

# Testing for signals on oligopolistic behaviour – case of Finnish and German pork meat price

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**Abstract**— Market integration of Finland toward EU has important implication to domestic agricultural policy. Our aim is to estimate the characteristics of the Finnish pork markets in relation to Germany. Our analysis use symmetric and asymmetric threshold error correction models. Pork prices are found cointegrated, and cointegration relationship of two counties is found asymmetric. A large positive shock in Germany is transmitted faster to Finland than a large negative one. It implies that a combination of co-operative processors and public quoted companies as in Finland, can smooth out some of the short term price fluctuations observed abroad.

**Keywords**— **cointegration, asymmetric, error correction.**

## I. INTRODUCTION

One of the main goals of the EU's common agricultural policy is to get spatially integrated agricultural commodity markets within and between all member states. In an integrated market, price information should be efficiently transmitted between the member states. EU commission claims that also domestic policies and regulations applied in the member countries, should support (or at least not to distort) the goal of achieving the informational efficient single European market. Particularly in Finland, with small and remote domestic market, the issue of market efficiency and transmission of market information have significant implications for two important domestic policy measures. The first is actions taken in accordance of the antitrust legislation on regulating the domestic food industry structures. The second is permission for domestic agricultural subsidy programs that supplement the CAP.

Spatial market integration is important for regulating the structure of food processing through antitrust legislation, because the domestic retail

businesses are highly concentrated in Finland<sup>1</sup>. Since a most common reason for the prevalence of vertical restraints in the food sector is the increasing market power of food retailers (McCorrison 2002), market concentration can be expected to have important implications particularly in the Finnish market. Concentrated market structure is known to be a key condition to add firms' incentives for oligopolistic behavior, such as non-cooperative Tacit collusion, strategic price signaling, and strategic investment (Tirole 1992). From the perspective of the Finnish meat market, the problem is that the domestic retailing is more concentrated than the domestic processing. Even though the processing industry is also quite concentrated, the Finnish processors are very small to cope in the overly competitive European wide and global exports market. An important question then is that what would be the efficient public policies to regulate the domestic meat processing industries, and to accept or promote means for improving their competitiveness. The crucial research question linked to the policies regulating structural development in the domestic meat processing is that what is the size of our market. In economic concepts, the issue is that how well the Finnish meat market is integrated in the European wide meat market and what are the characteristics of spatial transmission of price information between the Finnish and other European markets.

The EU commission allows for domestic agricultural subsidies only if spatial integration in the agricultural commodity market is maintained and, in the case of market entrants as Finland, also promoted. This might pose a problem from the Finnish perspective, since without domestic programs supplementing the CAP, competitive and spatially integrated agricultural commodity markets would require that also production costs should be spatially

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1. <sup>1</sup> In EU, the concentration of domestic retail businesses is the lowest in Italy and the highest is Finland

integrated between the member states. In the long run competitive market equilibrium, product prices and costs must be integrated, because excess profits do not exist. But agricultural production costs are known to be substantially higher in Finland than in the main agricultural areas of Europe. The Finnish costs cannot, therefore, be integrated with the competitive production costs and product prices in the EU. Since the equilibrium condition for European wide competitive market cannot rigorously hold, promoting the market integration may require that the CAP is supplemented by domestic policies in Finland.. Therefore, new information on the structure of market integration is required for justifying and designing means of the domestic policies that supplement the CAP.

## II. Goal

The goal is to estimate the characteristics of the Finnish pork in relation to German market. The goal is broader and deeper than just testing whether the markets are spatially integrated or not. The study

identifies sources of uncertainty in Finnish hog prices and obtains quantitative estimates of the relative contribution of internal versus external supply and demand shocks to the overall behavior of the market.

## III. The data

The data are weekly pork and beef prices in Finland and in Germany. The data span the years 1995-2004 (Figures 1 and 2). Each price series include 520 observations. The Finnish data are from the Information Centre of the Ministry of Agriculture and Forestry (TIKE). The Finnish data involved missing observations (12 pieces), which were filled in by the average of the previous and the following prices. The German data are from the German Centre for Documentation and Information in Agriculture (ZADI), which is the scientific information institute of the Federal Ministry of Consumer Protection, Food and Agriculture. The prices used in the study are the prices that are paid to the producer for one slaughtered kilogram of meat at the gate of the slaughterhouse. They don't include transportation costs to slaughterhouse. The prices are the average prices of the EUROP -quality classes, that have been weighted with the slaughterweights.

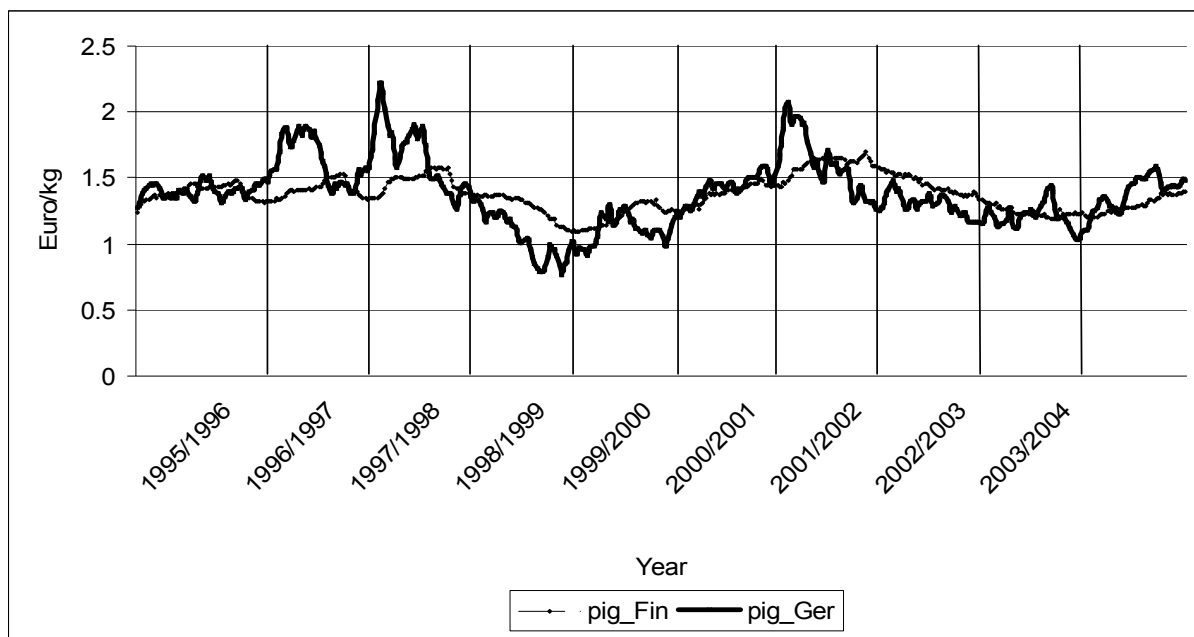


Figure 1. Pork (pig meat) prices in 1995-2004 in Finland and in Germany

## IV. ECONOMETRIC MODELS AND RESULTS

### A. Testing for unit roots

The first step in the analysis of the Finnish and German meat prices ( $p_t^{Fin}$  and  $p_t^{Ger}$ ) is to test for stationarity and the order of integration of the individual price series. Stationarity of the price processes is tested using a group of unit roots which include the Augmented Dickey-Fuller (ADF) test (1976), Phillips-Perron test (PP) (1988), and a test developed by Kwiatkowski-Phillips-Schmidt-Shin (KPSS) (1992). While the ADF, PP tests state the null hypothesis of non-stationarity or the presence of a unit root, the KPSS test defines stationarity as the null. Results of all the tests are given in Table 1.

Both ADF and KPSS tests indicate that Finnish pork contain a unit root component. However, ADF and KPSS tests have different results in German pork, but PP test supports the ADF tests, therefore, it is prudent to conclude that the series of German pork is nonstationary. For the first difference series, the results of all these unit root tests indicate they are stationary and are not reported here, thus Finnish pork and German pork are intergrated of order 1, designated as I(1).

Table 1. Unit Root Tests

Test	Finnish price	German price	Critical value at 5% <sup>a)</sup>	Critical value at 1% <sup>b)</sup>
ADF (intercept excluded)	-0.54	-1.22	-1.94	-2.57
ADF (intercept included)	-2.50	-2.50	-2.87	-3.44
KPSS (intercept included)	1.81**	0.39	0.46	0.74
Phillips-Perron (intercept included)	-2.09	-2.70	-2.87	-3.44

Notes: ADF is Augmented Dickey-Fuller test. KPSS is the  $\eta$ -test of Kwiatkowski et al. (1992). Phillips-Perron test is Phillips and Perron (1988) nonparametric test of unit root. Asterisk (\*) and (\*\*) denote significance level at 5 % and 1% respectively. a) denotes MacKinnon (1996) critical values for rejection of hypothesis of a unit root; b) denotes Kwiatkowski et al. (1992, Table 1)<sup>2</sup>

2. <sup>2</sup> Unit root testing and cointegration analysis are conducted using EVIEWS 5.1 (2004).

### B. Cointegration test

We test the cointegration between Finnish and German pork prices using Johansen's VAR-based ML method (Johansen and Juselius, 1990) with 4 lags according to both the Akaike and Schwarz criteria. The selected number of cointegrating relation by model is carried out by Eviews 5.1 and the results are presented in Table 2. The results of both the Max-Eigenvalue and Trace tests imply that the null hypothesis of zero cointegrating vector linking Finnish and German pork price can be rejected. Whether or not the constant is restricted to be part of the cointegration equation has no significant influence on these test results. Akaike information suggests that the model with restricted constant but no deterministic trend fits the data slightly better. Together with trace and Max-Eigenvalue information, we conclude that Finnish pork and German pork price are cointegrated.

### C. Symmetric and asymmetric Error Correction Model (ECM)

Since the series turned out non-stationary and cointegrated, an Error Correction Representation exists (Engle and Granger, 1987). Thus, the short-run dynamics and the long-run relationship of the price formation process are jointly estimated in the specification shown in equation (2a) and (2b)

Table 2. Johansen Cointegration Test Summary

<b>(a) Constant restricted</b>						
Hypothesized No. of CEs	Max- Eigenvalue	1% max	Trace statistic	1% trace	Akaike Information	Schwarz Criteria
r=0***	38.09	24.60	44.09	20.20	-10.9766	-10.8448
r=1	5.99	12.97	5.99	12.97	-11.0201	-10.8554
<b>(b) Constant unrestricted</b>						
Hypothesized No. of CEs	Max- Eigenvalue	1% max	Trace statistic	1% trace	Akaike information	Schwarz Criteria
r=0**	30.42	15.69	30.84	16.31	-10.9766	-10.8448
r=1	0.42	6.51	0.42	6.51	-11.0311	-10.8581

Note: Critical values based on MacKinnon-Haug-Michelis (1999). \*\*\* denotes rejection of hypothesis at 1% level

$$\Delta \ln p_t^{FIN} = \phi_0 + \beta_0 \Delta \ln p_t^{GER} + \beta_1 (\ln p_{t-1}^{FIN} - (k_0 + k_1 \ln p_{t-1}^{GER})) + \beta_2(L) \Delta \ln p_{t-1}^{GER} + \beta_3(L) \Delta \ln p_{t-1}^{FIN} + \varepsilon_t \quad (2a)$$

which is usually written in the form

$$\Delta \ln p_t^{FIN} = \phi_0 + \beta_0 \Delta \ln p_t^{GER} + \beta_1 ECT_{t-1} + \beta_2(L) \Delta \ln p_{t-1}^{GER} + \beta_3(L) \Delta \ln p_{t-1}^{FIN} + \varepsilon_t \quad (2b)$$

where  $ECT_{t-1} = \ln p_{t-1}^{FIN} - k_0 - k_1 \ln p_{t-1}^{GER}$  and is referred to as the Error Correction Term. This term describes the departure of prices from the long-run equilibrium between Finnish and German pork price at period t. That is why the process is a stationary I(0) process. On average  $ECT_{t-1}$  can be expected to be zero, but it may also be strongly autocorrelated as disequilibrium disturbances take time to be eliminated. Equation (2b) has the standard statistical properties of stationary models, since  $\Delta \ln p_t^{FIN}$ ,  $\Delta \ln p_t^{GER}$  and  $ECT_{t-1}$  are all I(0) variables, and  $\beta_3(L)$  and  $\beta_4(L)$  are lag polynomials. The main advantages of using the Error Correction Model (ECM) are twofold. First, it is easy to distinguish between short and long-run price response. Second, the speed of adjustment toward the long-run steady state values can be directly estimated.

Equation (2b) imposes a symmetry constraint such that both negative and positive price shocks and deviations from the long-run equilibrium (steady state) prices are incorporated into the observed prices at an equal speed. Adjustment of prices induced by deviations from the long-term equilibrium are

assumed to be continuous and a linear function of the magnitude of the deviation from long-term equilibrium. So, even very small deviations from the long-term equilibrium will always lead to an adjustment process on each market. This assumption might lead to a biased result, at least decrease the efficiency of the estimates, because it ignores the impact of transaction costs. In spatial markets, transportation costs, for example, may limit the transmission of price shocks below a critical level if potential gains from trade cannot outweigh these costs and hence a perfect price adjustment will not occur (Azzam, 1999, Meyer 2003). In addition, if there is significant unbalance of market power between the pork producers, processors and distributors, the price transmission may exhibit asymmetries. If the traders have market power against producers or they have potential to maintain collusion with their competitors through strategic price signalling, the Finnish price should move towards the steady state equilibrium slower from below than from above the equilibrium. Also negative shocks in the German prices should be transmitted to Finnish prices faster than positive price shocks. If meat traders believe that no competitor will

match a price increase but all will match a price cut, positive asymmetry will occur. Therefore, the estimating equation (2b) is further generalized for allowing thresholds effects in the discrepancy between the current price and the long-run equilibrium price. The idea then is that price is adjusted towards its long-run equilibrium only if the current price is sufficiently far below or far above the equilibrium price. The estimating equation now takes the form:

$$\begin{aligned} \Delta \ln p_t^{FIN} = & \phi_0 + \beta_1 \Delta \ln p_{t-1}^{GER} + \varphi_1 ECT_{t-1} \\ & + \varphi_2 D^- ECT_{t-1} + \varphi_3 D^+ ECT_{t-1} \\ & + S(t) + \beta_2(L) \Delta \ln p_{t-1}^{FIN} + \beta_3(L) \Delta \ln p_{t-1}^{GER} + \varepsilon_t \end{aligned} \quad (3)$$

where  $D^- = 1$  if  $ECT_{t-1} < c_1 < 0$ , and otherwise  $D^-$  equals zero. Similarly,  $D^+ = 1$  if  $ECT_{t-1} > c_2 > 0$ , and otherwise  $D^+$  equals zero. The base of the model is similar to that of von Cramon-Taubadel et al. (1995). The terms  $D^- ECT_{t-1}$  and  $D^+ ECT_{t-1}$  indicate error correction terms in which the Finnish price is either below ( $D^- ECT_{t-1}$ ) or above ( $D^+ ECT_{t-1}$ ) the long run equilibrium price. Asymmetric response is modeled through decomposition of the error correction term and the German price movements. This specification allows for two kinds of asymmetry. The first asymmetry is a possible discrepancy in the transmission of positive and negative price shocks between the Finnish and German market. That is, the value and significance of parameters  $\beta_1$ ,  $\varphi_1$ , and  $\varphi_2$ . The second type of asymmetry is a different price response when the observed domestic price is either below or above its steady state equilibrium. The econometric specification is further developed to control for endogenous thresholds in the price response on the lines suggested by Gil (2002) and by Meyer and von Cramon-Taubadel (2002).

Controlling for the thresholds is important for increasing the efficiency of the estimates and the power of testing for the market asymmetries. Persistent shocks in the transactions costs are controlled for, because they can generate a significant wedge between the Finnish and foreign prices even if the markets are efficient. The model is first estimated conditional on exogenously given thresholds,  $c_1$  and  $c_2$ . Obviously, the model (3) contains 3 different regimes of price adjustment. Endogenous thresholds,

*i.e.* values for  $c_1$  and  $c_2$ , are then simulated by a two-dimensional grid search procedure, which maximizes the likelihood function (Goodwin and Holt, 1999). In details we search for the first threshold between 5% and 95% of the largest negative ECT. Similarly, we search for the second threshold between 5% and 95% of the largest positive ECT. The error correction model is then re-estimated conditional on the threshold parameters. Applying the described search procedure yields two threshold parameters of  $c_1 = -0.175$ ;  $c_2 = 0.18$ , which are quite close in terms of the absolute values. Regime 1 is defined by those weekly prices where the negative deviation from the long-term equilibrium is below 17.5%. Regime 2, on the other hand is defined by those weekly prices where the positive deviation is over 18%. Averagely, the deviation represents roughly  $\pm 0.24\text{€}/\text{kg}$  slaughter weight. Regime 3 then corresponds to errors that are between the thresholds that define Regimes 1 and 2. The adjustment regime 2 contains 94.9% of all observations. Both regime 1 and 3 contains 13 observations out of total 520 observations.

Estimated coefficients of the general threshold error correction model and standard errors of these coefficients are reported in Table 3. It is clear from the results that the coefficient of the lagged error-correction term  $ECT_{t-1}$  is negative and statistically significant at one percent two tailed risk level, which supports Granger representation theorem (Engle and Granger, 1987). Also it further supports the validity of cointegrating relationship in equation (2b). Granger's theorem stated that  $ECT_{t-1}$  denotes the speed of adjustment to the long-run equilibrium, which is quite slow (only 3%) here. It implies that after a shock, each week 3% of the departure from the long run equilibrium will disappear. Compared to other price transmission studies, the speed of adjustment in the Finnish price as a response to a shock in the German price was estimated to be relatively low. Although several authors stress that policies impede the extent of price transmission (see for example Mundlak and Larson, 1992; Quiroz and Soto, 1996; Baffes and Ajwad, 2001; Abdulai, 2000; Sharma, 2002), it should be noted that other reasons such as high transaction

costs and other distortions may also be the cause for slow adjustment.

Table 3. Parameter estimates in the asymmetric error correction model for pork prices with threshold effects (Equation 3.)

Model variable	Equation 5(a)
Intercept	-0.0071***(0.0018)
German price difference $\Delta \ln p_t^{GER}$	0.0335(0.026)
$ECT_{t-1}$	-0.0287***(0.0057)
$D^- ECT_{t-1} < c_1$	-0.0203*(0.0117)
$D^+ ECT_{t-1} > c_2$	-0.0129(0.011)
Twice lagged Finnish price difference $\Delta \ln p_{t-2}^{FIN}$	0.087**(0.0459)
Fourth lagged Finnish price difference $\Delta \ln p_{t-4}^{FIN}$	0.0753**(0.0387)
Once lagged German price difference $\Delta \ln p_{t-1}^{GER}$	-0.0165(0.0277)
Negative German price difference $\Delta^- \ln p_t^{GER}$	-0.0259(0.0429)
Negative once lagged German price difference $\Delta^- \ln p_{t-1}^{GER}$	-0.0511(0.0431)
Week	0.0005***(0.0001)
Week square	-7.12E-6***(2.57E-6)
R-squared	0.2099
The sum of squared residual	0.0421
$\tau_1$	0.4245[~ F(4, 499)]
$\tau_2$	90.29***

Note: \*, \*\* and \*\*\* denote statistical significance at 10, 5, 1 percent levels, respectively.  $\tau_1$  = Breush-Godfrey LM test for autocorrelation. The most significant result for up to and including 2 lags is presented.  $\tau_2$  = Jarque-Bera normality test.

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The statistical insignificance of contemporaneous change (lagged price difference  $\Delta \ln p_t^{GER}$ ) indicates that one week might be too short

for the Finnish pork price to react and that weekly data is frequent enough to expose the process of price transmission.

The Finnish pork price reacts more rapidly to large positive shocks in the German price than to a large negative shock in the German price. In other

words the Finnish price adjusts faster towards the long run equilibrium from below than from above the equilibrium. When the price approaches the equilibrium (*i.e.* reaches the thresholds  $c_1$  and  $c_2$ ), the speed of adjustment is similar above than from below the equilibrium.

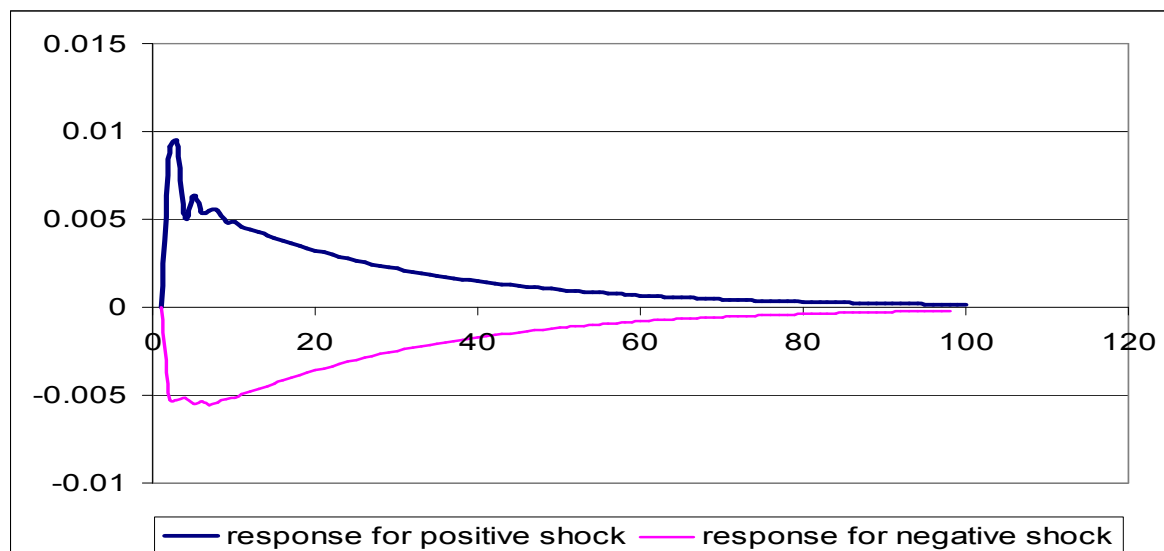


Figure 3. Impulse response of Finnish pork price return to the German pork return

In Figure 3, the results in Table 3 are used to estimate an impulse-response function to describe the dynamic interrelationship between German and Finnish pork prices. Vertical axis represents the Finnish pork price difference and horizontal axis describes the weeks after the shock. To be able to see the negative asymmetric effect, we define double change of German pork price return as a unit in German sample mean price, and response on the basis of sample mean. Thus the picture above shows how the Finnish pork price responds to a simulated persistent unit increase or decrease in the German pork price after up to over one year. From the picture, we can see that the asymmetric effect is obvious immediately after the shock, *i.e.* the Finnish pork price responds more rapidly to the simulated positive shock than to the negative shock of similar magnitude. However, the response of Finnish pork price to the positive and negative shocks becomes symmetric after 10 weeks. As Table 4 shows, a unit change in German price has little contemporaneous reaction in the Finnish price. Thus, most of the discrepancy between

the equilibrium price and observed price is corrected by a factor of only 0.03 per week after the shock. Therefore, the Finnish pork price return goes back to its equilibrium value very slowly and it takes more than 50 weeks until most of the shock is absorbed.

## V. CONCLUDING REMARKS

This study has very important economic implications at two different levels. First, better and statistically tested knowledge on the transmission of price information can be used to justify domestic agricultural policies and infer whether the domestic meat markets exhibit oligopolistic behavior in the extent that it decreases society welfare.

We examined price cointegrating relationship between Finnish and German pork meat market using asymmetric threshold error correction model, which recognizes the non-stationary nature of the price data

and allows for asymmetric price responses. In asymmetric threshold error correction model, we use two thresholds to identify three regimes.

A significant cointegrating relationship was found between the German and Finnish pork prices. Even if the long run relationship between the German and Finnish price exists, the adjustment is relatively slow compared to the corresponding results in the literature. Only 3% of the disequilibrium is decreased during each week after a shock is observed in the German pork price. In the short-run, the German price has only a negligible effect on the Finnish pork price. It may result from the fact that Finnish own lagged pork price is the dominating short run dynamic of Finnish pork price.

The long run cointegration relationship was found asymmetric. The estimated model with two thresholds and three regimes, which indicates that the symmetric middle regime is wide: +/- 20% as measured from the German price. Only larger than 20% price shocks, transmit asymmetrically to the Finnish market. A large positive shock in the German price is transmitted faster to Finland than a large negative price shock. In other words, when the Finnish price is far below the long run equilibrium it is adjusted faster towards the equilibrium compared to the case when the Finnish price is far above the equilibrium. The result does not, therefore, support strategic price signalling or oligopolistic behaviour by processor and retailers, such that negative price shocks observed abroad would be transmitted faster to the domestic market than positive shocks.

With regards to the sources of price volatility, the results indicate that domestic sources are likely to dominate the transmission of foreign shocks in the domestic market. In particular, short term price fluctuations abroad are not significant sources of price volatility in the Finnish market. Nevertheless, the price series seem to have significant cyclical behaviour. Whether the observed term structure is stochastic or deterministic, remains a topic for further statistical testing.

The relatively slow and sluggish response of domestic price to the price shocks in the foreign market supports the view that the Finnish meat chain, which is a combination of co-operative processors and

public quoted companies, can smooth out some of the short term price fluctuations and high price volatility observed abroad. Another reason for the sluggish price movements may be in the structure of delivery and pricing contracts between the meat processors and meat purchasing groups at the whole sales level. The economic performance and efficiency of these contracts cannot explicitly be studied by the reduced form price models and they are, therefore, left here for future research.

## REFERENCES

1. McCorrison, S. (2002) Why should imperfect competition matter to agricultural economists? *European Review of Agr. Econ.* Vol 29 3:349-372.
2. Tirole, J.(1992) *The Theory of Industrial Organization.* 479 p. The MIT Press, Cambridge Massachusetts.
3. Kwiatkowski, D., Phillips, P., Schmidt, P. & Shin, Y. 1992. Testing the null hypothesis of stationarity against the alternative of a unit root." *Journal of Econometrics* 54: 159–178.
4. Johansen, Søren and Katarina Juselius (1990) Maximum Likelihood Estimation and Inferences on Cointegration-with applications to the demand for money. *Oxford Bulletin of Economics and Statistics*, 52, 169-210.
5. Engle, Robert F. and C.W.J. Granger (1987), Cointegration and Error Correction: Representation, estimation, and Testing, *Econometrica*, 55 (1987):251-276.
6. Azzam, Azzeddine M. (1999): Asymmetry and Rigidity in Farm-Retail Price Transmission. *American Journal of Agricultural Economics*, 81. 525-533.
7. Meyer, J. & von Cramon-Taubadel, S. 2002. Asymmetric Price Transmission: A Survey. Paper presented in the 10th EAAE-Congress in Zaragoza in August 2002. Available in CD-rom: Exploring Diversity in the European Agri-Food System. X Congress, European Association of Agricultural Economists (EAAE). Programme. Zaragoza, Spain, 28-31 August 2002. Available in Internet: <http://www.eaae.org/activities/indexa.htm>
8. Goodwin, B., Holt, M., (1999) Price transmission and asymmetric adjustment in the US beef sector.
9. Mundlak, Y. & Larson, D.F. (1992). On the transmission of world agricultural prices. *World Bank Economic Review*, 6:399-422.



10. Baffes, J.(1991) "Some further evidence on the Law of One Price." American Journal of Agricultural Economics, 4:21-37.
11. Abdulai, A. (2000). Spatial price transmission and asymmetry in the Ghanaian maize market. Journal of Development Studies, 63: 327-349.
12. Sharma, R. (2002). The transmission of world price signals: concepts, issues and some evidence from Asian cereal markets. Paper submitted to the OECD Global Forum on Agriculture, OECD CCNM/GF/AGR 10.

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