refers to how prices at one level of the food chain are passed on to the other level (Bunte, 2006). Just the price is considered for a basic mechanism connecting the different market levels. The traditional economic literature has assumed that price changes are fully transmitted from one stage to another as a reaction on demand or supply price shocks (Brännlund 1991). Currently, this symmetric price transmission does not use to be a natural outcome of the market reactions. In an extended study, Peltzman (2000) shows that symmetric price transmission is more exception than the rule. Such an asymmetry is often linked to the issue of market power as an indicator of the level of competition in processing and distribution (Conforti, 2004). During past years, various studies and researches have been conducted with the primary aim to measure market power. Particularly higher concentration and vertical integration have let to structural changes mainly in the food supply chain and contributed to economic imbalances between the subjects in the chain (EC, 2014).

Number of literature suggests that one of the main reasons for imperfect or asymmetric price transmission may be market structure and increased concentration of processing and retail subjects (Vavra and Goodwin, 2005) as well as the presence of unequal market power (Meyer and Cramon-Taubadel, 2004; McCorriston et al., 2001), type of commodity, for instance perishable products (Fernández-Amador et al., 2010), inflation (Ray et al., 2006), asymmetric information (Busse Silva-Russo and Zettelmeyer, 2006), government regulations (Bolotova and Novakovic, 2012), adjustment costs (Zachariasse and Bunte, 2003) and other factors.

The price transmission exists as a process of horizontal price transfer between the markets of different regions, or vertical transfer between different stages in the supply chain. The horizontal price movements between spatially differentiated markets at the same stage of the supply chain are also known as the spatial price transmission (Garcia-German et al., 2014, Palkovic, 2012, Istorti and Esposti, 2012, Asche et al. 2007). In the case of well-functioning integrated markets in standard conditions, the price changes (e.g. from European market) should reflect into the domestic prices relatively smoothly, with a short-lag that is necessary to transfer price between markets.

Price transmission at various stages of the vertical chain got a lot of attention in the literature, particularly in the last years (Capps and Sherwell, 2007; Fernández-Amador et al., 2010; Stewart and Don, 2011; Bakucs et al., 2012; Bonnet et al., 2015; Zeng and Gould, 2016 and others). Findings of such studies can help to assess the functioning of trade agreements with respect to individual commodities (Mengel and Cramon-Taubadel, 2014), market competition, they are considered as important characteristics of the description of overall market activities (Goodwin and Harper, 2000) and allows to improve the understanding of price behavior. These changes are usually determined by the speed, magnitude and the nature of the adjustments, which respond to market shocks at the different levels of the chain (Vavra et. al. 2005).

Studies usually vary in terms of the examined goods, countries, time frequencies or periods and model specification. The importance of this issue is confirmed by the number of studies dealing with price transmission using various econometric methods (Frey and Manera, 2007). According to the literature, we can differ the basic types of approaches to examine price transmission.

- The first group also called *the early asymmetries models*, is characterized by Autoregressive Distributed Lags Models. Initial empirical studies of APT included the application of variations of a variable splitting method proposed by Wolffram (1971) and later refined by Houck (1977) and Ward (1982). Ward (1892) examined the impact of wholesale prices on retail using monthly US vegetable prices. Also, Kinnucan and Forker (1987) used these approaches at the prices of various dairy products.
- Later, in the early 1990s, economic researchers started to use the *equilibrium corrective approaches*, consisted of partial adjustment models (PAMs) or error correction models (ECM). Bacon (1991) examined the relationship between oil product prices, retail gasoline prices without taxes and exchange rates using the PAM quadratic model, as well as Shin (1994) or Salas (2002). In 1987, Engle and Granger (1987) estimated the error correction model, later modified by Granger and Lee (1989), who tested various types of asymmetry supported by both PAM and ARDL approaches.
- In the mid-1990s, the *Modern econometric models* started to be applied and include Regime Switching Models (RSM) (Powers, 1995) or systems of equations, in economic literature

known as vector autoregressive models (VAR) (Miller and Hayenga, 2001) vector error correction models (VEC) (Goodwin and Holt, 1999; Cechura and Sobrova, 2008) or variable mode vector models (VRS) used by i.e. Serra and Goodwin (2003) or Aguero (2004).

The aim of the study is the application of Enders and Granger (1998) methodology, which include error correction models with threshold cointegration. The benefit of using this modelling technique is that it considers times series characteristics of variable as well as suppose a non-linear symmetric adjustment. The theory does not guide us in the exact model specification and therefore in this paper we used four different threshold models: threshold autoregression model, consistent threshold autoregression model, momentum threshold autoregression model, and consistent momentum threshold autoregression model with the purpose to choose the best – fitting model for price transmission analyses of beer in Slovak market.

3 METHODOLOGY

Data used in the analyses is based on 219 observations consist of monthly commodity prices of malt barley and retail prices of beer (bottled beer in supermarkets and draught beer in restaurants) in Slovakia. Time - series data cover period from January 2001 to March 2019. Prices were obtained from database id Statistical Office of Slovak Republic.

Table 1 Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Malt barley price	219	174.171	27.346	125.000	260.900
Bottled beer price	219	1.173	0.148	0.860	1.400
Draught beer price	219	1.729	0.364	1.100	2.400

Source: calculated

As the first step, we test the stationarity of time series using two unit-root tests: The Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test. PP test was conducted because the ADF test loses its power for sufficiently large values of lags. It includes an automatic correction to the Dickey-Fuller process for autocorrelated residuals. The number of lagged difference terms to include is often determined empirically; the idea is to include enough terms so that the error term in the test is serially uncorrelated. The number of lags of a dependent variable is determined by the Akaike Information Criterion (AIC).

Johansen cointegration test

As a second test of cointegration we employ the Johansen approach to test for cointegration. The Johansen approach is based on a vector autoregressive model and reformulates it into a vector error correction model:

$$Z_t = A_1 Z_{t-1} + \ldots + A_k Z_{t-k} + \varepsilon_t \tag{1}$$

$$\Delta Z_t = \sum_{i=1}^{k-1} \Gamma_i \Delta Z_{t-i} + \Pi Z_{t-k} + \varepsilon_t \tag{2}$$

where Z_t is a vector of non-stationary variables, A are different matrices of parameters, *t* is time subscript, *k* is the number of lags and ε_t is the error term assumed to follow i.i.d. process with a zero mean and normally distributed N(0, σ2) error structure. The estimates of Γ_i measure the short-run adjustment to changes in the endogenous variables, while Π contains information on the long-run cointegrating relationships between variables in the model.

Threshold cointegration approach

The above cointegration tests assume symmetric price transmission. In order to capture asymmetric movements in the residuals, Enders and Granger (1998) and Enders and Siklos (2001) propose to use threshold cointegration approach. Assuming the long run relationship between two nonstationary variables *X* and *Y:*

$$Y_t = \lambda_0 + \lambda_1 X_t + \mu_t \tag{3}$$

where μ is the error term. Engle and Granger (1987) show, that cointegration exists if the null hypothesis $\rho=0$ is rejected in:

$$\Delta \mu_t = \rho \mu_{t-1} + \xi_t \tag{4}$$

where ξ is the error term for the residuals. Adjustment of the series of residuals expressed in

$\rho\mu_{t-1}$ would be symmetric. To capture the asymmetry in adjustment process, a two-regime threshold cointegration approach should be used:

$$\Delta\mu_t = I_t\rho_1\mu_{t-1} + (1 - I_t)\rho_2\mu_{t-1} + \xi_t \tag{5}$$

where I_t is the Heaviside indicator $I_t=1$ *if* $\mu_{t-1} \geq \tau$ or $I_t=0$ *if* $\mu_{t-1} < \tau$. If μ_{t-1} is bigger than the threshold τ, then adjustment is at the rate ρ_1 . If μ_{t-1} is smaller than the threshold τ , adjustment is shown in ρ_2. When $\rho_1=\rho_2$, then the adjustment process is symmetric. If the null hypothesis $\rho_1=\rho_2=0$ is rejected, then X and Y are cointegrated and the following TAR model is estimated:

$$\Delta Y_t = \theta_Y + \delta_Y^+ E_{t-1}^+ + \delta_Y^- E_{t-1}^- + \sum_{j=1}^{J} \alpha_{Yj}^+ \Delta Y_{t-j}^+ + \sum_{j=1}^{J} \alpha_{Yj}^- \Delta Y_{t-j}^- + \sum_{j=1}^{J} \beta_{Yj}^+ \Delta X_{t-j}^+ + \sum_{j=1}^{J} \beta_{Yj}^- \Delta X_{t-j}^- + \upsilon_{Yt} \tag{6}$$

where ΔY_t and ΔX_t are dependent and independent variables in their first differences, E is the error correction term, δ represents the speed of adjustment coefficients of ΔY_t if Y_{t-1} is above and below its long-run equilibrium, θ, δ, α and β are coefficients and υ is the error term, t is time subscript and j is the number of lags.

Two error correction terms are defined as:

$$E_{t-1}^+ = I_t\mu_{t-1} \tag{7}$$

$$E_{t-1}^- = (1 - I_t)\mu_{t-1} \tag{8}$$

Enders and Granger (1998) and Enders and Siklos (2001) proposed also a model for cointegration, known as a momentum threshold autoregressive model. The term “momentum” describes the rate of acceleration of prices and takes into account steep variations in the residuals; it is especially valuable when the adjustment is believed to exhibit more momentum in one direction than the other. Heaviside Indicator in this case is $I_t=1$ *if* $\Delta\mu_{t-1} \geq \tau$ or $I_t=0$ *if* $\Delta\mu_{t-1} < \tau$.

To summarize, four asymmetric models are considered in our study. They are threshold autoregression model with threshold value equal to zero; threshold autoregression model with threshold value estimated (consistent threshold autoregression model); momentum threshold autoregression model with threshold value equal to zero; and consistent momentum threshold autoregression model with threshold value estimated. A model with the lowest AIC and BIC will be used.

4 RESULTS

Price development in the Slovak beer market

The key agricultural raw material for beer production is malting barley and its cultivation has a long-term tradition in Slovakia. Mainly due to the seasonality of the weather is with this commodity recorded the high price volatility during the whole observed period. The fastest growing of malting barley prices were also recorded in 2007-2008 as well as between the years 2011-2013 not just because of the weather changes but also the global economic situation in Europe.

Conversely, the consumer prices of the final products i.e bottled and draft beer were relatively stable over the long term, with a slightly year-on-year increase. During the observed period, the excise tax has been changed a couple of times. The latest changes were realized in January 2012 when the excise duty rate decline in about 13%. The beer prices remained at their original level or were gradually growing.

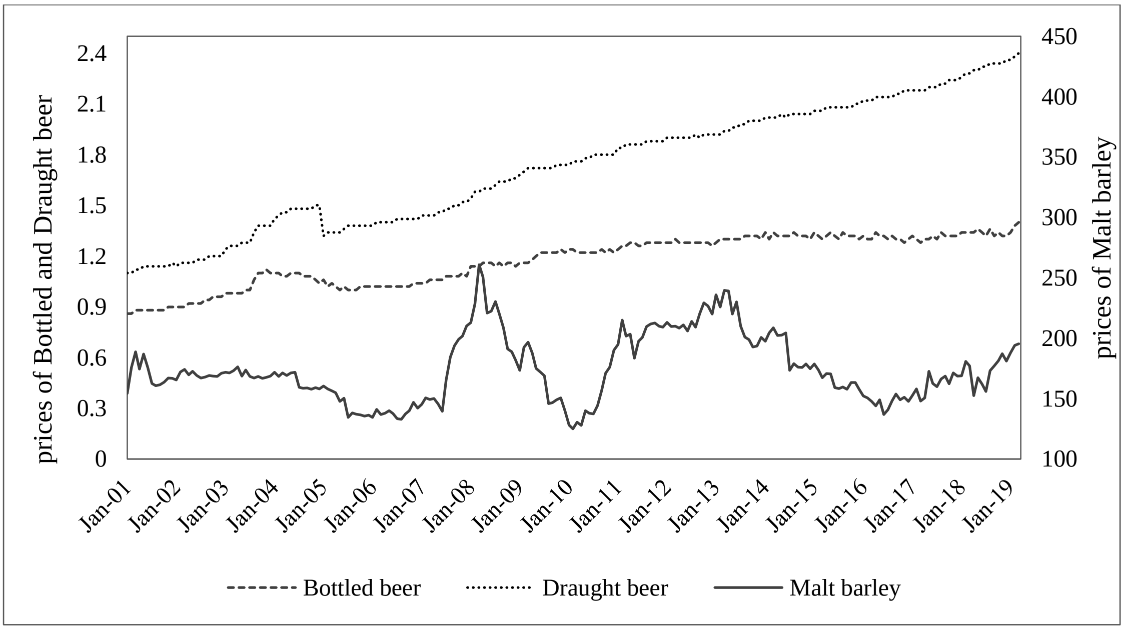

Figure 1 Development of malt barley and beer prices (in EUR per tonne and EUR per liter respectively).

Source: ATIS and Slovak Statistical Office database

Development of production in brewing-malting industry in Slovakia

For malt production, the Slovak malting barley is the economically most suitable. Its cultivation has a long tradition in Slovakia. Malt production fluctuated slightly in the period 2013-2017 in relation to raw material quality and demand in the domestic and international markets, but in 2017 the production reached a value of more than 242 thousand tons.

The total annual production of Slovak breweries covers about 60% of domestic consumption.

The data in the following Figure 2 shows that in the period 2015-2017, the production of alcoholic beverages without mixed drinks decreased by 20.7%. In 2017 total beer production reached about 233 million liters. On the contrary, a significant increase in production was recorded for non-alcoholic beer without mixed drinks (+92.3%). The brewing industry responded adequately to the increased demand for mixed beverages containing a proportion of alcoholic or non-alcoholic beer, which resulted in an expansion of their production by 41.5%.

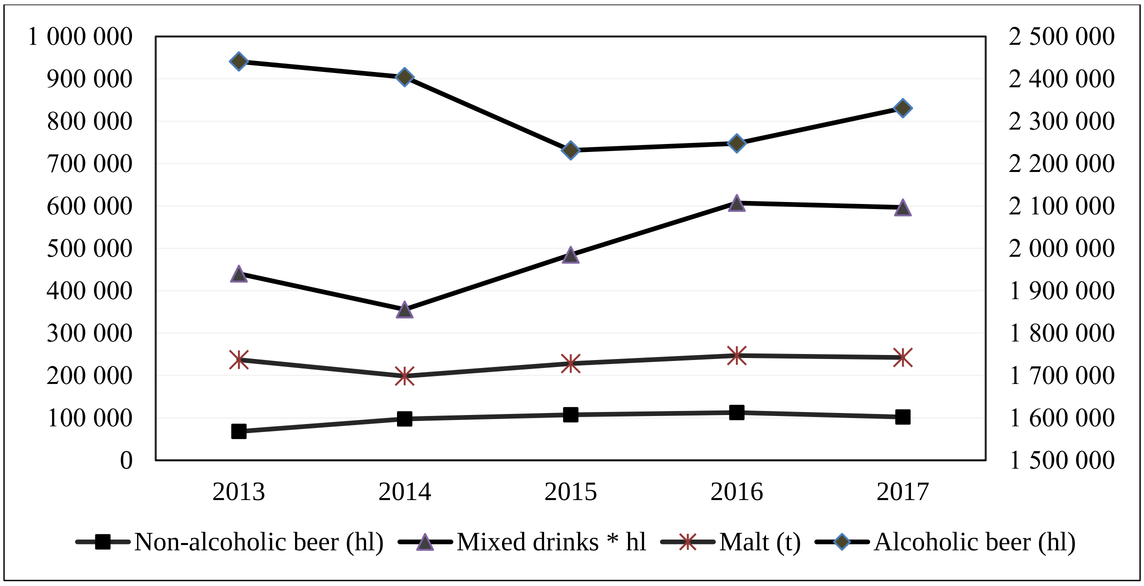

Figure 2 Development of selected products of the brewing-malting industry 2013-2017 (alcoholic beer- right axis, non-alcoholic beer, mixed drinks, malt -left axis)

Source: Potrav (MPRV SR) 1-02, NPPC-VUEPP calculations

Note: * mixed drinks: Radler and Cider alcoholic and non-alcoholic beverages

Foreign trade of brewing-malting industry

The Slovak brewing and malting industry trades in foreign markets mainly with beer, malt, and brewery grains. Malt is one of our most important export commodities of plant origin after the first processing. The export of malt in 2017 amounted to more than 87% of the total domestic production (212 thousand tons) (EY, 2018) and also represents 77,5% of the total export value of the brewing and malting industry.

The total value of exports decreased by 15.8% over the years 2012 - 2017. In the same period, total imports increased by almost half (+47.9%). Slovak consumption is characterized by a relatively high proportion of beers produced abroad (more than 1.6 million hl in 2017) and according to the Slovak Beer and Malt Association, a significant part of imported beers come from the Czech Republic (about 90%). In the long term it shows a positive trade balance, however comparing borderline years 2012-2017 there has been recorded a significant downward trend with decline up to 54,4% (Figure 3).

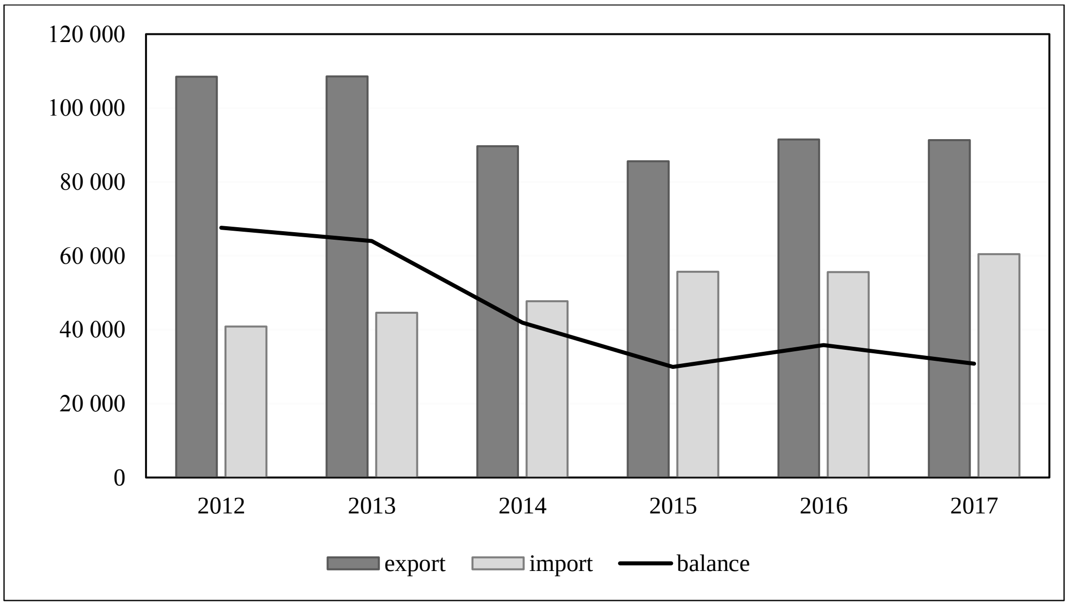

Figure 3 Slovak Foreign Trade - Brewing and Malting Industries 2012-2017 (in thousand EUR)

Source: Statistical Office of the SR, NPPC-VÚEPP calculations

Cointegration results

Non-stationary time series can lead to statistically significant results due to purely spurious correlation. We therefore tested for the stationarity of the price series using augmented Dickey Fuller (ADF) and Phillips Perron (PP) tests. The Augmented Dickey-Fuller and Phillips-Perron tests confirmed[2] that all our time series are non-stationary; we stationarized them by taking first differences. The tests indicated that all variables were stationary in first differences. The lags of the dependent variable in the tests were determined by Akaike Information Criterion (AIC). The stationarity tests showed that the original time series are non-stationary and could be used for cointegration analysis.

Johansen cointegration test results indicate that there is a cointegration relationship between producer prices of malt barley and consumer prices of bottled beer or draught beer significant at 5% level and 1% level respectively. Johansen test does reject the null hypothesis of no-cointegration. However, the link between the producer and consumer price may show some asymmetry and so we check also the presence of non-linear relationship.

Table 2 Johansen cointegration test results

Variables	Rank	5% critical	1% critical	Johansen trace statistics
Malt barley – Bottled beer	0	19.96	24.60	24.3089
	1	9.42	12.97	3.9845
Malt barley – Draught beer	0	19.96	24.60	27.9453
	1	9.42	12.97	5.5107

Source: calculated. Note: model with restricted constant was considered

Threshold cointegration

Threshold cointegration models allow for non-linear relationship between producer and consumer prices and vice versa. The theory does not guide us in the exact model specification and therefore in this paper we used four different threshold models: threshold autoregression model, consistent threshold autoregression model, momentum threshold autoregression model, and consistent momentum threshold autoregression model.

[2] Results of the tests are available upon request from the corresponding author.

Table 4 Threshold cointegration test results

Model	TAR	cTAR	MTAR	cMTAR
Bottled beer				
Threshold	0.000	-0.092	0.000	-0.008
Lags	1	1	1	1
AIC	-1151.685	-1153.530	-1149.201	-1152.165
BIC	-1138.165	-1140.011	-1135.681	-1138.645
ρ1	0.001	0.002	-0.027**	-0.029***
ρ2	-0.033***	-0.039***	-0.009	0.015
Φ(H0:ρ1=ρ2=0)	3.943**	4.891***	2.680*	4.188**
F(H0: ρ1=ρ2)	3.425*	5.283**	0.951	3.907**
Draught beer				
Threshold	0.000	-0.120	0.000	0.018
Lags	1	1	1	1
AIC	-1130.261	-1133.154	-1122.545	-1126.314
BIC	-1116.741	-1119.634	-1109.025	-1112.794
ρ1	0.009	0.011	-0.005	-0.035**
ρ2	-0.023***	-0.026***	-0.011	-0.003**
Φ(H0:ρ1=ρ2=0)	5.005***	6.508***	1.092	2.986*
F(H0: ρ1=ρ2)	8.012***	10.991***	0.256	4.010**

*Notes: *,**,*** denote significance at the 1%, 5% and 10% significance levels*

According to AIC and BIC selection criterias we choosed the appropriate number of lags and found out that the consistent threshold autoregression model with non-zero threshold value (-0.092 for bottled beer and -0.120 for draught beer) is the best fitting model. Threshold cointegration tests lead to the same results as Johansen cointegration test. However, estimated models show, that the prices are cointegrated with threshold adjustment. From the tests it follows that there is strong evidence of negative asymmetry for producer price of barley. The null hypothesis $\rho_1=\rho_2$ is rejected at 5% significance level in case of bottled beer and 1% significance level in the model for draught beer.

The results of tests suggest that it is not appropriate to use a symmetric error correction model as it may fail to detect the important effects of positive or negative shocks. From this reason we estimated asymmetric error correction models. The first column in table 5 shows the coefficients of variables influencing producer price of malt barley and second column gives the impacts on consumer price of bottled beer.

Table 5 Adjustment estimates

	Bottled beer		*Draught beer*	
	producer	*consumer*	*producer*	*consumer*
(Intercept)	-0.367	0.002	-1.061	0.004**
X.diff.cons.t_1.pos	18.794	-0.262***	96.189	-0.042
X.diff.cons.t_1.neg	51.614	-0.437***	17.054	-0.107
X.diff.prod.t_1.pos	0.209*	0.000	0.194	0.000
X.diff.prod.t_1.neg	-0.189	0.000	-0.183	0.000
X.ECT.t_1.pos	-0.093**	0.000	-0.081**	0.000
X.ECT.t_1.neg	-0.028*	0.000	-0.042*	0.000

Source: calculated

Note: *,**,*** denote significance at the 1%, 5% and 10% significance levels.

Because the price pairs are cointegrated with threshold adjustment we have estimated error correction models. As seen from the results, most of the short term adjustments and error correction terms are not significantly different from zero. Consumer prices of bottled beer are affected by their own past development, but do not have significant impact on producer prices of barley.

The point estimates of the coefficients for the error correction terms in the model explaining producer prices of barley are negative as expected and significantly different from zero. It implies that producer prices react with different speed to positive and negative deviations. On the other side consumer prices do not react to shocks in producer prices. In the case of bottled beer equation, the coefficient from negative deviation is -0.028, which is significant at 10% level while the coefficient from positive deviation is significant at 5% level with higher magnitude -0.093, meaning that the price of barley responds to shocks in consumer prices of beer bringing positive deviation much faster, than the one in opposite direction. The same applies for draught beer model, when the producer prices of barley react with different speed and magnitude on price shock in draught beer market. The error correction coefficients of -0.081 and -0.042 indicate that as much as 8.1% and 4.2% of a unit divergence from the long-run equilibrium is corrected each month, respectively. This implies that prices of malt barley adjust faster to positive divergences from the long-run relationship as compared to negative deviations.

CONCLUSION

This paper analyzed vertical price transmission along beer supply chain in Slovakia. Johansen test results revealed that the price series are cointegrated, which means there is a long run relationship between producer prices of barley and consumer prices of bottled beer and draught beer. Later on we found an evidence of asymmetry in price transmission. The coefficients for error correction terms in the models with producer prices as dependent variable, are significant and have expected negative sign. While the sign of ECTs in models with consumer prices is wrong, the coefficients are not statistically significant. Therefore, it seems that in the short term consumer prices of bottled beer and draught beer has some different responding speed to positive and negative deviations but the difference is weak.

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