SPATIAL INTEGRATION ON THE HUNGARIAN MILK MARKET

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ABSTRACT

The geographical separation of markets is of a special importance in agriculture, as often, agricultural products are bulky and/or perishable, and the place of consumption may be different from that of production, implying possibly expensive transport costs (SEXTON ET AL., 1991). The imperfectly integrated markets may send wrong price information signals to producers and other actors of the marketing chain, resulting incorrect production and marketing decisions. The aim of the article is to map the horizontal integration on the milk market in the Hungarian milk market using up-to-date Vector Error Correction (VECM) and Threshold Error Correction (TEVCM) methods.

Key words: horizontal integration, transition economy, threshold cointegration

1. INTRODUCTION

The geographical separation of markets is of a special importance in agriculture, as often, agricultural products are bulky and/or perishable, and the place of consumption may be different from that of production, implying possibly expensive transport costs (SEXTON et al. 1991). Horizontal market integration means, that it takes some time for the exogenous shocks to transform and reach the various geographically separated markets. The imperfectly integrated markets may send wrong price information signals to producers and other actors of the marketing chain, resulting incorrect production and marketing decisions. Thus it may happen for example that livestock in one region decreases, and in another one increases, regional prices diverge, because the price information flow between the markets is wrong. If this occurs, market price changes between the regions do not necessarily reflect relevant economic phenomena (GOODWIN and SCHROEDER 1991).

The phenomena spatial price transmission has long been in the focus of empirical research. The importance of the topic is emphasised by the wide range of methods developed to study horizontal integration (see FACKLER and GOODWIN 2001). Because price data is often non-stationary, recent papers emphasise the importance of using up-to-date econometric techniques, capable of handling non-stationary and cointegrated data. Except a few European studies (e.g. MEYER 2004, SERRA et al. 2006), most research is concentrated on various product markets in the United States (see FACKLER and GOODWIN 2001 for a comprehensive review). As far as we are aware, until now, there has been no published research focusing on spatial integration of agricultural prices in the Central and East European Countries. Because of the low developed market institutions and market inefficiencies, spatial price evolution in transition economies is perhaps of greater importance than in developed economies.

This paper aims to fill this gap using Hungarian data. We employ Vector Error Correction and Threshold Vector Error Correction methods to study regional market integration in the Hungarian milk sector. The paper is organised as follows. Section 2 briefly describes the theory of spatial integration. Section 3 reviews the empirical methodology, than section 4 presents the empirical analysis. The results are discussed in section 5.

2. SPATIAL INTEGRATION OF MARKETS

Research on the spatial integration of agricultural markets is often used to test the efficiency of agricultural markets. Perfectly integrated markets are usually assumed to be efficient as well. TOMEK and ROBINSON (2003), defines the two axioms of the regional price differences theory:

1. The price difference in any two regions or markets involved in trade with each other equals the transfer costs.
2. The price difference between any two regions or markets not involved in trade with each other is smaller than the transfer costs.

Let's consider, two spatially different markets, where the price of a given good in time *t* is P_{1t} and P_{2t} respectively. The two markets are considered integrated, if the price on market 1. equals the price on market 2. corrected with transport costs, K_t:

$P_{1t} = P_{2t} + K_t$ (1)

Trade between the two markets occurs only if $|P_{1t} – P_{2t}| > K_t$. To put it other way, the arbitrage ensures that prices of the same good traded in spatially separate markets equalise. Early studies of horizontal integration employed correlation and regression analysis. These papers usually tested some form of the *Low of One Price, LOP*. Consider equation (2):

$P_{1t} = \beta_0 + \beta_1 P_{2t}$ (2)

According of the *strong version* of *LOP*, prices of a given good on the spatially separated markets are equal, and they move perfectly together in time. Using the coefficients of equation (2), the necessary conditions are $\beta_0 = 0$, and $\beta_1 = 1$. In real life however, the *strong version* occurs only very rarely, therefore the *weak version* of *LOP* was also defined. The *weak version* states that only the price ratio is constant, the actual price level is different due to transport and other transfer costs. Using again the notation of equation (2), the necessary restrictions are $\beta_0 \neq 0$ and $\beta_1 =1$.

With the evolution of time series econometrics, recent papers test a more general (wider) notion of horizontal integration of spatially separated markets. In this case the long-run co-movement of prices is analysed, the *strong* and *weak versions* of *LOP* however, remain testable hypotheses.

3. EMPIRICAL METHODOLOGY

To avoid the danger of spurious regression with potentially non-stationary variables, cointegration needs to be tested. The Johansen cointegration procedure is based on estimating the following Vector Error Correction Model (equation 3):

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + ... + \Gamma_{k-1} \Delta Z_{t-k+1} + \Pi Z_{t-k} + u_t \quad (3)$$

,where $Z_t = [\, P^1_t, P^2_t]'$, a (2 x 1) vector containing the prices in region 1 and 2, , both I(1), Γ_1 ,….Γ_{k+1} are (2x2) vectors of the short-run parameters, Π is (2x2) matrix of the long-run parameters, u_t is the white noise stochastic term.

$\Pi = \alpha\beta`$ (4),

where matrix *α* represents the speed of adjustment to disequilibrium and *β* is a matrix which represents up to (n - 1) cointegrating relationships between the non-stationary variables. Trace and maximum Eigen-value statistics are used to test for cointegration. Once (3) is estimated we can proceed to test for weak exogeneity and then for linear restrictions on the *β* vector. One obvious candidate would be to test whether the elements of the vector are of the (-1, 1) form, i.e. the markets are perfectly integrated. The terms of vector *α* (factor loading matrix) measure the speed at which the variables adjust towards the long-run equilibrium after a price shock. The *α* vector of the weakly exogenous variable equals zero. To find the direction of the Granger causality between the two price series, restrictions are tested on the *α* vectors.

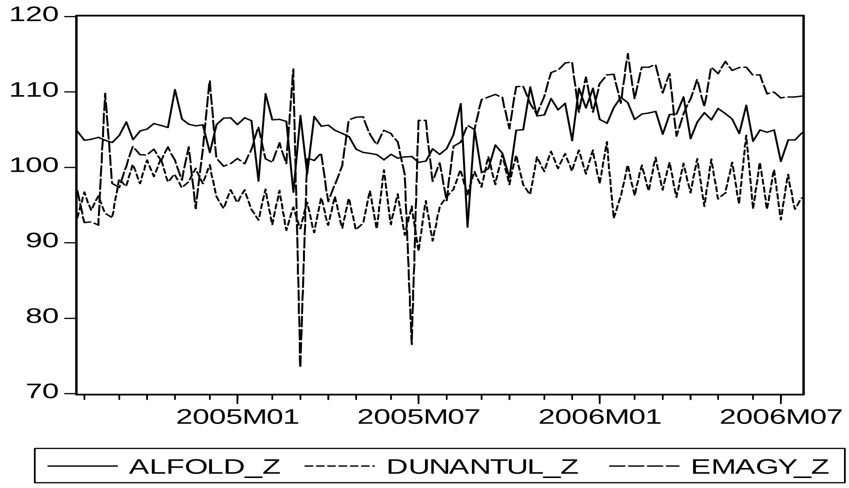
A number of studies (e.g. BARRETT 2001, FACKLER and GOODWIN 2001, GOODWIN and PIGGOTT 2001) have questioned the appropriateness of the linear VECM models, arguing that it ignores the transaction costs that might occur. Threshold Error Correction Models (TVECM), estimate a threshold below which the cointegration is inactive since it does not worth trading because of the low price difference. One the threshold value is exceeded, cointegration becomes active. We employ the procedure developed by HANSEN and SEO (2002) that applies a gridsearch to simultaneously estimate the elements of the *β* cointegrating vector, and the threshold. The threshold value is than tested for significance (the null hypothesis is linear cointegration against the threshold cointegration alternative hypothesis) using a *Supremum Lagrange Multiplier* (supLM) statistic. The distribution of the test statistic is non-standard, therefore critical values are obtained by *bootstrapping*.

4. EMPIRICAL ANALYSIS AND RESULTS

4.1. Data

Aggregated milk price data of three Hungarian regions, *Alföld*, *Dunántúl* and *Északmagyarország* was used for the empirical analysis. 105 weekly observations, between 26th of July 2004 and 24th of July 2006 were available. The price data is collected by the Agricultural Economics Research Institute (AKI), and are available through the Market Information System (https://pair.akii.hu). The database contains plastic bagged, boxed and long-life (UHT) milk prices. The long-life milk was excluded from the analysis, because it is mostly sold through supermarket chains, quite often at discounted prices or offers as part of the given shop's marketing policy, therefore one can not expect these prices to move together in various regions. Our analysis focuses exclusively on plastic bag (noted:_z) and boxed milk prices (noted: _D) in the three regions, collected at current prices (figures 1 and 2).

Figure 1. Plastic bagged milk prices by regions (HUF/l)



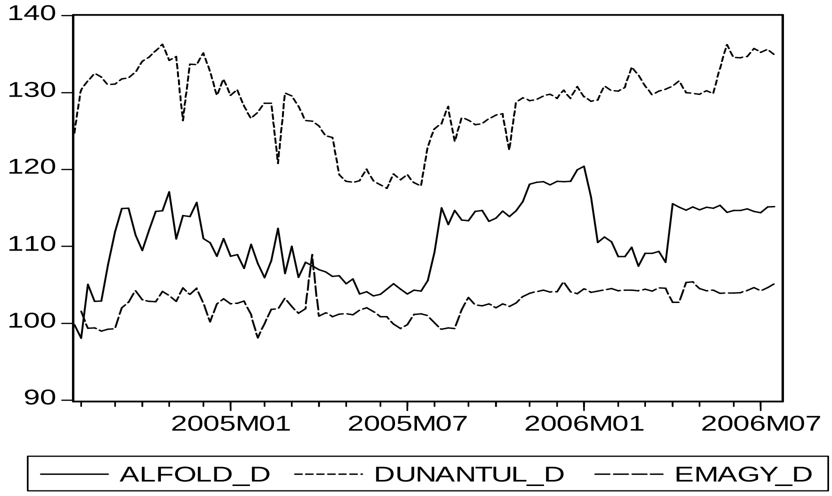
Source: AKI Market Information System

4.2. Stationarity

ADF[1] unit root test (DICKEY and FULLER 1979, 1981) results for all price series are presented in table 1. All series proved to be I(1) except *emagy_d* and *emagy_z* that seem to be trend stationary at 5%. Considering however the notoriously low power properties of the unit root tests, we carefully consider all price series as integrated of order one.

Figure 2. Boxed milk prices by regions (HUF/l)

[1] ADF tests were run using Eviews 5.0



Source: AKI Market Information System

Table 1. ADF unit root tests

Variable	Specification	Lag length	Test statistic
alfold_d	Constant	0	- 2.68
	Constant and trend	0	- 2.89
dunantul_d	Constant	1	- 1.75
	Constant and trend	1	- 1.77
emagy_d	Constant	2	- 2.85
	Constant and trend	0	- 4.92
alfold_z	Constant	2	- 2.89
	Constant and trend	2	- 2.90
dunantul_z	Constant	12	- 1.70
	Constant and trend	12	- 1.56
emagy_z	Constant	4	- 1.81
	Constant and trend	0	- 9.27

The ADF test critical values corresponding to 0.90 (0.95) confidence intervals are –2,581 (-2,889) with constant and, –3,152 (-3,453) with constant and trend. The AIC criteria was used to select the lag length.

4.3. Linear cointegration analysis

Results of the Johansen cointegration analysis[2], are presented in table 2.

The *Pantula-principle* (HARRIS 1995) was used to simultaneously test the deterministic form (constant, trend) of the model, and the number of cointegrating vectors. Both the trace and maximum Eigen value tests indicate that boxed milked prices in *Alföld* and *Dunántúl* are not integrated, that is, there is no long-run relationship between them. The rest of the boxed milk and all the milk in plastic bag price region pairs are cointegrated with one cointegration vector. The long-run relationships between cointegrated price pairs are presented in table 3.

Table 2. Johansen cointegration analysis (VECM)

[2] Eviews 5.0 was used for the Johansen cointegration analysis, VECM estimation and testing various hypotheses.

Model	Lag length	H_0	Trace test		λ_{max} (max Eigen value) test	
			Test statistic	95% critical value	Test statistic	95% critical value
alfold_d – dunantul_d	1	*r=0*	11.72	20.26	7.92	15.89
		r=1	3.80	9.16	3.80	9.16
alfold_d – emagy_d	0	*r=0*	20.26	12.32	19.84	11.22
		r=1	0.41	4.12	0.41	4.12
dunantul_d – emagy_d	1	*r=0*	21.37	20.26	19.59	15.89
		r=1	1.78	9.16	4.28	1.78
alfold_z – dunantul_z	1	*r=0*	18.06	12.32	18.05	11.22
		r=1	0.00	4.12	0.00	4.12
alfold_z – emagy_z	1	*r=0*	20.09	12.32	20.171	11.22
		r=1	0.01	4.12	0.014	4.12
dunantul_z – emagy_z	1	*r=0*	22.10	12.320	22.10	11.22
		r=1	0.00	4.12	0.00	4.12

Table 3. The long-run cointegrating relationship ($P_{1t} = \beta_0 + \beta_1 P_{2t} + e$)

Model	β_0	β_1	LR test β_1 = -1
alfold _d- emagy_d	-	- 1.085 (0.008)‡	$\chi^2(1)=12.21$**
dunantul_d – emagy_d	287.63 (80.69)	- 4.049 (0.786)	$\chi^2(1)=12.97$**
alfold_z – dunantul_z	-	- 1.08 (0.006)	$\chi^2(1)=16.38$**
alfold_z – emagy_z	-	- 0.994 (0.011)	$\chi^2(1)=0.251$
dunantul_z – emagy_z	-	- 0.920 (0.009)	$\chi^2(1)=17.71$**

‡ standard errors in brackets
** significant at 1%

Except the *dunantul_d – emagy_d* model, none of the other models have constant in the cointegrating relationship[3], and the region prices are cointegrated with a coefficient close to -1. The low standard errors however suggest that the coefficients are significant, and statistically different from -1. A value of -1 suggests perfect market integration (without constant the *strong version of LOP*), whilst a coefficient different from -1 indicates imperfect integration. We employ a Likelihood Ratio, (LR) test to formally test the β_1 = -1 nullhypothesis, the results are presented in the last column of table 3. Of all the models only the *alfold_z – emagy_z* model does not reject the null hypothesis[4], these markets may be considered as perfectly integrated.

The elements of the α vector, the speed of adjustment to the long-run equilibrium (see equation 4), and their significance is presented in table 4.

[3] The constant could be interpreted as proxy for the constant part of the transport and marketing costs between the regions (DAWSON and DEY 2002)

[4] Zero constant, and β_1 values close to -1 indicate proportional transaction costs, independent from the price. Because that would exclude some transaction cost items (e.g. comissions, risk premia, brokerage fees), the non-zero constant and coefficient different from -1 are not necessarily surprising results, and they do not suggest the lack of market integration (GOODWIN and PIGGOTT 2001).

Table 4. The speed of adjustment vector, α

Model	Variable	α vector	t - statistics
alfold_d – emagy_d	alfold_d	- 0.174	- 3.245
	emagy_d	0.107	3.197
dunantul _d– emagy_d	dunantul_d	- 0.056	- 1.622
	emagy_d	0.086	4.191
alfold_z – dunantul_z	alfold_z	- 0.345	- 3.546
	dunantul_z	0.167	2.127
alfold_z – emagy_z	alfold_z	- 0.093	- 1.938
	emagy_z	0.431	- 4.469
dunantul _z– emagy_z	dunantul_z	- 0.02	- 0.06
	emagy_z	0.576	4.876

Most t-statistics associated with the individual α values are significant, the result of the LR tests are presented in table 5.

Table 5. Weak exogeneity (Granger causality) tests

Model	Variable	Exogeneity test	LR test statistic
alfold_d – emagy_d	alfold_d	$\alpha_{alfold\_d} = 0$	$\chi^2(1) = 9.915^{**}$
	emagy_d	$\alpha_{emagy\_d} = 0$	$\chi^2(1) = 9.64^{**}$
dunantul_d – emagy_d	dunantul_d	$\alpha_{dunantul\_d} = 0$	$\chi^2(1) = 2.45$
	emagy_d	$\alpha_{emagy\_d} = 0$	$\chi^2(1) = 15.155^{**}$
alfold_z – dunantul_z	alfold_z	$\alpha_{alfold\_z} = 0$	$\chi^2(1) = 11.625^{**}$
	dunantul_z	$\alpha_{dunantul\_z} = 0$	$\chi^2(1) = 4.55^{*}$
alfold_z – emagy_z	alfold_z	$\alpha_{alfold\_z} = 0$	$\chi^2(1) = 3.786$
	emagy_z	$\alpha_{emagy\_z} = 0$	$\chi^2(1) = 19.029^{**}$
dunantul_z – emagy_z	dunantul_z	$\alpha_{dunantul\_z} = 0$	$\chi^2(1) = 0.003$
	emagy_z	$\alpha_{emagy\_z} = 0$	$\chi^2(1) = 22.002^{**}$

* significant at 5%
** significant at 1%

None of the α values in the *alfold_d – emagy_d* and *alfold_z – dunantul_z* models is zero, therefore none of the milk prices in these reagions is weakly exogenous related to the milk price in the other region. It follows that the price information is flowing in both directions resulting bidirectional causality, i.e. there is no dominant market amongst these pairs of regions. In the *dunantul_d – emagy_d* model, the milk price of the *Dunántúl* region is weakly exogenous, that is, the error correction mechanism does not affect short-run price setting. It results that the boxed milked price information is unidirectional, from the weakly exogenous (dominant), that is, from the *Dunántúl* region towards the *Északmagyarország* region. Similarly, in the *alfold_z – emagy_z* model, the *Alföld* region, in the *dunantul_z – emagy_z* model the *Dunántúl* region is the dominant market.

4.4. Threshold cointegration analysis

A common property of all linear (VECM) models discussed so far, is that the horizontal transmission is independent from the size of the shocks to the system. TVECM models[5] however, are able to determine the relationship between the milk prices in various regions, by paying attention to the magnitude of the shocks. We employ HANSEN and SEO (2002)

[5] Routines written in GAUSS programming language, available on B. Hansen's homepage (http://www.ssc.wisc.edu/~bhansen/) were used to test the threshold cointegration, estimate the threshold values, and cointegrating coefficients.

methods to estimate the cointegration coefficients and the threshold value[6]. The first column of table 6, presents the cointegration coefficients, the second one the threshold value, the third and fourth the percentage of observations belonging to each regime. The supLM statistic testing the VECM null hypothesis against the TVECM alternative hypothesis is in the last column, together with the *bootstrapped* critical values in brackets.

Table 6. Threshold cointegration analysis (TVECM)

Model	Cointegration coefficient	Threshold	Regime I. %	Regime II. %	supLM test statistic
alfold_d – emagy_d	1.60	282	78.4	21.5	12.51 (13.62) ‡
dunantul_d – emagy_d	0.26	69.36	70.5	29.4	12.85 (15.00)
alfold_z – dunantul_z	0.71	40.02	5.8	94.2	12.40 (15.93)
alfold_z – emagy_z	0.42	54.31	5.8	94.2	19.72 (17.56)
dunantul_z – emagy_z	0.57	30.24	5.8	94.2	20.64 (16.49)

‡ 5% critical values computed by 1000 *Bootstrap* replications.

For *alfold_z – emagy_z* and a *dunantul_z – emagy_z* models, the supLM test rejects the linear model in favour of the threshold cointegration. From theoretical considerate, and the results obtained with linear cointegration, one would expect cointegration coefficients close to 1. Estimated coefficients however, differ from 1 for all models, therefore because the lack of identification, the threshold values can not be interpreted. Although in the *alfold_z – emagy_z* and *dunantul_z – emagy_z* models, the threshold is significant and the test statistic rejects the linear cointegration null hypothesis, only 6% of all observations belong to the first regime (9 observations only). To estimate a fully specified TVECM model, one would need longer time series.

5. Discussion of the results, conclusions

In this study, we employ econometric techniques to analyse the spatial integration on the Hungarian milk sector, using boxed and plastic bag milk price data from 3 Hungarian regions. Despite the various changes in the past one and a half decade, the spatial structure of Hungarian milk production remained fairly stable. Although the spatial concentration of the production has increased, the hierarchy in terms of production of the individual counties remained the same. Together with results obtained on previous spatial integration studies in various other countries, and the theoretical considerate, we would expect to have the three Hungarian regions highly integrated, maybe characterised by the *strong version of LOP*. Graphical inspection of boxed and plastic bagged milk price series (Figures 1. and 2.), show that regional prices of the products behave rather differently during the studied period. The price of the plastic bag milk changes frequently, but with small amplitude, whilst boxed milk prices are less volatile, however the magnitude of the occasional price changes is much larger. This is largely explained by the differences between the two product categories. First, plastic bag milk is usually retailed for one or two days, having frequent (daily) deliveries, thus frequent prices changes are more feasible. Boxed milk is not much different from plastic bag milk, however its shelf life is longer, and therefore changing prices is slightly more difficult.

[6] The algorithm may be adjusted to consider an *a priori* given cointegrating relationship, and only do a gridsearch for the threshold value. In this study, both theoretical considerents and the results of the linear cointegration analysis suggests a cointegrating coefficient equal to – 1 (perfect integration). The supLM test however, does not reject the linear models in the favour of the threshold cointegrating specification.

Second, 42% of the total Hungarian retailed milk is in plastic bagged, 31% boxed, and 27% is long-life milk, thus the quick retailing of large quantities also increases price volatility.

Thus not surprisingly, the empirical analysis revealed linear cointegration (i.e. long-run relationship) between plastic bag milk price series in all regions. More, the constant terms proved to be zero, and the cointegration coefficients are close to 1 (in absolute value), suggesting that markets are characterised by the *strong version of the LOP*. LR tests however rejected the perfect integration null hypothesis for all plastic bagged milk price pairs except *alfold_z – emagy_z*. The analysis has revealed that there is a bidirectional causality relationship between plastic bagged milk prices in *Alföld* and *Dunántúl* regions, however each of them are dominant markets – determine prices – with respect to the *Északmagyarország* region. One may conclude that horizontal integration on the plastic bag milk prices is mostly according to *a priori* expectations, close to perfect integration.

For the *alfold_z – emagy_z* and *dunantul_z – emagy_z* plastic bag milk price pairs, the TVECM analysis rejected the linear cointegration null hypothesis in favour of the threshold cointegration alternative, the cointegration coefficients however were not those expected, (around the value of 1) and thus because identification problems the threshold values can not be interpreted. It is likely however, that with longer time series and less aggregated, e.g. county level data, TVECM models are more appropriate for spatial integration research than VECM models are.

The Hansen test did not reject the linear cointegration null hypothesis in favour of the TVECM for any boxed milk price pair. The *alfold_d - emagy_d* price pair is close to perfect integration, the relationship between the *dunantul_d - emagy_d* regional price pairs are not conform theory, and finally, the *alfold_d - emagy_d* price pairs are not even cointegrated, i.e. there is no long-run relationship between these regions' prices. This surprising result, might be due to the quality of the data we used.

When discussing our empirical results, we must face the problem of the data aggregation level. Econometric literature has long paid attention to the information losses, and bias introduced by aggregated data (SHUMWAY and DAVIS 2001). Despite this, there are only a small number of studies analysing aggregation problems on real data. LYON and THOMPSON (1993) focus on temporal and spatial aggregation using alternative marketing margin models, concluding, that model selection is greatly influenced by data aggregation. VON CRAMON-TAUBADEL et al. (2006) use German shop level data to analyse the effects of aggregating cross-sectional data. The experiment shows, that aggregated data produces results, if data is used for shop level price transmission analysis. It therefore seems likely, that empirical results based on average (aggregated) data introduce some bias into the individual price behaviour analysis.

What are the implications for the present research? First, using aggregated data may lead to interpretation problems, since for example transport costs within one region may be higher than between two regions. Second, by using aggregated data on region level, we can not on draw inference about county level market integration. Finally, to model transaction costs, we would need less aggregated, (county level) data.

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