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information between the meat
market of Finland and other EU
countries**
- testing for signal on oligopolistic
behaviour

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Hintainformaation välittyminen Suomen ja Saksan lihamarkkinoiden välillä

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Hintainformaation välittyminen ja keskittyneen vähittäiskaupan aiheuttama epäsymmetrisyys Suomen lihamarkkinoilla

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MTT Taloustutkimus

Tiivistelmä

Tavoite

Tutkimuksen tavoitteena oli estimoida aikasarjaekonometrian menetelmin Suomen ja Saksan lihamarkkinoiden välinen yhteisintegraatio ja hintainformaation välittyminen suomalaisten ja saksalaisten lihamarkkinoiden välillä. Tavoitteena oli selvittää kuinka nopeasti ja millä tavalla hintainformaatio välittyy Suomen ja Saksan välillä.

Keskeinen tavoite oli selvittää tukevatko havaitut hintasarjat väitteitä sellaisesta strategisesta hintagnalloinnista, jossa kotimainen kauppa ylläpitäisi normaalia korkeampia voittomarginaaleja siirtämällä ulkomaan markkinoilla havaittavat negatiiviset hintashokit positiivisia hintashokkeja nopeammin kotimaisiin tuottajahintoihin. Hypoteesin mukaan kotimainen kauppa käyttäisi vahvaa markkina-asemaansa hyväksi niin, että se pyrki painamaan kotimaista hintatasoa alas mahdollisimman nopeasti ulkomaisiin hintashokkeihin vedoten, mutta pyrki siirtämään hinnankorotuksia, vaikka hinnat olisivat ulkomaanmarkkinoilla nousseet.

Tutkimusaineisto ja menetelmät

Tutkimusaineisto koostui suomalaisista ja saksalaisista viikoittaisista hintasarjoista. Suomalaiset sarjat ovat MMM:n tietopalvelukeskuksesta (TIKE) ja saksalaiset sarjat tilattiin laitoksesta nimeltä German Centre for Documentation and Information in Agriculture (ZADI). Kussakin hintasarjassa oli 520 havaintoa ja ne kattoivat ajanjakson 1995-2004. Eläintautitapausten määrä ja ajoitus selvitettiin erikseen.

Hintainformaation kulkusuunta testattiin Grangerin kausaalisuustesteillä. Ekonometriset mallit rakennettiin ja ohjelmoitiin niin, että ne mahdollistivat epäsymmetrisen hintainformaation välittymisen. Saksan markkinoilla havaittujen positiivisten hintashokkien välittymisnopeus voi mallissa poiketa negatiivisten hintashokkien välittymisnopeudesta. Suomalaisen hinnan korjausmekanismin annettiin poiketa myös sen mukaan, onko havaittu hinta pitkän aikavälin tasapainohinnan ylä- vai alapuolella. Kaupankäynti- ja kuljetuskustannuksiin liittyvät vaikutukset (transactions costs) puolestaan otettiin huomioon mallittamalla hintamuutoksille kynnysarvoja. Kynnysarvoja suurempiin hintashokkeihin voidaan reagoida pieniä hintashokkeja nopeammin. Tällä tavoin voitiin mallittaa riittävän suurten, kynnysarvojen ylittävien hintashokkien vaikutukset markkinoilla sekä se, ettei pienillä hintamuutoksilla ole transaktiokustannusten vuoksi merkittäviä vaikutuksia hintainformaation välittymiseen. Suurten eläintautitapausten (esim. BSE) vaikutukset otettiin malleissa erikseen huomioon.

Tulokset

Tutkimustulosten mukaan suomalaiset naudanlihamarkkinat eivät ole merkittävästi yhteisintegroituneet saksalaisiin naudanlihamarkkinoihin. Tulos puoltaa näkemystä, että kotimainen naudanliha poikkeaa tuotteena niin paljon ulkomailta tuodusta naudanlihasta, että kotimainen hinta ei merkittävästi reagoi ulkomaisiin hintashokkeihin. Kotimaisen naudanlihan hinta määräytyy ensisijaisesti sen tarjonnan ja kotimaisen kysynnän perusteella. Markkinoilla on edellytyksiä maksaa hintapreemiota kotimaiselle naudanlihalle, mikäli sen tarjonta ei muutoin vastaa kysyntää.

Suomalaiset sianlihamarkkinat puolestaan ovat tulosten mukaan yhteisintegroituneet saksalaisten sianlihamarkkinoiden kanssa. Hintainformaatio välittyy Saksan suurilta markkinoilta Suomen pienille markkinoille, mutta ei päinvastoin. Toisin sanoen, saksalainen hinta vaikuttaa suomalaiseen hintaan mutta suomalainen hinta ei vaikuta saksalaiseen hintaan.

Sianlihamarkkinat ovat epäsymmetriset ja kynnysarvot ovat merkitseviä. Sianlihan hinta reagoi Suomessa nopeammin positiiviseen kuin negatiiviseen hintashokkiin Saksan markkinoilla. Suurten positiivisten hintashokkien välittyminen poikkesi kaikkien muiden hintashokkien välittymisnopeudesta. Tulos ei näin ollen tue näkemystä tai hypoteesia sellaisesta strategisesta hintasignalloinnista, että kotimainen kauppa siirtäisi ulkomaan markkinoilla havaittavat negatiiviset hintashokit positiivisia hintashokkeja nopeammin kotimaisiin tuottajahintoihin.

Kaiken kaikkiaan hintamuutosten välittyminen myös Suomen ja Saksan sianlihalihamarkkinoiden välillä on erittäin hidasta. Eräänä syynä hitaisiin hintareaktioihin voi olla kotimaisen kaupan ja lihanjalostuksen varsin pitkäaikaiset hinta- ja toimitussopimukset. Hintamuutosten jäykkyyteen voi olla osansa myös sillä, että kotimainen lihanjalostusteollisuus perustuu osittain tuottajien omistamiin osuuskuntiin, joilla voi olla halukkuutta ja kykyä vakauttaa markkinoita ja vaimentaa tuottajahintojen vaihtelua.

Avainsanat: Lihamarkkinat, markkinaintegraatio, markkinoiden tehokkuus, hintasignallointi, Euroopan Unioni, Suomi.

Abstract:

This paper estimates market integration between the Finnish and German pork and beef markets. An econometric error correction model that allows for threshold effects and asymmetric price response is estimated. The data are weekly price observations during the period of 1995-2004. Each price series have 520 observations. The results suggest that the Finnish beef prices are stationary and they are not co-integrated with the German price. Thus, the domestic and imported beef may be treated as different goods by consumers. The pork prices are integrated of the first order $I(1)$ and they are also co-integrated. The threshold effects are significant and the price adjustment process is asymmetric, but slow in all regimes. The price transmission process has rigidities that may be a result from the concentrated processing and retailing sectors.

Key words: Agricultural commodity market, market integration, prices, beef, pork, Finland, Germany.

1. 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.

1.1. Market integration vs. anti-trust regulations

Spatial market integration is important for regulating the structure of food processing through antitrust legislation, because the domestic retail businesses are highly concentrated in most European countries. The concentration is the lowest in Italy and the highest in Finland, where five largest retailers took as much as 96 per cent of the total food market in the mid 90's.¹ 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). Non-cooperative Tacit collusion is particularly important since it

can protect the existing firms from horizontal price competition and maintain wider marketing margins than would be possible in the competitive equilibrium. Thus, it allows dominant retailers to charge monopoly rents within the food chain at the cost of the firms, upstream in the food chain, and at the cost of consumers, downstream in the food chain.

Oligopolistic characteristics of the food chain are often asymmetric, including one or two dominant firms. The dominant market participants raise even more concerns on price leader behavior and increased welfare losses for the society (McCorrison 2002, Kovenock and Widdows 1998). In the Finnish case, a dominant retailer may also use potential imports as a credible threat to negotiate favorable terms of trade with a local food supplier, when the supplier is too small of having fair access to the exports market.

Strategic price signaling is an efficient means for maintaining unspoken collusion in an oligopolistic market (e.g. Brown and Yuchel 2000). Firm's reputation and willingness to signal its commitment to maintain collusion are important in maintaining high profits, which likely result in asymmetric price adjustment. When the firm's input price, for example, increases the firm will quickly forward the increase to the output prices in order to signal to its competitors that collusion will be maintained. But when the input prices fall, the firm is reluctant to decrease output prices to avoid signaling that the firm is undermining the collusion. Because trading in the food chain represents a repeated and dynamic game, the asymmetric price signaling can be used to avoid costly punishment (price war) among the competitors (Damania and Yang 1998).

Oligopolistic behavior can significantly decrease society welfare (e.g. Connor 2005). Therefore, most countries and also Finland have developed extensive antitrust regulations that retard industry participants from collusive pricing, investing in entry barriers, or merging into consortiums of dominant market shares (see e.g. Breit and Elzinga 1996).

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. A striking observation is, for example, that Denmark, which has a competitive meat sector in the global market, has allowed for merges of meat processors even though these merges have resulted in higher than 80 per cent domestic market shares. Merges resulting in that large domestic market shares would unlikely be accessible under the current Finnish antitrust regulations. Should similar merges be accepted or promoted also in the Finnish meat processing to gain better international competitiveness even if the merges concentrate meat processing from the domestic market perspective?

According to the Finnish antitrust office, merges of food processors that result in large market shares pose problems in Finland. The Finnish market may not be well integrated in the other European market places since the trade flows between these markets are small (e.g. Purasjoki 1999). Another claim is that the observed trade flows are modest, since there has not been price arbitrage between the markets. Firms have not been able to profit from foreign trade (e.g. Hemilä 1999). This claim suggests that markets are informational efficient and integrated.

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.

1.2. Market integration vs. supplementing the CAP by domestic programs

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 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. Nevertheless, the EU commission repeatedly stresses if the domestic agricultural subsidies distort the integration of the Finnish market into the European single market. Therefore, new information on the structure of market integration is required for justifying and designing means of the domestic policies that supplement the CAP.

2. Goal

The goal is to estimate the characteristics of the Finnish pork and beef markets in relation to their markets elsewhere in Europe. 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 and beef prices and obtains quantitative estimates of the relative contribution of internal versus external supply and demand shocks to the overall behavior of the market. The specific research questions are: To what extent do external demand and supply shocks get transmitted to domestic prices, and what is the role of concentrated food retailing in the transmission? Does most of the market

uncertainty originate from outside or inside the domestic market? With these results it can be judged whether the market has significant asymmetries that result from oligopolistic behavior within the Finnish meat chain, down streams from meat producers. This way we get a clearer picture of the effectiveness of government policies designed to facilitate meat sector adjustment. With this knowledge the competitiveness of meat sector can be improved.

3. The data

The data are weekly pork and beef prices in Finland and in Germany. The data span the years 1995-2003 (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 German data are from the German Centre for Documentation and Information in Agriculture (ZADI). It 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.

The Finnish data involved missing observations (12 pieces), which were filled in by the average of the previous and the following prices. The missing observations are in the Finnish pig prices: week number 27 (year 1998), 51 (year 1998), 20 (year 1999), 29 (year 2001), 37 and 38 (year 2002), 33 (year 2002), week number 1 (year 2003) and week number 50 (year 2004). From the Finnish beef prices the missing observations are: week number 27 (year 1998), 51 (year 1998), 20 (year 1999), week number 33 (year 2002) and week number 50 (year 2004). In German data both beef and pork series were complete.

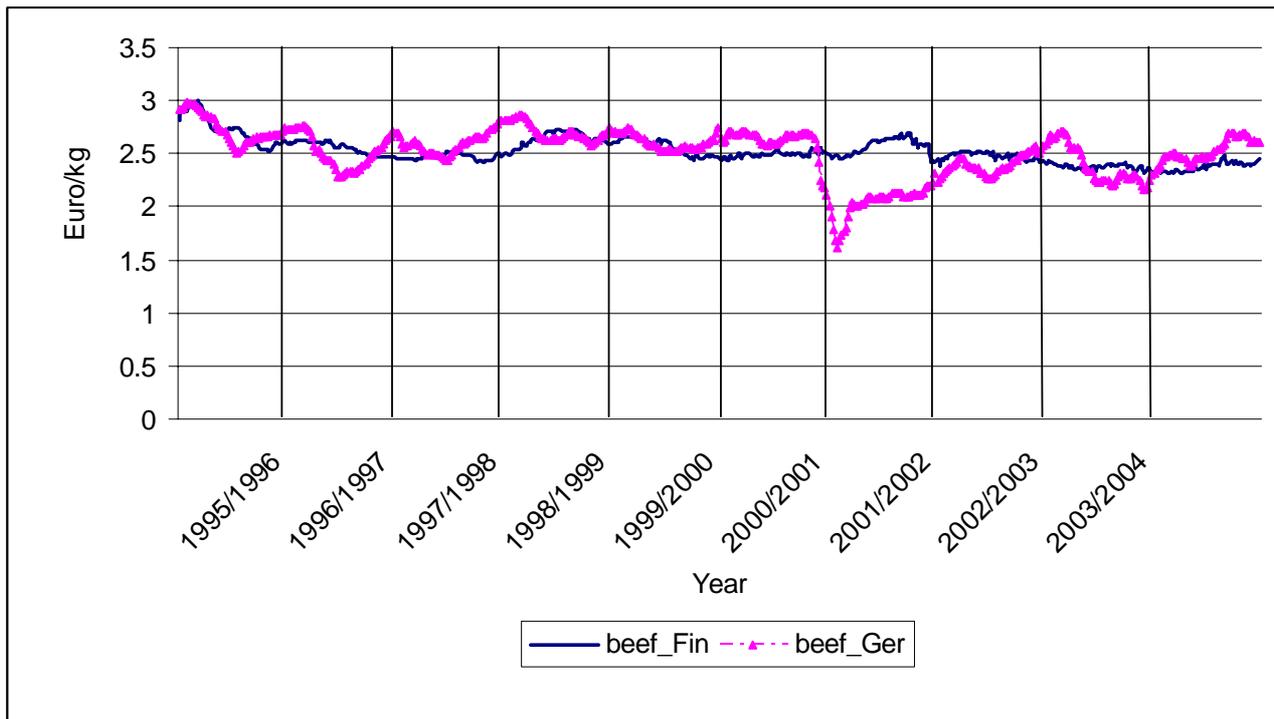


Figure 1. Beef prices in 1995-2004 in Finland and in Germany.

The year 2004 was ending with the EU pig market in crisis and prices reached a nadir for the year. After having fallen unrelentingly since the spring of 2001 – a drop of almost 40 % - prices started to bottom out in 2004 (Agra Europe 2003b).

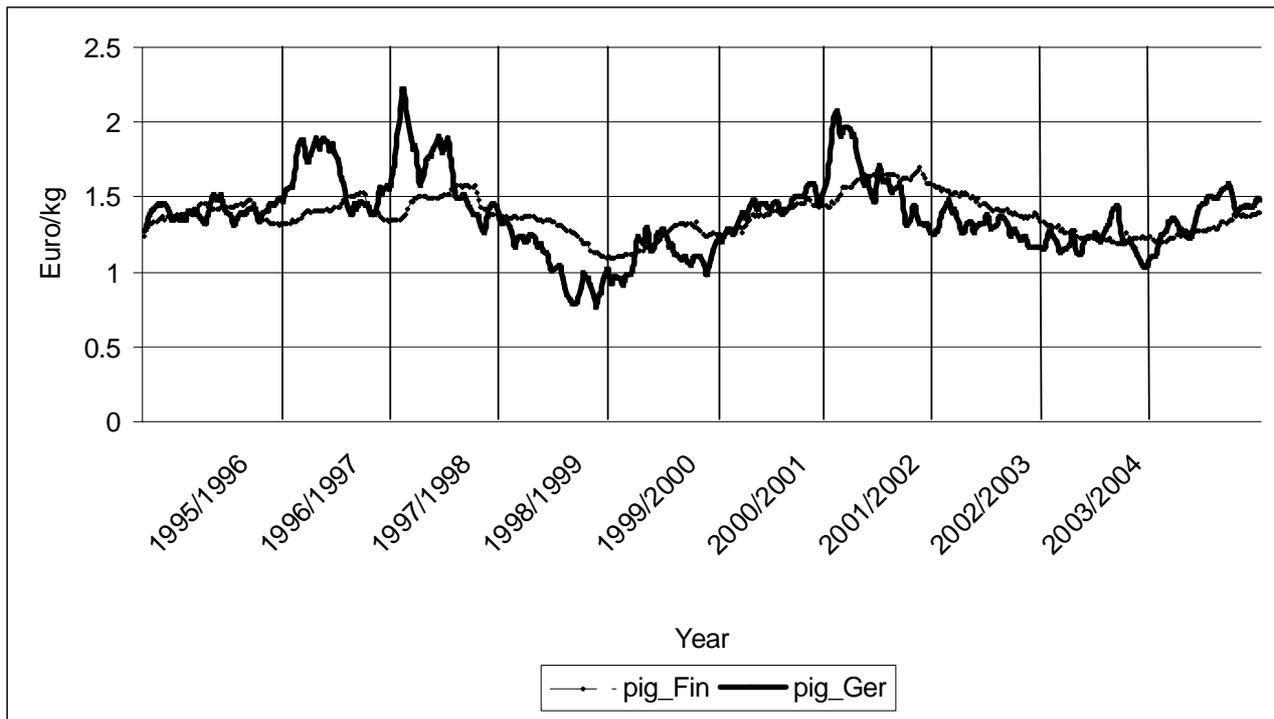


Figure 2. Pork (pig meat) prices in 1995-2004 in Finland and in Germany.

According to Agra Europe (2003a) the number of cattle infected with BSE is plummeting across the EU. The peak of the epidemic was in year 1992. In Finland only one bovine infected with BSE have been found (Figure 3). The infected bovine was found in December 2001. The situation is different in Germany. In Germany the first bovine infected with BSE was found in 1992. Since then the number of BSE infected bovines that have been found have risen dramatically reaching the peak in the year 2001. In the year 2001 125 bovines infected with BSE were founded. (OIE 2004.) (The list of the exact dates of the foundings can be found in http://www.bse-info.de/Home/tabelle_html (in German)). In addition to that the German authorities have admitted that untested bovines have reached the retail market. They first suspected that the number of untested bovines that had reached the retail market would be as high as 17 000 bovines. After all they considered it to be 510 untested bovines. In addition to that they admit that from all the BSE tests made, in 10 000 tests the information is insufficient (Finfood 2004.)

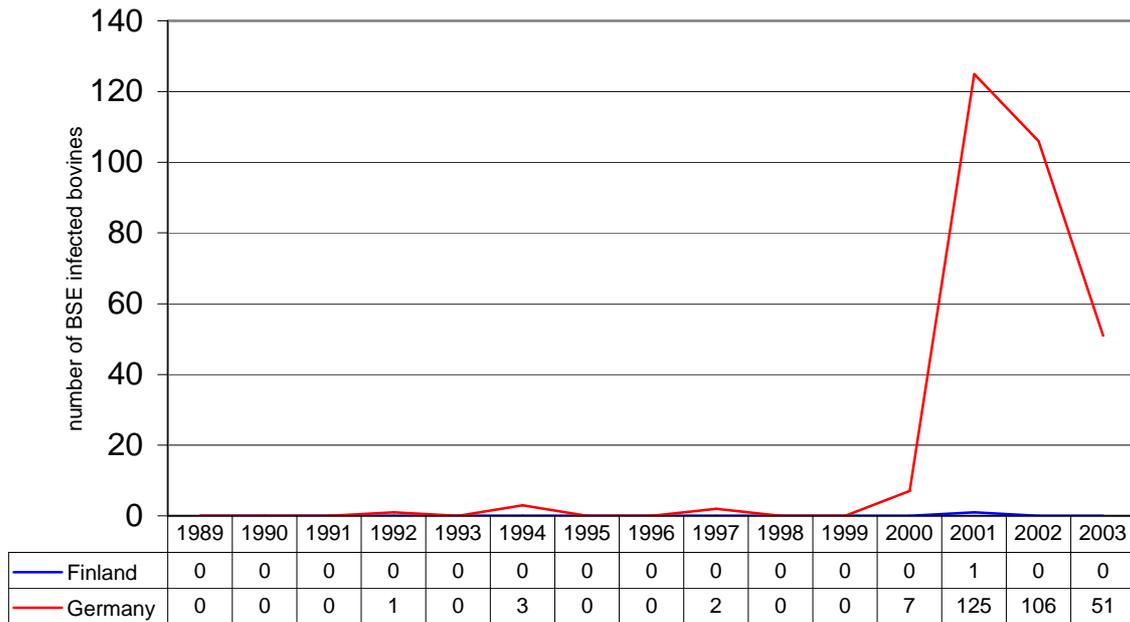


Figure 3. The number of cattle infected with BSE in Finland and in Germany 1989-2003 (OIE 2004).

In year 2003 meat consumption in Germany rose considerably and as a result of that German self-sufficiency in meat dropped 3 % to 92 % despite an overall rise in meat production (Agra Europe 2004). The rise in consumption was seen in all meats except in lamb. Pig meat accounted for 60 % of the total meat consumption in 2003. Although domestic pigmeat output had never been as high, it was not enough to cover demand. According to ZMP, BSE fears no longer play a role in demand for beef with increased consumer trust raising per capita beef consumption to 14 % of the total meat consumption in 2003. (Agra Europe 2004.)

In the year 1997, there was an epidemic of classical swine fever in the Netherlands, Spain, Belgium and Germany (OIE 2005a). This classical swine fever affected prices, but didn't affect aggregate quantity of pork consumed. In year 2001 there was foot and mouth disease in the Great Britain (OIE 2005b).

4. Econometric Model Specifications

Autoregressive econometric time series models are specified to estimate time series properties of the pork and beef prices in Finland and to test for market integration and asymmetric price transmission between the Finnish and German markets. Farm gate prices are used in estimation since they should reflect any oligopolistic behavior downstream from agriculture.

4.1. 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. The Monte Carlo simulations by Schwert (1989) showed that the ADF tests have low power and are sensitive to the choice of lag-length. The unit root tests are known to have low power problems in small samples, particularly, if the series include structural breaks (Kwiatkowski et al.1992; Leybourne & Newbold 2000).

The KPSS tests, on the other hand, have good power properties. PP test is an alternative (nonparametric) method of controlling for serial correlation when testing for a unit root. Since no single unit root test is without some statistical shortcomings, in terms of size and power properties, a group of unit root tests are applied to statistically determine the order of integration of the time-series used in cointegration analyses. (Murthy and Nath, 2003)

Results of all the tests are given in Table 1. ADF tests indicate stationarity, and the KPSS tests confirm this for Finnish beef and German beef. Thus, it was concluded that there is strong evidence that these two series are stationary. Meanwhile, the 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 5% ^{a)}	at	Critical value at 1% ^{b)}
	Finnish beef	Finnish pork	German Beef	German Pork			
ADF (intercept excluded)	-1.07	-0.54	-0.52	-1.22	-1.94		-2.57
ADF (intercept included)	-3.29*	-2.50	-3.29*	-2.50	-2.87		-3.44
KPSS (intercept included)	0.46	1.81**	0.28	0.39	0.46		0.74
Phillips-Perron (intercept included)	-2.71	-2.09	-2.96*	-2.70	-2.87		-3.44

ADF is Augmented Dickey-Fuller test. KPSS is the η -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 at al. (1992, Table 1)²

4.2. Cointegration test

Potential cointegration relationship between the I(1) ordered prices which are Finnish and German pork are tested for by Engle-Granger tests to verify whether there is a stable long-run price relationship between the prices and whether an Error Correction Model (ECM) would later be a justified specification in further testing the characteristics of the price formation processes. A linear cointegration of the two original I(1) series can though result in a series that is stationary, I(0). If a

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

stationary cointegration exists between Finnish and German pork price, the two series are considered cointegrated varying around a fixed level (Engle and Granger, 1987).

These tests were carried out first by regressing the Finnish price on the intercept and the German price by the standard OLS method. Thus, the estimating equation is:

$$\ln p_t^{FIN} = k_0 + k_1 \ln p_t^{GER} + v_t \quad (2)$$

where k are parameters and v_t is an error.

Causality relationship between the German and Finnish meet series is tested for by the Granger (1988) causality tests. These tests can be used for making inference on the direction of the transmission of price information. For beef series Granger causality is rejected in both directions. So we conclude that there is absence of integration between Finnish and German beef market. Meanwhile, the null hypothesis of “German pork price does not Granger cause Finnish pork price” is rejected, but not vice a versa. Thus, the test suggests that Granger causality runs one-way from German pig price to Finnish pig price and not the other way. Furthermore, Table 2 reports the long-run cointegrating relationship, estimated as equation (2), by OLS procedure.

Table 2: Result of regression of Finnish pork price on the German price

$\ln p_t^{FIN} = 0.22 + 0.32 \ln p_t^{GER}$ <p style="text-align: center;">(33.66)***(17.93)***</p>		(3)
ADF = -3.14**	Phillips-Perron = -3.19**	
KPSS = 0.23***	LM (2)= 6847	

Note: t-values in parentheses. **, * denote statistical significance at 5, 1 percent levels, respectively. LM(2) is Breusch-godfrey Serial Correlation Test

In Table 2, the calculated t-values are presented within the parentheses. The ADF, Phillips-Perron and KPSS tests performed on the residuals, gathered from the cointegrating equation (2), indicate that the residuals are stationary and hence confirm the presence of a cointegrating

relationship between Finnish and German pork price. However, a large value for LM serial correlation test strongly suggests that the residuals are autocorrelated. Therefore, we further 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 3. 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.

Table 3. Johansen Cointegration Test Summary

(a) Constant restricted

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) Constant unrestricted

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

4.3. 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:

$$\Delta \ln p_t^{FIN} = \phi_0 + \beta_0 \Delta \ln p_t^{GER} + \beta_1 (\ln p_{t-1}^{FIN} - (k_0 + k_1 \ln p_{t-1}^{GER})) + \beta_2(L) \Delta \ln p_{t-1}^{GER} + \beta_3(L) \Delta \ln p_{t-1}^{FIN} + \varepsilon_t \quad (4a)$$

which is usually written in the form

$$\Delta \ln p_t^{FIN} = \phi_0 + \beta_0 \Delta \ln p_t^{GER} + \beta_1 ECT_{t-1} + \beta_2(L) \Delta \ln p_{t-1}^{GER} + \beta_3(L) \Delta \ln p_{t-1}^{FIN} + \varepsilon_t \quad (4b)$$

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 (4) 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 failure of including the error correction term will lead to an inappropriately specified relationship where only short-run dynamics are included. 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. The estimation result is listed in Table 4 as below.

Table 4. Parameter estimates in symmetric error correction model for pork prices (Equation 4b)

Model variable	Equation 4(b)
Intercept	5.06E-5(0.0004)
German price difference $\Delta \ln p_t^{GER}$	0.0236(0.0168)
ECT_{t-1}	-0.0348***(0.0056)
Once lagged Finnish price difference $\Delta \ln p_{t-1}^{FIN}$	0.0297(0.0428)
Twice lagged Finnish price difference $\Delta \ln p_{t-2}^{FIN}$	0.1269***(0.0426)
Third lagged Finnish price difference $\Delta \ln p_{t-3}^{FIN}$	0.0208(0.0423)
Fourth lagged Finnish price difference $\Delta \ln p_{t-4}^{FIN}$	0.0979***(0.0415)
Once lagged German price difference $\Delta \ln p_{t-1}^{GER}$	-0.0616***(0.0213)
Twice lagged German price difference $\Delta \ln p_{t-2}^{GER}$	0.0326(0.0232)
Third lagged German price difference $\Delta \ln p_{t-3}^{GER}$	-0.05** (0.0207)
Fourth lagged German price difference $\Delta \ln p_{t-4}^{GER}$	0.0333*(0.0174)
R-squared	0.176
The sum of squared residual	0.044
τ_1	0.027[~ F(4, 515)]
τ_2	137.18***

Note: *, ** and ***denote statistical significance at 10, 5, 1 percent levels, respectively.

τ_1 = Breush-Godfrey LM test for autocorrelation. The most significant result for up to and including 4 lags is presented. τ_2 = Jarque-Bera normality test

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 (4). Granger's theorem stated that ECT_{t-1} denotes the speed of adjustment to the long-run equilibrium, which is quite slow (only 4%) here. It implies that after a shock, each week 4% 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.

Lagged price changes in Finnish price ($\Delta \ln p_{t-2}^{FIN}; \Delta \ln p_{t-4}^{FIN}$) and in German price ($\Delta \ln p_{t-1}^{GER}; \Delta \ln p_{t-3}^{GER}$) captures the short-term effect on the price adjustment in Finnish pork price. The statistical insignificance of contemporaneous change (lagged price $\Delta \ln p_t^{GER}$) 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 estimated model satisfies certain diagnostic criteria that is the absence of serial correlation (τ_1). However, non-normality implies that the subsequent test results must be interpreted with caution or the estimated model is not yet the best specification for the price process. The estimation model should be further improved.

Equation (4) 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 (Heckscher 1916, Azzam, 1999, Meyer 2003). In addition, if there exists 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, we tested for this asymmetry estimating the model in the form:

$$\Delta \ln p_t^{FIN} = \phi_0 + \beta_1 \Delta^- \ln p_{t-1}^{GER} + \varphi_1 ECT_{t-1} + \varphi_2 ECT_{t-1}^- + S(t)' + \beta_2(L) \Delta \ln p_{t-1}^{FIN} + \beta_3 \Delta \ln p_{t-1}^{GER} \quad (5)$$

where $ECT_{t-1}^- = ECT_{t-1}$ when ECT_{t-1} is negative and otherwise ECT_{t-1}^- equals zero. Similarly, the short term asymmetric response is identified by the term $\Delta^- \ln p_{t-1}^{GER} = \Delta \ln p_{t-1}^{GER}$ when $\Delta \ln p_{t-1}^{GER}$ is negative. Otherwise $\Delta^- \ln p_{t-1}^{GER}$ equals zero. Under the null hypothesis of symmetry, φ_2, β_1 all equal zero and the model has the statistical properties of the standard ECM specification in (4). Also a second order polynomial with respect to time $S(t)$ was added in the model to control for price cycles that depend on the passage of time. Passage of time is measured by the week number.

The estimating equation (5) 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:

$$\Delta \ln p_t^{FIN} = \phi_0 + \beta_1 \Delta^- \ln p_{t-1}^{GER} + \varphi_1 ECT_{t-1} + \varphi_2 D^- ECT_{t-1} + \varphi_3 D^+ ECT_{t-1} + S(t) + \beta_2(L) \Delta \ln p_{t-1}^{FIN} + \beta_3(L) \Delta \ln p_{t-1}^{GER} + \varepsilon_t \quad (6)$$

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 β_1 , φ_1 , and φ_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 Cramen-Taubadel (2002). These thresholds can be caused, for example, by transactions costs related to foreign trade or by the well known implications of the standard menu costs.

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 (6) 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.

Table 4. Parameter estimates in the asymmetric error correction model for pork prices with threshold effects (Equation 6.)

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
τ_1	0.4245[~ F(4, 499)]
τ_2	90.29***

Note: *, ** and ***denote statistical significance at 10, 5, 1 percent levels, respectively.

τ_1 = Breush-Godfrey LM test for autocorrelation. The most significant result for up to and including 2 lags is presented. τ_2 = Jarque-Bera normality test.

Estimated coefficients of the general threshold error correction model and standard errors of these coefficients are reported in Table 4. Compared with Table 3, neither of the positive nor negative German price difference have significant effect on the Finnish pork price, which indicates that the changes (either positive or negative) in German pork price do not have significant impact on Finnish pork price in a short-run. In contrast, the error correction terms (ECT_{t-1} , $D^- ECT_{t-1}$) have negative signs and are statistically significant. Interestingly, $D^+ ECT_{t-1}$ has also negative sign but it does not significantly differ from zero. Figure 4 demonstrates the price adjustment (Δp_t), as a

function of deviations from the long-term equilibrium, represented by a piecewise linear asymmetric error-correction model (ECM) with two endogenous thresholds (*i.e.* three regimes).

The results suggest that the speed of adjustment of Finnish pork market to German market, as reflected by the error correction coefficients, was estimated to be quite low. 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.

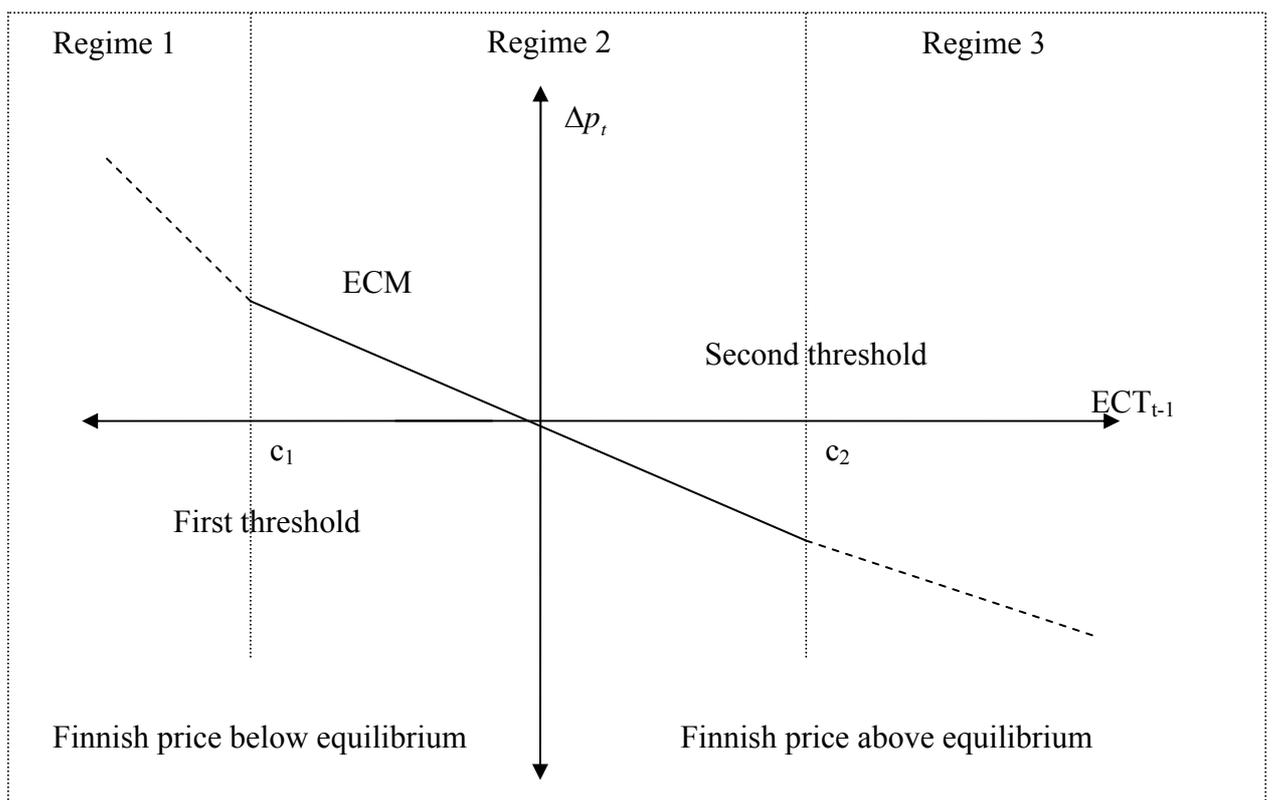


Figure 4: Characteristics of the asymmetric price response within the three regimes identified by the two threshold parameters c_1 and c_2 .

In Figure 5, the results in Table 4 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 below shows how the Finnish pork price responds to a simulated persistent unit increase or decrease in the German pork price after up to 120 weeks. 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 0.04 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.

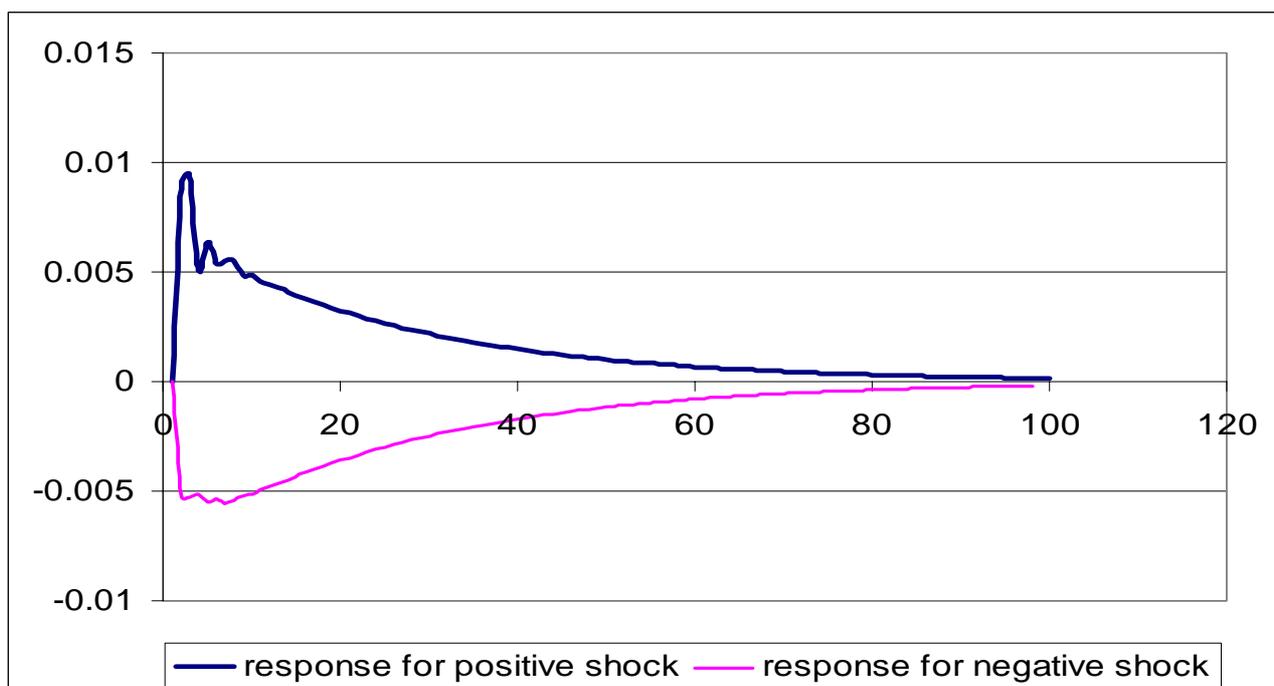


Figure 5. Impulse response of Finnish pork price return to the German pork return.

5. 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. Particularly, the results concerning asymmetric price signaling of Tacit collusion are beneficial in judging the efficiency and competitiveness of our meat market. Second, better knowledge of the term structure and volatility processes for hog and beef prices and the sources of this volatility, will be of interest to farmers and extension agents needing to make and advise on investment decisions during the ongoing very rapid structural adjustment.

We examined price cointegrating relationship between Finnish and German meat market using both symmetric error correction model and 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.

The results suggest that the beef price series are stationary both in Germany and in Finland. Thus, the prices are not cointegrated, which supports a view that domestic beef in Finland is perceived by consumers as a different good from imported beef.

Nevertheless, a significant cointegrating relationship was found between the German and Finnish pork prices. Information flow between the markets is unidirectional such that German pork prices Granger-cause the Finnish price, but not the other way round. 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 4% 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

- Abdulai, A..2000. Spatial price transmission and asymmetry in the Ghanaian maize market. *Journal of Development Studies*, 63:327-349.
- Agra Europe. 2003a. BSE numbers plummeting across the EU. Agra Europe No. 2081, November 21, 2003.
- Agra Europe. 2003b. Glimmer of hope for EU pig market. Agra Europe No. 2083, December 5, 2003.
- Agra Europe. 2004. German meat consumption rises. Agra Europe No. 2122, September 10, 2004.
- Azzam, Azzeddine M. 1999. Asymmetry and Rigidity in Farm-Retail Price Transmission. *American Journal of Agricultural Economics*, 81: 525-533.
- Baillie, R. T. & Myers, R. J. 1991. Bivariate GARCH Estimation of the Optimal Commodity Futures Hedge. *J. of Applied Econometrics* 6:109-134.
- Baffes, J. 1991. Some further evidence on the Law of One Price. *American Journal of Agricultural Economics*, 4:21-37.
- Ben-Kaabia, M., Gil, José M. & Boshnjaku, L. 2002. Price transmission asymmetries in the Spanish lamb sector. 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>
- Brait, W. & Elzinga K. G. 1996. *The Antitrust Casebook. Milestones in Economic Regulation*. 3rd Ed. 442 p. The Dryden Press, Orlando Florida.
- Brown, S. and Yucel, M. 2000. Gasoline and Crude Oil Prices: Why the Asymmetry? *Federal Reserve Bank of Dallas, Economic and Financial Review* 3rd quart: 23-29.
- Campbell, J. Y. & Lo, A. W. & MacKinlay, A. C. 1997. *The Econometrics of Financial Markets*. Princeton University Press, Princeton.
- von Cramon-Taubadel, S., Loy, J.-P. and Musfeldt, E. (1995). Empirische Methoden zur Analyse der Marktintegration am Beispiel des EU-Schweinefleischmarktes. *Schriften der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaues* 31: 119-137.
- Damania, R. & Yang, B. 1998. Price Rigidity and Asymmetric Price Adjustment in a Repeated Oligopoly. *Journal of Institutional and Theoretical Economics* Vol 154:659-679.
- Dixit, A. K. & Pindyck, R. S. 1994. *Investment under Uncertainty*. 468 pp. Princeton, New Jersey. 468pp.
- Engle, Robert F. and C. W. J. Granger 1987. Co-integration and Error Correction: Representation, Estimation, and Testing, *Econometrica*, 55, 251-276.
- Finnish Food Information Service. 2004. News of the Finnish Food Information Service 08.01.2004. (in Finnish). Available: <http://www.finfood.fi./finfood/finnfool.nsf> Cited 17 November 2004.
- Hamilton, J. D. 1994. *Time Series Analysis*. Princeton University Press. New Jersey.799pp.
- Hemilä, K. An interview in News Paper entitled “Maaseudun Tulevaisuus” July 29, 1999.
- 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.
- Kovenock, D. & Widdows, K. 1998. Price Leadership and Asymmetric Price Rigidity. *European Journal of Political Economy* Vol 73(3):373-382.
- 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.
- Leybourne, S.J. & Newbold, P. 2000. Behavior of Dickey-Fuller *t*-tests when there is a break under the alternative hypothesis. *Econometric Theory* 16: 779–789.

- Mundlak, Y. & Larson, D.F. 1992. "On the transmission of world agricultural prices." *World Bank Economic Review*, 6:399-422.
- McCorrison, S. 2002. Why should imperfect competition matter to agricultural economists? *European Review of Agr. Econ.* Vol 29 3:349-372.
- 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>
- Myers, R. J. & Piggot, R. R. & Tomek W. G. 1990. Estimating sources of Fluctuations in the Australian Wool Market: An Application of VAR Methods. *Australian J. of Agr. Econ.* 34:242-262.
- OIE. 2004. No. of reported cases of BSE worldwide (excluding the United Kingdom). World Organisation for Animal Health. http://www.oie.int/eng/info/en_esbmonde.htm Cited 17 November 2004.
- OIE. 2005a. EUROPE / 2003 / Classical swine fever. Animal Health Status. <http://www.oie.int/hs2/report.asp> Cited 26 April 2005.
- OIE. 2005b. EUROPE / 2001 / Foot and mouth disease. Animal Health Status. <http://www.oie.int/hs2/report.asp> Cited 26 April 2005.
- Phillips, P.C:B and P.Perron (1988), "Testing for a Unit Root in Time Series Regression", *Biometrics*, 54, 334-346.
- Purasjoki, M. An interview in News Paper entitled "Maaseudun Tulevaisuus" July 29, 1999.
- Quiroz, J. A. & R. Soto 1996. International Price signals in agricultural markets: do governments care? Unpublished mimeo, GERENS and ILADES/Georgetown University.
- 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(2002)10.
- Tirole, J. 1992. *The Theory of Industrial Organization*. 479 p. The MIT Press, Cambridge Massachusetts.

Notes

- 1.* The recent entry of Lidl in the Finnish market may not alone significantly decrease the market share of the five largest retail distributors. But if the market penetration of Lidl is successful, it may well get into the group of five largest distributors.

