Price transmission on the Hungarian milk market

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Abstract- **In this paper we focus on the vertical price transmission on the Hungarian milk market. We employ Gregory – Hansen methodology to simultaneously search for a break point and a cointegrating relationship between the logs of producer and retail prices of milk. Price transmission is asymmetric on both long and short-run, and after November 2000, the marketing margin has increased. We present a number of events that possibly explain the structural break.**

Keywords- **Price transmission, Gregory-Hansen cointegration, Hungarian milk market**

I. INTRODUCTION

The question of price transmission in the agro-food industry has been the object of much research in the recent years (see Meyer and von Cramon-Taubadel, 2004, for a survey). Within all the products under scrutiny the relationship between farm price and the retail prices of milk has received a great deal of attention in Europe as well as in the USA in the recent years. One main question in the debate about milk price relationships concerns whether retail milk price "responds" to changes in the farm price. This question assumes that a relationship between these prices exists and is persistent over time. We know however that the milk market is quite complex, includes wholesaler and intermediate goods. Moreover, EU countries have benefit from the EU dairy policy including import quotas, export subsidies, domestic production and consumption subsidies, intervention prices, as well as domestic production quotas, while non-EU countries like Hungary before the 1st of May 2004 had a different intervention policy. Although there is much research about various aspects of this process, such as competitiveness, structural change, etc, analyses focusing on agricultural price transmission have attracted only scant resources.

Price transmission may be a distinct subject for transition countries due to two reasons. First, because of the inherited pre-1989 distorted markets, low developed price-discovery mechanisms and often ad-hoc policy interventions, transitional economies could be expected to have generally larger marketing margins and more pronounced price transmission asymmetries. Second, when time series are relatively long some parameters may change over time. So far the empirical research focusing on structural breaks with special emphasis on long-run equilibrium relationships between prices at two different changes of a supply chain is limited (e.g. Dawson and Tiffin, 2000; Dawson et al. 2006; Guilloteau et al. 2005). However, we may expect that in a transition country the possibility of structural breaks may be larger due to profound structural changes along agri-food chains than in developed countries.

Given the high level of interest in the relationship among prices at the farm, wholesale and retail level, for milk we propose to closely examine these relationships using monthly time series data on these two levels using up-to-date cointegration methods. The paper is organised as follows. Section 2 presents the Hungarian milk sector, followed by the applied methodology in section 3. Section 4 focus on the empirical analysis, and finally, section 5 concludes.

II. HUNGARIAN MILK SECTOR

At the end of eighties the state (21.1 %) and collective farms (55.5 %) dominated milk production in 1989, respectively, compared to 23.4 by private farms. The average herd sizes of the three main farm types were: state farms (1300 cows), collective farms (300 cows) and small holders (1.4 cows). However, the structure of dairy production has changed considerably during the last 15 years. The number of cow decreased from the 497 thousands head in 1992 to 334 thousands by 2005. The number of dairy farms decreased between 1996 and 2005 dramatically by 59 percent for private farms, the fall was modest for agricultural enterprises, 14 per cent. The average herd size by farm types illustrates unambiguously the dual production structure in Hungarian milk sector. Surprisingly, the average herd size decreased from 326 to 295 in agricultural enterprises, whilst it grew from 2.9 to 6.2 in private farms (Table 1). In 2005, agricultural enterprises accounted for 67 per cent of output in terms of cow number, whilst the share of private farms was 33 per cent.

The declining tendency of milking cows was not followed by reduced milk production because of increasing yields. The dairy farm structure is different in agricultural enterprises and private farms. 95 per cent of private farms have less than 10 cows, while 74 per cent of agricultural enterprises have more than 100 cows.

The share of farms below 10 cows in herd stock is 71 per cent for private farms and 0.1 per cent for agricultural enterprises. The emerging share of medium size dairy farms is only 13 per cent.

Table 1. Average cow herd size in Hungary

Year	Private farms	Economic organisations	Total
1996	2.9	326	9.4
1997	3.6	331	10.1
1998	3.9	359	11.1
1999	4.3	353	11.5
2000	3.5	308	10.9
2001	4.3	320	11.8
2002	4.4	324	12.8
2003	4.9	298	14.3
2004	4.5	295	12.5
2005	6.2	295	18.2

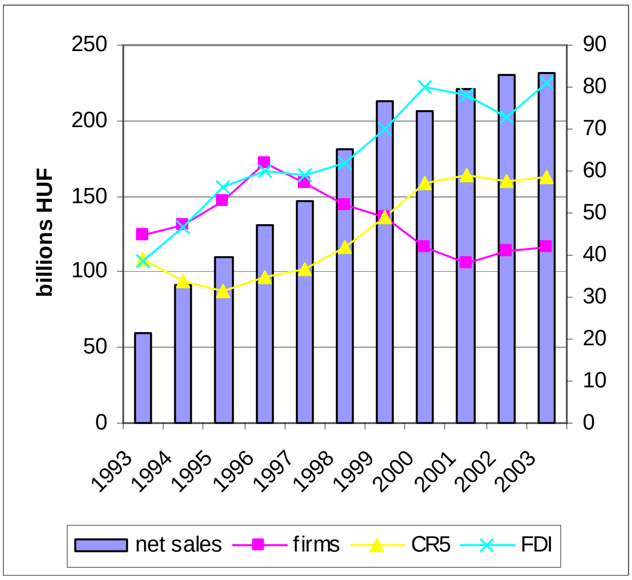
Source : Hungarian Central Statistical Office (HCSO)

In short, polarised structure of Hungarian dairy farms has not changed considerably during the analysed period. In Hungary the structure of milk production can be divided into three main groups differing in concentration, technology and in some respect in market segmentation as well:

- The agricultural enterprises and a minority (3-7%) of the private farmers mostly keeping more than 100 cows (300-600 on average) producing and selling to the processors.
- Around 17-20% of the private farmers having 10-20-30 cows trying to produce for the processors.
- Finally, most of the private farmers (71%) mainly having less than 10 cows.

Figure 1 provides information about Hungarian dairy industry including the number of dairy processors, net sales, concentration ratio (the share of top five firms in total net sales and the role of FDI in owners' equity. The net sales in nominal term show a continuous increase in the period under investigation. Since the data cover all firms with more than 20 employees, the number of firms have increased only slightly between 1993 and 1996, then decreased up to 2001 and it stabilised at around 40. Other words, there is no an indication of market entry but rather firm growth. Simultaneously, the concentration processes had delayed in the Hungarian milk processing industry in the first half nineties. The CR5 index has increased significantly between 1997 and 2000 reaching almost 60 percent levels. Jansik (2000) studying the foreign direct investment (FDI) in Hungary, finds that industries characterised by a oligopolistic market structure (sugar, vegetable oil, tobacco, soft drinks, starch) were privatised in the early 1990s, having over 70% foreign ownership of their capital.

Figure 1. Evolution of total sales, number of firms, concentration and the role of FDI in owners equity in the dairy industry sector in Hungary



Source: Research Institute for Agricultural Economics, Hungarian Central Statistical Office

Dairy processing is one of the four largest food industry, accounting for over 12 per cent of the total Hungarian food processing output. The privatisation of dairy industry started late, in the mid 1990s, and was characterised by low FDI. However, in the second half of nineties the largest dairy firms were bought by foreign investors, resulting a high level role of FDI in Hungarian dairy industry.

Agricultural subsidy is provided through a system of minimum prices, budgetary support, and border measures. The Agricultural Market Regulation Act of 1993 directly regulates markets for wheat (for human consumption), feed maize, milk, live cattle and pigs for slaughter, by providing market price support via minimum guaranteed prices, paid up to a production quota limit, and government purchases in the case of market instability. Support to reduce farm input costs includes capital grants linked to interest rate concessions to cover production cost, and reduction in the fuel tax and payments for irrigation development. Imports tariffs and export subsidies are used for most important agricultural products. Export subsidies constitute an important, albeit declining, policy instrument to regulate crops and animal product market. Imports are regulated by *ad valorem* tariffs and tariff rate quotas.

Milk sector was supported by several ways. First, there is an indicative price system, with the possibility of intervention. If producers do not find a buyer, they may in theory sell their quality milk to the State at a guaranteed price that is lower than the indicative price. In recent years, market prices were usually higher than the trigger price; therefore intervention has not been activated. Individual dairy quotas were introduced in 1996. Second, budgetary payments based on output include mainly quality and intervention payment. Third, area and headage payments, they were HUF 20 000 (USD 77) per dairy cow in 2002. Fourth, payments based on input use, include subsidised interest rate and guarantees for farm credit (around 45% of total), capital grants (15%) and fuel tax concessions (20%). Market price support had a predominant role in subsidizing milk sectors. Payments based on input use and on output had an increasing role, but their share was below 25 per cent of total support.

The National Land Fund was amended and a new institutional system was established to reassessment of land policy. The main amendments entail giving anyone who is renting farmland priority over family farmers for purchasing or renting arable land. The duration of land lease for National Land Funds lands will decline from 50 to 20 years, while in the case of private persons this will increase from 10 to 20 years. Land sales to foreigners and legal entities are prohibited. Special attention and support is given to the creation and development of producer marketing organisations. Agricultural insurance is supported at a rate of 30 per cent of the fees charged. In the context of food safety, new labelling rules are applied on dairy products, eggs, and most foods of vegetable origin entered into force as from April 2002.

According to the Copenhagen Agreement, Hungary uses the Single Area Payment Scheme (SAPS). Hungarian farmers in 2004 receive 305.81 million EUR direct payments. The calculation of the milk direct payments because of CNDP is complicated. According to the CAP Reform adaptation agreement in the milk sector CDNP is even higher than in the other sectors of agriculture, in total it amounts to 60%. The 85% direct payment (25%-from the EU, 60%-from Hungary) with 1,947,280 tons of milk quota means 22.81 million EUR. From this amount the subsidy paid according to the SAPS must be subtracted which is 5.84 million EUR. The 16.97 million EUR left is divided by the quota the result is 8.71 EUR subsidies for a ton of milk.

III. METHODOLOGY

A. Testing for unit roots

Most macroeconomic time series are not stationary over time, i.e. they contain unit roots. That is, their mean and variance are not constant over time. Utilising the standard classical estimation methods (OLS) and statistical inference can result in biased estimates and/or spurious regressions. There are a large number of unit root tests[1] available in the literature (see Maddala and Kim, 1998 for a comprehensive review). Maddala and Kim (1998) argue, that because of the size distortions and poor power problems associated with the commonly used Augmented Dickey-Fuller unit root tests, it is preferable to use the DF-GLS unit root test, derived by Elliott, Rothenberg and Stock (1996). With structural breaks in the time series, the unit root tests might lead to the misleading conclusion of the presence of a unit root, when in fact the series are stationary with a break. Several unit root tests were developed to handle the problem. The Perron (1997) test performs an endogenous search for the breakpoints by computing the t-statistics for all possible breakpoints, then choosing the breakpoint selected by the smallest t-statistic, that being the least favourable one for the null hypothesis.

B. Cointegration analysis

Even though many individual time series contain stochastic trends (i.e. they are not stationary at levels), many of them tend to move together over the long run, suggesting the existence of a long-run equilibrium relationship. Two or more non-stationary variables are cointegrated if there exists one or more linear combinations of the variables that are stationary. This implies that the stochastic trends of the variables are linked over time, moving towards the same long-term equilibrium. The two most widely used cointegration tests are the Engle-Granger two-step method (Engle and Granger, 1987) and Johansen's multivariate approach (Johansen, 1988).

Gregory and Hansen (1996) introduce a methodology to test for the null hypothesis of no-cointegration against the alternative of cointegration with structural breaks. 3 models are considered under the alternative. Model 2 with a change in the intercept:

$$y_{1t} = \mu_1 + \mu_2 \varphi_{t\tau} + \alpha^{\mathrm{T}} y_{2t} + e_t \text{ , t = 1,…,n.} \quad (1)$$

Model 3 is similar to model 2, only contains a time trend:

$$y_{1t} = \mu_1 + \mu_2 \varphi_{t\tau} + \beta t + \alpha^{\mathrm{T}} y_{2t} + e_t \text{ , t = 1,…,n.} \quad (2)$$

Finally, model 4 allows a structural change both in the intercept and the slope:

$$y_{1t} = \mu_1 + \mu_2 \varphi_{t\tau} + \alpha_1^T y_{2t} + \alpha_2^T y_{2t} \varphi_{t\tau} + e_t \text{ ,}$$

t= 1,…,n. (3)

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[1] Consider the first order autoregressive process, AR(1): $y_t = \rho y_{t-1} + e_t$, t =…,-1,0,1,2,…, where e_t is white noise.

The process is considered stationary if $|\rho| < 1$, thus testing for stationarity is equivalent with testing for unit roots (ρ= 1). Rewriting to obtain:

$\Delta y_t = \delta y_{t-1} + e_t$ where $\delta = 1 - \rho$, the test becomes:

$H_0 : \delta = 0$ against the alternative $H_1: \delta < 0$.

Because usually the time of the break in not known *a priori*, models (1) – (3) are estimated recursively allowing T to vary between the middle 70% of the sample:

$$\left|0.15n\right| \le T \le \left|0.85n\right|$$

For each possible breakpoint, the ADF statistics corresponding to the residuals of models (1) – (3) are computed, then the smallest value is chosen as the test statistic (being the most favourable for the rejection of the null). Critical values are non-standard, and are tabulated in Gregory and Hansen (1996).

C. Asymmetrical error correction representation

With the development of cointegration techniques, attempts were made to test asymmetry in a cointegration framework. Von Cramon-Taubadel (1998) demonstrated that the Wolffram-Houck type specifications are fundamentally inconsistent with cointegration and proposed an error correction model of the form:

$$\Delta RP_t = \alpha + \sum_{j=1}^{K} (\beta_j^+ D^+ \Delta FP_{t-j+1}) + \sum_{j=1}^{L} (\beta_j^- D^- \Delta FP_{t-j+1}) +$$

$$\varphi^+ ECT^+_{t-1} + \varphi^- ECT^-_{t-1} + \sum_{j=1}^{P} \Delta RP_{t-j} + \gamma_t \qquad (4)$$

The error correction term, (ECT_t), is in fact the residual of the long-run (cointegration) relationship:

$ECT_{t-1} = \mu_{t-1} = RP_{t-1} - \lambda_0 - \lambda_1 FP_{t-1}$; λ_0 and λ_1 are coefficients. The error correction term is than segmented into positive and negative phases (ECT^+_{t-1} and ECT^-_{t-1}), such that:

$ECT_{t-1} = ECT^+_{t-1} + ECT^-_{t-1}$.

Using a VECM representation as in (11), both the short-run and the long-run symmetry hypothesis can be tested, using standard tests. Valid inference requires one price to be weakly exogenous on both long and short run with respect to the parameters in (4). Following Boswijk and Urbain (1997) we test for the short-run exogeneity by estimating the marginal model (5), than perform a variable addition test of the fitted residuals $\hat{v}_t$ from (5) into the structural model, (4):

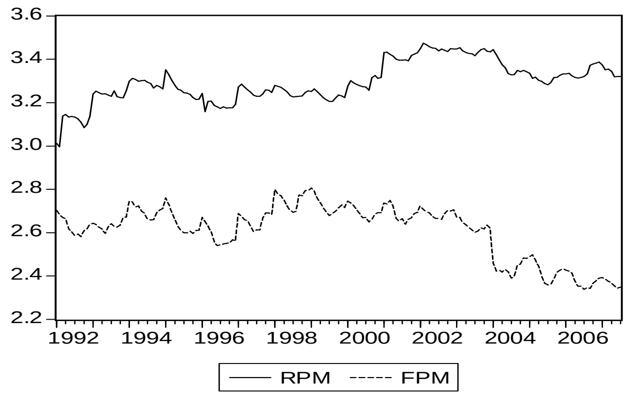
$$\Delta P^P_t = \psi_0 + \psi_1(L)\, \Delta P^R_{t-1} + \psi_2(L)\, \Delta P^P_{t-1} + v_t \qquad (5)$$

Long-run exogeneity is tested by the significance of the error correction terms in the equations (4), and (5).

IV. EMPIRICAL ANALYSIS

Milk producer and retail prices were collected from the Hungarian Central Statistical Office (HCSO), from January 1992 to July 2007, resulting a database of 187 monthly observations for both time series. Prices were deflated to January 1992, using the Hungarian Consumer Price index (CPI), than logs were taken. The transformed producer (FPM) and consumer (RPM) prices are presented on figure 1.

Figure 1. The log of Hungarian producer and retail prices of milk



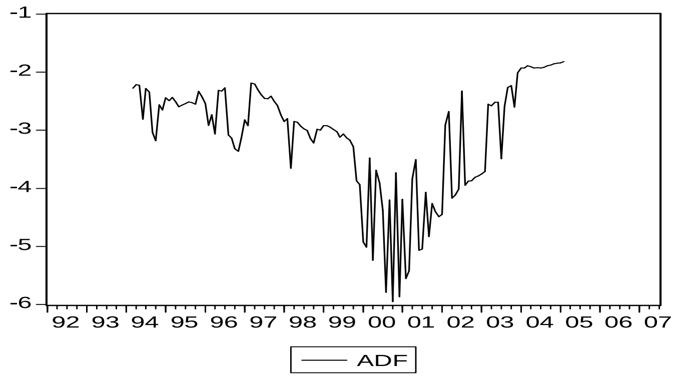
Source: Own calculations using HCSO data

DF-GLS, and Perron (1997) unit root tests[2] reveal that none of the price series is stationary, therefore cointegration framework is needed to analyse the price series. Standard cointegration tests (Engle-Granger and Johansen) could not reject the no cointegration null. One reason might be that not only the individual series, but also the long-run relationship between them is also subject to level shifts.

The Gregory-Hansen (1996) cointegration test in the presence of level shifts[3], generated the recursively estimated ADF statistics in figure 2. The minimum, (- 5.951), corresponding to a structural break occurring in November 2000, is significant at 1%, rejecting the no cointegration null in favour of the cointegration with regime shift alternative hypothesis.

[2] Unit root test results are not presented here, but they are available from authors upon request.
[3] Lag length was selected by downward t-statistic chosen autoregressive process, with 14 maximum number of lags.

Figure 2. Recursively estimated Gregory - Hansen AFD statistics



Source: Own calculations using HCSO data

The long-run relationship is (t- statistics in brackets):

$$RPM = 2,344 + 0,184E + 0,332FPM \qquad (6)$$

(26,33) (23,18) (9,983)

where, $E = \begin{cases} 0 & if \quad t < November \quad 2000 \\ 1 & if \quad t \geq November \quad 2000 \end{cases}$.

To test competitive market structure hypothesis, restrictions were applied to equation (6). The $\beta_{RPM} = - \beta_{FPM}$ homogeneity restriction was rejected, $F(1,184) = 400.92$, ($p = 0.00$). It follows, that Hungarian milk market is characterised by mark-up pricing, with an elasticity of transmission $\varepsilon_{FPM} = 0.332$.

Exogeneity test results for producer prices are $\chi^2(1) = 0.326$ ($p = 0.56$), for retail prices are $\chi^2(1) = 15.695$ ($p = 0.00$). It results, that producer prices are weakly exogenous, on the long-run, producer prices determine retail prices. After segmenting the error correction terms resulted from equation 6 onto positive and negative sections, a VECM model similar to equation 4 was estimated. Long and short-run symmetry test results are presented in table 2:

Table 2. Long and short-run symmetry tests on the Hungarian milk market

Hypothesis	Long-run	Short-run
Null: symmetry	$\varphi^+ = \varphi^-$	$\sum_{j=1}^{K} (\beta_j^+ D^+ = \sum_{j=1}^{L} (\beta_j^- D^-$
Alternative: asymmetry	$\varphi^+ \neq \varphi^-$	$\sum_{j=1}^{K} (\beta_j^+ D^+ \neq \sum_{j=1}^{L} (\beta_j^- D^-$
Test statistic	$F(1,172) = 4.393$ ($p = 0.03$)	$F(1,172) = 3.727$ ($p = 0.05$)

The null hypotheses are rejected, it results, that price transmission on the Hungarian milk market is asymmetrical on both long and short-run, i.e. the eventual producer price increases are transmitted more rapidly and fully to the consumer level than producer price decreases. In addition, after November 2000, the marketing margin increases (equation 6). What can be the reason for the increase of the marketing margine? Table 3 presents data from GfK Hungaria Market Research Institute. In 2000, the volume of milk and milk products consumption stagnated, or only slightly increased, whilst the value of consumption increased, supporting our results.

Table 3. Changes of milk products consumption in Hungarian households.

Product	Quantity	Value
Milk	0	+16 %
Cheese	+1 %	+18 %
Fruit yoghurt	+8 %	+14 %
Sour cream	-7 %	+10 %

Source: GfK Hungária Market Research Institute ConsumerScan
Note: changes in January – September 2000, related to January – September 1999

Figure 1 presents the situation of the milk processing industry during the analysed period. In 2000 the number of firms decreased, sales however increased, and thus the market share of the 5 largest companies increased. It is quite likely, that the bankruptcy in 2000 of one of the major milk processing firms, MiZo, also contributed to the increased concentration, and the increasing market power of the processing-retail sectors. This explains the asymmetrical price transmission in the sector.

The polarised production structure is another explication for the asymmetrical transmission. 95% of the individual milk farms have less than 10 cows, whilst 74% of agricultural enterprises operating in the milk sector have more than 100 cows. According to the production structure, sales, technology and market share, Hungarian milk farms may be grouped into 3 categories:

- agricultural production companies, and a small proportion of individual farms (3%), which have more than 100 cows (on average 300 – 600), and sell to processors;
- 17 – 20% of individual farms, owning 10 to 30 cows, and trying to sell for producers;
- 71% of individual milk farms, which have less than 10 cows.

Only a few of these farmers are able to produce efficiently large quantities, others produce for self consumption or directly sell their products on local markets.

V. CONCLUSIONS

In this study we used Gregory-Hansen cointegration in the presence of level shift methodology to analyse the vertical price transmission between the producer and retail prices of milk in Hungary. We identified a structural break in the long-run equilibrium relationship occurring in November 2000, after which the marketing margin increased. Major changes in the structure of Hungarian milk sector explained the occurrence of the structural break. Price transmission analysis revealed that transmission on the Hungarian milk sector is asymmetric on both long and short-run. This is not surprising considering the production and processing structure of the sector. It follows, that processors and retailers may delay or not fully transmit producer price decreases to the consumer level, thus reducing the efficiency of the sector.

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