What causes asymmetric price transmission in agro-food sector? Meta-analysis perspective

Zoltán Bakucs[1], Jan Fałkowski[2*], Imre Fertő[1]
[1]Institute of Economics, Research Centre for Economic and Regional Studies Hungarian Academy of Science, Corvinus University of Budapest
[2]University of Warsaw, CEAPS

Contributed Paper prepared for presentation at the 86th Annual Conference of the Agricultural Economics Society, University of Warwick, United Kingdom

16 - 18 April 2012

*Corresponding author: Jan Fałkowski; Długa 44/50; 00-241 Warsaw, Poland, jfalkowski@wne.uw.edu.pl

PRELIMINARY DRAFT

Abstract

There now exists a large literature on price transmission in agro-food sectors. However, a great majority of empirical studies focus on the existence of asymmetry and, by and large, do not allow investigating the reason for its presence or absence. This is in sharp contrast to the theoretical literature that provides a number of explanations for why we should expect (a)symmetry. In response to this, this paper tries to uncover the reasons for price asymmetric transmission in the agro-food chain. To do so, we use meta-analysis drawing on the existing studies from this area. While there are some limitations to our data, we believe that this perspective could be very useful in advancing our understanding of price transmission mechanisms. Our findings suggest that asymmetric price transmission in farm-retail relationship is more likely to occur in sectors/countries with more fragmented farm structure and more restrictive regulations on price controls in retail sector. Instead, more restrictive regulations on entry barriers and operational conduct of retail trade tend to promote symmetric price transmission. The latter is also more likely in the presence of strong processing industry.

Keywords: Price transmission, meta-regression analysis

JEL code: Q11

What causes asymmetric price transmission in agro-food sector? Meta-analysis perspective

Zoltán Bakucs, Jan Fałkowski, Imre Fertő

1. Introduction

Market volatility remains one of the most important research fields in agricultural economics. On one hand, this is of relevance from micro-perspective as large and unexpected price movements strongly affect agricultural households' welfare. On the other hand, market distortions are often cited as a ground for state intervention. In this sense, the problem of market volatility is also high on the agenda from macro-perspective. To better understand the nature of price movements economists made some effort to analyse the mechanism of price transmission, i.e. the way that price movements are transmitted along the various stages of the agro-food chain (from farm to processing and retail levels).

This analysis mainly focuses on establishing whether price movements are symmetric or not. Studies from this field have tried to see whether price decreases are transmitted along the chain with equal speed and magnitude as price increases. In recent years a number of empirical works have been published that greatly improve our knowledge in this respect (see for example Meyer and von Cramon-Taubadel, 2004 for an overview). This was possible, among others, thanks to huge advancement in econometric tools in general, and time series analysis in particular. However, the findings of these studies are ambiguous. Asymmetries in price transmission have been detected in some countries and sectors but not in others. This leads to a general conclusion that the presence of (a)symmetric price transmission is conditional on local circumstances. It is disturbing though, that the exact mechanisms through which these local conditions affect the nature of price movements remain mostly unknown.

This is interesting since there are a number of theoretical arguments that try to explain why price transmission could be asymmetric. In fact, as far as the causes of price transmission asymmetries are concerned, the recent literature has paid much more attention to theory than empirics. Among the arguments that have been provided to account for asymmetric price movements one can list, for instance, the presence of market power (see e.g. McCorriston et al., 1998, 2001), the so-called 'menu costs' argument (see e.g. Bailey and Brorsen, 1989; Levy et al., 1997), the presence of inflation (Ball and Mankiw, 1994), government support (Kinnucan and Forker, 1987) or various

stocks management practices (Reagan and Weitzman, 1982; Wohlgenant, 1985; Balke et al., 1998).

Given this stark difference between theoretical work and empirical application, this paper tries to link the presence of price (a)symmetries with exact causes. Thus, we apply meta-analysis and draw on the results of recent papers from the field. More specifically, we try to relate the presence of price (a)symmetries identified in these studies to a number of socio-economic characteristics of the analysed sectors/countries and to methodological features of the models that these studies applied. Our focus is on the role of factors that are likely to affect the bargaining power of actors operating at farm, processing and retail level. By doing so, we aim at complementing the existing literature on price transmission by providing some systematic evidence on the causes of asymmetric price movements along the agro-food supply chain.

The closest contribution to our paper is the study by Frey and Manera (2007), who employ meta-analysis to studies on price transmission in agricultural and oil markets. Three key differences distinguish our approach from theirs. First, we concentrate on research published after 2003, resulting in only two common papers. This could be of importance, as one can assume that the results from recent papers are based on a more robust methodology, encompassing continuous improvements in time series econometrics. Thus we aim to reduce the risk of biased results due to misspecification errors that may have affected earlier price transmission studies. Second, we restrict our sample to studies covering only European agricultural markets. This, in turn, reduces, at least to some extent, the risk that cases under our investigations are not comparable to each other[1]. Third, and perhaps most importantly, Frey and Manera (2007) document only the relationship between the presence of price (a)symmetry and methodological approaches used in the analysed studies. We instead also propose to link price transmission (a)symmetry with socio-economic characteristics of sectors/markets under investigation. This is important as it allows us to relate our results to the existing theoretical predictions. Thus, except for applying the 'old approach' to new data, we also present new results. While the data that we use have some limitations, we nonetheless believe that this approach may still offer some new insights on the phenomenon of (a)symmetric price transmission.

[1] Obviously there is still a great amount of heterogeneity within European agricultural markets. Nevertheless, organization of European markets, especially those within the EU borders, assures somewhat more reliability of the within European comparisons as compared to American-European or Asian-European comparisons.

The remainder of the paper is organised as follows. Section 2 presents our methodological approach and the data that we use in the empirical analysis. Section 3 displays our results and Section 4 concludes.

2. Methodology, data

Based on the existing theoretical literature, price transmission mechanism could be thought of as a function:

$$p_{cs} = W(X_{cs}) \tag{1}$$

where *p* denotes the variable that characterises the presence of price transmission asymmetry, and *X* are the socio-economic market characteristics, both referring to country *c* and sector *s*. *W(.)* is the reduced-form function that aims at capturing potentially complex interactions between these two. *X* includes, for instance, market structure, regulatory framework or bargaining power of actors operating at subsequent stages of the agro-food supply chain. The mapping from socio-economic characteristics into price transmission mechanism induced by (1) can be studied empirically. To do this, consider the following empirical model of the form:

$$p_{cs} = \delta_c + \gamma_s + \beta X_{cs} + \varepsilon_{cs} \tag{2}$$

where δ_c is a country fixed effect, γ_s is a sector fixed effect and ε_{cs} is an error term. β is a vector of coefficients to be estimated.

Given that our dependent variable draws on the results from the existing studies on price transmission (see further), we couch our empirical analysis in a meta-analysis framework. Meta-analysis is the quantitative analysis of a body of studies and aims at evaluating the existing empirical evidence (Stanley, 2001). While originally it was used in research areas other than agricultural economics, recently it is quickly entering this field as well. Recent 'agriculture-oriented' studies that use this approach include, among others, Hess and von Cramon-Taubadel (2007), Gallet (2007, 2010), Johnston and Duke (2009) or Lagerkvist and Hess (2011).

Our empirical strategy is as follows. Based on the literature review, we identify studies that investigate price behaviour in a number of countries and sectors. We code our dependent variable as a dummy equal to one if a given paper found asymmetric price transmission and equal to zero otherwise. As a second step, drawing on various sources, we collect the data that on various

socio-economic aspects of countries and sectors covered in the identified studies. Given theoretical predictions concerned with price transmission asymmetry, we mainly focus on characteristics that may be related to market power. Thus, our focus is on variables approximating market structure and bargaining power of farmers, processors and retailers.

In principle, meta-analysis investigates the extent to which statistical heterogeneity between results of multiple studies can be related to methodological characteristics of models that these studies apply. Therefore, in our regression analysis we also check whether the identified price transmission results are influenced by these methodological characteristics. Consequently, we also investigate the following relationship:

$$p_i = F(ET_i, FREQ_i, OMC_i, \mu_i) \tag{3}$$

where i denotes the study under investigation, *ET* stands for estimation technique; *FREQ* describes the data frequency, *OMC* include other model characteristics (whether it is a multiple-results or single result study; sample size) and μ is an error term. What should be emphasised however, is that our aim is not to assess in any way whether these approaches were appropriate. Instead we wish to assess whether methodological choices have any impact on the obtained results.

Data

As far as the data on price transmission presence/absence is concerned, we draw on the results from 20 recent papers from the price transmission literature. These studies focus on European agricultural sector and investigate price transmission mechanism for 69 cases. Detailed list of these papers is presented in Table 1. To our knowledge, this is the most comprehensive list of studies investigating price behaviour along the European agro-food chain. It was based on various scientific data bases including Scopus, Science Direct, Emerald, EconLit, Web of Science and Google Scholar.

Table 1. List of identified studies on price transmission in European agro-food chain

Paper	Country	Sector
Bakucs et al. (2006)	Germany	pork
Bakucs et al. (2007)	Hungary	Vegetables
Bakucs & Ferto (2005)	Hungary	Pork
Bakucs & Ferto (2008)	Hungary	Milk
Bakucs & Ferto (2006)	Hungary	Beef
Bakucs & Ferto (2009)	Hungary	Pork
Ben-Kabia & Gil (2007)	Spain	Lamb

Bojnec & Peter (2005)	Slovenia	Pork
		Beef
Cechura & Sobrova (2008)	Czech Republic	Pork
Fałkowski (2010)	Poland	Milk
Fernandez et al. (2010)	Austria	Apple
Guillen & Franquesa (2010)	Spain	Pork
		Beef
		Eggs
		Lamb
		Rabbit
		Poultry
Hassouneh et al. (2010)	Spain	Beef
Karantinis et al. (2011)	Sweden	Pork
London Economics (2004)	Austria	Carrot
	Austria	Potato
	Denmark	Vegetables
	Denmark	Bread
	Denmark	Flour
	Denmark	Eggs
	France	Bread
	France	Poultry
	Germany	Apple
	Germany	Potato
	Germany	Carrot
	Germany	Poultry
	Germany	Milk
	Germany	Cheese
	Germany	Butter
	Netherlands	Potato
	Netherlands	Beef
	Netherlands	Bread
	Netherlands	Eggs
	Spain	Potato
	United Kingdom	Fruit
	United Kingdom	Vegetables
	United Kingdom	Vegetables
	United Kingdom	Beef
	United Kingdom	Lamb
	United Kingdom	Bread
	United Kingdom	Eggs
	United Kingdom	Milk
Luoma et al. 2004	Finland	Pork
Luoma et al. 2004	Finland	Beef
Reziti & Panagopuolos (2008)	Greece	Vegetables
		Fruit
		Food
		Vegetables
		Fruit
		Food
Rezitis & Reziti (2011)	Greece	Milk
Serra & Goodwin (2003)	Spain	Milk
		Milk
		Milk
		Milk

Below we briefly present basic information on the studies that we use in our analysis. While price transmission could be analysed for different pairs of actors operating at various stages of the agro-food supply chain, most of the cases that we identified (67) relate to farm-retail price transmission. The remaining two cases relate to farm-wholesale relationship and to farm-processor relationship. As presented in Table 2, our sample is not uniformly distributed over geographic regions or countries. Most of the observations, 57, are for the Western Europe (the so-called 'old EU members') and only 12 are for the Central and Eastern European countries. Moreover, five countries, namely Spain, the United Kingdom, Hungary, Germany and Greece account for almost 2/3 of all the sample.

Table 2. Number of observations by country

Country	N	percentage	percentage of APT
Austria	5	7.2	10.7
Czech	1	1.4	3.6
Denmark	4	5.8	0.0
Finland	2	2.9	0.0
France	2	2.9	3.6
Germany	8	11.6	7.1
Greece	7	10.1	14.3
Hungary	8	11.6	7.1
Netherlands	4	5.8	0.0
Poland	1	1.4	3.6
Slovenia	2	2.9	3.6
Spain	14	20.3	35.7
Sweden	3	4.3	7.1
United Kingdom	8	11.6	3.6
Total	69	100.0	100.0

Further, as reported in Table 3, most of the cases under investigation (43) concern livestock products. Crop production instead is represented by 26 observations, and thus accounts for roughly 38% of our sample.

Table 3. Number of observations by sector

product	N	percentage	percentage of APT
livestock	43	62.3	82.1
vegetables	8	11.6	7.1
fruit	5	7.2	0.0
food	2	2.9	7.1
potato	6	8.7	0.0
cereals	5	7.2	3.6
total	69	100.0	100.0

Tables 4-6 present some methodological characteristics of the studies under consideration. As shown, majority of cases, 52 (75%), couch the analysis in a vector error correction models (VECM) framework. 12 studies, i.e. 17% of the total number of observations, use threshold VECM approach. We also have few studies that are based on the earliest methodological approach to investigate price transmission mechanism, namely the approach that abstracts from time series cointegration analysis (6 cases, i.e. roughly 9% of all identified studies).[2] A short description of these various approaches is presented in an Annex. Further, the majority of studies use monthly rather than weekly data (Table 5). Of the 56 studies investigated, 20 report the causality running from farm to retail, 7 report the opposite direction, whereas 29 report that the causality running in both directions (Table 6).

Table 4. Number of observations by methodology

methodology	N	percentage	percentage of APT
Houck	6	8.7	14
VECM	40	58.0	32
TVECM	12	17.4	7
Gregory-Hansen	4	5.8	32
Regime switching	1	1.4	4
General-to specific	3	4.3	4
Asymmetric non-linear auto regressive distributed lag model	3	4.3	7
total	69	100.0	100

Table 5. Number of observations by data frequency

frequency	N	percentage	percentage of APT
monthly	62	89.9	82.1
weekly	7	10.1	17.9
total	69	100.0	100.0

Table 6. Number of observations by causality

causality direction	N	percentage	percentage of APT
causality farm to retail	20	35.7	52.6
causality retail to farm	7	12,5	10.5
bidirectional causality	29	51,8	36.8
total	56	100.0	100.0

Dependent variable

[2] As one of the earliest application of this approach was the study by Houck (1977), in Table 4 we refer to it as 'Houck approach'.

Our dependent variable is a dummy variable equal to one if the paper detects asymmetric price transmission and equal to zero if symmetric transmission has been detected.

Independent variables

To investigate the effect of the agro-food supply chain characteristics upon price transmission asymmetry, we include the following explanatory variables. Variable *size* measures the size of the sector and is captured by the number of farm holdings operating in a given sector. To assure the comparability across countries and/or sectors, it is standardized over total number of farm holdings in a given country. Including this variable is due to predictions originating from the interest group theory that relates the strength of an interest group to a number of its members (Olson, 1965). According to this theory, the larger the group, the higher transaction costs incur in order to decide about, and undertake, certain actions. What follows, this variable is expected to positively affect the presence of price transmission asymmetry as it should be negatively correlated with farmers' bargaining power. These data come from the EU Farm Accountancy Data Network (FADN).

To further control for farmers' bargaining power, we also include two other variables that aim at capturing the sector's farm structure. On the one hand, we control for the share of land utilised by farm holdings of economic size between 0 and 4 ESU (variable *0_4_ESU*). This way we control for the relative farm fragmentation/importance of the smallest farms. To also control for the other extreme, we include a variable *100_over_ESU* which measures the share of land operated by farm holdings equal to or larger than 100 ESU. This variable aims at capturing the relative strength of largest farms. Since it is plausible to assume that farm's economic size is positively related to its bargaining position vis-a-vis downstream sector, we expect the variable *0_4_ESU* (*100_over_ESU*) to have a positive (negative) effect on the probability to observe asymmetric price transmission. These data also come from the FADN.

While the former three variables aimed at capturing most important characteristics of the farm sector, we also try to control for main characteristics of the retail sector. In general, there are two main problems with variables that could be used here. First, the literature is not unanimous with respect to the proxy that one should use to measure the retailers' market power (see e.g. Meyer and von Cramon-Taubadel, 2004). Second, even if we assume that the first problem is solved, it is still quite difficult to find the data on a uniform measure that would be available for more than

a few countries. Given these problems and the ongoing debate, we focus here on regulations governing the retail trade. These data come from the OECD and were collected via the OECD Regulatory Indicators Questionnaire. While these data point to a number of important aspects of the functioning of retail sector, it should be noted that the regulatory indicators that we use concern the whole retail sector and not food retailing as such. This should be kept in mind while interpreting our results. Based on these data we construct three variables: *entry_barriers*, *operational_restrictions* and *price_controls*. Each index is ranging from 0 to 6 with higher values indicating more restrictive regulations. The former two variables seem to act in favour of smaller retailers as compared to large-scale retailers (normally entry barriers and/or operational restrictions relate to hyper- and super-markets rather than to smaller shops). In such case, they simultaneously improve the farms' bargaining position vis-a-vis retailers, to the extent they contribute to a more balanced bargaining power between farms and retailers, and they should promote symmetric price transmission. It should be noted however, that entry barriers shelter incumbent retailers and this should strengthen bargaining position of the latter. It follows, that an opposite effect of *entry_barriers* cannot be excluded. As far as the expected impact of *price_controls* on price transmission asymmetry is concerned, it should be positive. This is because, limits imposed on the price competition between retailers may result in stronger pressure to use vertical pricing policy to increase market share. Asymmetric price adjustments could be seen as an example of such policy.

To have a complete coverage of subsequent stages of the agro-food supply chain, we also include a variable measuring the strength of the processing industry. Variable *manufacturing_turnover* measures the average turnover per manufacturing enterprise in a given agricultural sector. The average is calculated over the period 1995-2008.[3] This variable is based on the FADN data.

We classify countries into following main groups: Western refers to old EU member states whilst Eastern describes Central European countries. In addition we divide Western countries into two subgroups. North group includes Austria, Denmark, Finland, France, Germany, Sweden, Netherlands, UK, while South refers to Greece and Spain.

As far as the regressions linking price transmission asymmetry to methodological aspects are concerned, we use the following explanatory variables. Variable *Houck* is a dummy

[3] In some cases however the data was not available for all this period and in such cases the average was calculated over the shorter time-span.

distinguishing papers that use the pre-cointegration approach. Variable *VECM* on the other hand is a dummy distinguishing studies relying on vector error correction models. All other papers, i.e. those that rely on non-linear methodologies, act as a reference group.

3. Results

While estimating our meta-analysis regressions, we employ various approaches including the parametric estimator, the semiparametric maximum likelihood estimator of Klein and Spady (1993) and the semi-nonparametric estimators of Gallant and Nychka (1987). To save space, below we only present results from the latter approach. Estimations based on this approach performed best in terms of statistical significance. In addition, likelihood ratio tests report that semi nonparametric estimators outperform traditional probit models with one exception (see column 3). Our main results linking price transmission (a)symmetry to agro-food supply chain characteristics are reported in Table 7.

Table 7 Price transmission asymmetries & agro-food supply chain characteristics – semi-nonparametric maximum likelihood estimator

	APT					
Entry_barriers	-0.705***			-0.608	0.182	-1.383***
Price_control	1.573***			1.654***	1.031***	1.173***
Operational_restrictions	-0.159			-0.956***	-1.322***	0.026
Size		-2.932***		5.764***	0.743	3.219***
0_4_ESU		8.180***		7.920*	3.396	7.236***
100_over_ESU		-2.415***		-7.503***	-3.466***	-1.217
Manufacturing_turnover			-0.034***	-0.039***	-0.067***	-0.055***
Western					3.058***	
South						1.463***
North						-0.187
Log pseudolikelihood	-40.936	-33.698	-41.988	-28.625	-28.320	-25.015
n	67	62	65	56	56	56
Likelihood ratio test of Probit model against SNP model:						
p-value	0.010	0.0110	0.289	0.0490	0.0362	0.0222

Several interesting points arise from this analysis. First, we find that the probability of asymmetric price transmission is the higher, the bigger is the sector under investigation. This could be explained in two ways, both building on Olson's (1965) interest group theory. On one hand, the more farmers in a given production sector, the more difficult it is for them to organize themselves and bargain with retailers. This is a direct consequence of the collective action

problem that deteriorates with a growing number of group members. On the other hand, the higher the number of farmers in a given production sector, the easier it should be for the retailer to find potential supplier. This, in turn, should positively affect the retailers' bargaining position.

This reasoning is further supported by the fact that price asymmetric movements are negatively correlated with the share of land operated by holdings with more than 100 ESU, which is the second key point to be observed. At the same time we find a positive correlation between price asymmetries and the share of land in the smallest holdings (0-4 ESU). This latter result however is statistically insignificant. Overall then, we find that asymmetric price transmission is the higher (lower) the more fragmented (concentrated) is the farm structure. The explanation of this fact rests on a positive relationship between the size of the farm and its bargaining power.

Third, moving on to the effect of regulations affecting the retail sector, we find that asymmetric price transmission is less likely in a scenario where retailers' activities are constrained by 'entry barriers' regulations. At first glance, this result could be counter intuitive as entry barriers shelter incumbents from potential rivals and thus may lead to increased margins and, possibly, more rigid price adjustments. Note, however, that entry barriers, if put in place, are mostly directed against large-scale retailers. This, in turn, should act in favour of smaller retailers, possibly allowing them to increase their market share. Given that retailers' size should be one of important determinant of their bargaining power, this may at the same time be beneficial to farmers. Consequently, the more balanced the bargaining power of farmers and retailers, the more likely to observe symmetric price transmission.

In similar vein, we observe that price transmission is less likely to be asymmetric in the presence of regulations restricting large retailers opening hours. Again, the argument explaining this finding could be linked to lower market share of large retailers (relative to small shops) which results in more convenient conditions for farmers.

Further, our results indicate that price movements tend to be more asymmetric if price competition between retailers is limited (price controls may forbid, for instance, putting the dumping prices/keeping retail prices too low). A possible interpretation to account for this result could be the following. Price controls (strongly) limit the set of 'horizontal-competition' tools that retailers may use to increase their market share. Consequently, they may resort to 'vertical-

competition' tools, i.e. try to increase their market share through delayed and/or asymmetric adjustments in prices along the supply chain.

Finally, we also look at the potential impact of the processing industry, and find that farm-retail price transmission asymmetry is less likely to occur when food manufacturing turnover (per enterprise) is higher. A potential explanation for this result draws on the fact that in the situation where the processing industry plays a dominant role in the supply chain price asymmetries may now move to farm-processor and processor-retailer relationships. In such case, farm and retail prices may move together, so symmetric transmission is more likely to be observed.

As far as the results on the influence of methodological characteristics are concerned (Table 8), they could be summarised as follows. Firstly, the probability to detect asymmetric price transmission is higher for studies using methodological approaches other than Houck or VECM. Secondly, asymmetries are more likely to be found in studies using weekly rather than monthly data. This is fully in line with arguments and findings presented elsewhere (von Cramon et al., 2003; Frey and Manera, 2007). Thirdly, there is also some evidence that asymmetries are found more often for livestock rather than crop products. Finally, compared to Central and Eastern Europe, price asymmetric behaviour is more (less) likely to be found in southern (northern) countries.

Table 8. Price transmission asymmetries & modeling approach – semi-nonparametric maximum likelihood estimator

	APT	
vecm	-1.723***	-1.478**
Houck	-4.049***	-5.147***
monthly	-4.046***	-4.394***
livestock	0.599	2.946***
Western	-0.856	
south		1.543**
north		-1.401**
Log pseudolikelihood	-38.235	-36.145
N	69	69

4. Conclusions

In this paper we investigate the underlying reasons for price transmission. Our methodology rests on meta-analysis and empirical results obtained from a number of studies in the field. More specifically, we try to relate the presence/absence of price transmission asymmetry in farm-retail

relations detected by the existing studies to various characteristics of the agro-food supply chain. Our focus is on factors that are likely to affect the bargaining power of actors operating at subsequent stages of the supply chain. In addition, we investigate the extent to which the results found in the literature on price transmission are influenced by the methodological approaches that formed the basis for these findings.

Overall, our results are in line with the existing theories predicting that price transmission asymmetries are more likely in the presence of (retailers') market power. More specifically, we find that asymmetries are present in sectors with bigger number of farm producers and less likely to occur in scenarios with more concentrated farm structure. This is in accordance with Olson's interest group theory, as it is plausible to assume that both the number of farm producers and farm fragmentation negatively affect farmers' bargaining power. Further, price transmission asymmetries seem to be related to regulatory framework that governs the operation of retail sector. Our results suggest that asymmetries are less likely in the presence of operational restrictions on retail trade (e.g. entry barriers and 'opening hours' restrictions). On the other hand, distortions in the price relationship between retailers and suppliers are more likely to occur in the presence of regulations limiting price competition between retailers. Finally, we document that farm-retail price relationship tends to be symmetric in the presence of strong processing sector. This may be due to the latter actor being a dominant player in the supply chain and thus influencing both farm and retail prices.

Obviously, there is a question to what extent our results are affected by the, so called, omitted variables bias. Note that our data do not provide any information on government support, stock management practices or menu costs, i.e. factors that are mentioned as important price transmission determinants in addition to market power. This, in turn, may impact our results. For instance, if we assume that government support positively affects both the presence of asymmetric price transmission as well as the relative number of farmers in a given sector, our coefficient on *size* variable would be too big. Further, we do not have any direct measure on the bargaining power of agents operating at subsequent stages of the supply chain. Consequently, we have to rely on proxies. This obviously rises the question whether these proxies really measure what we want to measure. These issues clearly point that the results we show should be treated with caution. Nevertheless, we believe that the approach that we adopt here could be useful in improving our understanding of factors responsible for asymmetric price movements. Clearly,

much remains to be done and this short paper could be only a small building block in bridging the gap between theory and empirics in studying causes of (a)symmetric price transmission.

References

Amador, O.F., Baumgartner, J., Cuaresma, J.C. (2010), "Milking the Prices: The Role of Asymmetries in the Price Transmission Mechanism for Milk Products in Austria", *WIFO Working Papers*.

Bailey, D. and Brorsen, B.W. (1989), Price Asymmetry in Spatial Fed Cattle Markets, *Western Journal of Agricultural Economics* 14(2), pp. 246-252

Bakucs, L.Z., Fertő, I. (2005), "Marketing margins and price transmission on the Hungarian pork meat market", *Agribusiness,* vol. 21, no. 2, pp. 273-286.

Bakucs, L.Z., Fertő, I. (2008), "Price transmission on the Hungarian milk market", *2008 International Congress, August 26-29, 2008, Ghent, Belgium,* European Association of Agricultural Economists, .

Bakucs, L.Z., Fertő, I. (2006), "Marketing margins and price transmission on the Hungarian beef market", *Acta Agriculturae Scand Section C,* vol. 3, no. 3-4, pp. 151-160.

Bakucs, L.Z., Fertő, I., Hockmann, H., Perekhozhuk, O. (2006), "Farm to retail price transmission on the pork market: A German-Hungarian Comparison", in: Cutriss, J., Balmann, A., Dautzenberg, K., Happe, K., (eds.): *Agriculture in the face of changing markets, institutions and policies: challenges and strategies*, Studies on the agricultural and food sector in Central and Eastern Europe, Vol. 33, pp. 414-429.

Bakucs, L.Z., Fertő, I., Szabo, G.G. (2007), "Price transmission in the Hungarian vegetable sector", *Studies in Agricultural Economics,* , no. 106.

Bakucs, L.Z., Fertö, I. (2009), "Marketing and Pricing Dynamics in the Presence of Structural Breaks: The Hungarian Pork Market", *Journal of International Food, Agribusiness Marketing,* vol. 21, no. 2, pp. 116-133.

Balke, N.S., Brown, S.P.A., Yücel, M.K. (1998), „Crude Oil and Gasoline Prices: An asymmetric Relationship?", *Federal Reserve Bank of Dallas, Economic Review*, First Quarter, pp. 2-11.

Ball, L., Mankiw, N.G. (1994), "Asymmetric Price Adjustment and economic Fluctuations", *The Economic Journal* 104, pp. 247-261.

Ben-Kaabia, M., Gil, J.M. (2007), "Asymmetric price transmission in the Spanish lamb sector", *European Review of Agricultural Economics,* vol. 34, no. 1, pp. 53-80.

Ben-Kaabia, M., Gil, J.M., Ameur, M. (2005), "Vertical integration and non‐linear price adjustments: The Spanish poultry sector", *Agribusiness,* vol. 21, no. 2, pp. 253-271.

Bukeviciute, L., Dierx, A., and Ilzkovi, F. (2009), "The functioning of the food supply chain and its effect on food prices in the European Union", EUROPEAN ECONOMY Occasional Papers No 47, Brussels

Bojnec, S., Peter, G. (2005), "Vertical market integration and competition: the meat sector in Slovenia", *Agricultural and food science,* vol. 14, no. 3, pp. 236-249.

Čechura, L., Šobrová, L. (2008), "The price transmission in pork meat agri-food chain", *Agricultural Economics–czech,* vol. 54, pp. 77-84.

Conway, P. and G. Nicoletti (2006), "Product Market Regulation in non-manufacturing sectors in OECD countries: measurement and highlights", OECD Economics Department Working Paper No.530, Paris

Fałkowski, J. (2010), "Price transmission and market power in a transition context: evidence from the Polish fluid milk sector", *Post-Communist Economies,* vol. 22, no. 4, pp. 513-529.

Frey, G., Manera, M. (2007), "Econometric Models of Asymmetric Price Transmission". *Journal of Economic Surveys*, vol. 21, no. 2 pp. 350-515

Gallet, C.A. (2010), Meat Meets Meta: A Quantitative Review of the Price Elasticity of Meat, *American Journal of Agricultural Economics* 92(1), 258-272.

Gallet, C.A. (2007), The Demand for Alcohol: A Meta-Analysis of Elasticities, *Australian Journal of Agricultural Economics* 92(1), 258-272.

Gallant, A. R., – D. W. Nychka. (1987), "Semi-nonparametric maximum likelihood estimation". *Econometrica* 55 (2), pp. 363-390.

Guillen, J., Franquesa, R. (2010), "Testing for market power in the Spanish meat market: price transmission elasticity and asymmetry using econometric models", *International Journal of Computational Economics and Econometrics,* vol. 1, no. 3, pp. 294-308.

Hassouneh, I., Serra, T., Gil, J.M. (2010), "Price transmission in the Spanish bovine sector: the BSE effect", *Agricultural Economics,* vol. 41, no. 1, pp. 33-42.

Hess, S., von Cramon-Taubadel, S. (2007), Meta-analysis of general and partial equilibrium simulations of Doha Round outcomes, *Agricultural Economics* 37 (1), 281-286.

Johnston, R.J., Duke, J.M. (2009), Informing Preservation of Multifunctional Agriculture when Primary Research Is Unavailable: An Application of Meta-Analysis, *American Journal of Agricultural Economics* 91 (5), 1353-1359.

Karantininis, K., Katrakylidis, K., Persson, M. (2011), "Price Transmission in the Swedish Pork Chain: Asymmetric non linear ARDL", *2011 International Congress, August 30-September 2, 2011, Zurich, Switzerland,* European Association of Agricultural Economists, .

Kinnucan H.W., Forker O.D. (1987), "Asymmetry in Farm-Retail Price Transmission for major Dairy Products", *American Journal of Agricultural Economics*, 69, pp. 285-292.

Klein, R., Spady, R. (1993), "An efficient semiparametric estimator of the binary response models". *Econometrica* 61 (2), pp. 387-421.

Lagerkvist, C.J., Hess, S. (2011), A meta-analysis of consumer willingness to pay for farm animal welfare, *European Review of Agricultural Economics* 38 (1), 55-78.

Levy, D., Bergen, M., Dutta, S., Venable, R. (1997), "The magnitude of menu costs: Direct evidence from large U.S. supermarket chains", *Quarterly Journal of Economics* 112(3), pp. 791-825.

London Economics, (2004), "Investigation of the determinants of farm-retail price spreads", *London Economics and Defra.*

Luoma, A., Luoto, J., Taipale, M. (2004), *Threshold cointegration and asymmetric price transmission in Finnish beef and pork markets,* Pellervo Economic Research Institute.

McCorriston, S., Morgan, C.W., Rayner, A.J. (1998), "Processing Technology, Market Power and Price Transmission", *Journal of Agricultural Economics* 49(2), pp. 185-201.

McCorriston, S., Morgan, C.W., Rayner, A.J. (2001), "Price transmission: the interaction between market power and returns to scale", *European Review of Agricultural Economics* 28(2), pp. 143-159.

Meyer, J., von Cramon-Taubadel, S. (2004), "Asymmetric price transmission: a survey". *Journal of Agricultural Economics*, 50, pp. 581–611.

Olson, M. (1965), *The Logic of Collective Action: Public Goods and the Theory of Groups*, Harvard University Press.

Reagan P., Weitzman M. (1982), Asymmetries in price and quantity adjustments by the competitive firm, *Journal of Economic Theory*, Vol. 27, pp. 410-420.

Reziti, I., Panagopoulos, Y. (2008), "Asymmetric price transmission in the greek agri‐food sector: some tests", *Agribusiness,* vol. 24, no. 1, pp. 16-30.

Rezitis, A.N., Reziti, I. (2011), "Threshold Cointegration in the Greek Milk Market", *Journal of International Food, Agribusiness Marketing,* vol. 23, no. 3, pp. 231-246.

Serra, T., Goodwin, B.K. (2003), "Price transmission and asymmetric adjustment in the Spanish dairy sector", *Applied Economics,* vol. 35, no. 18, pp. 1889-1899.

Stanley, T.D. (2001), "Wheat from Chaff: Meta-Analysis As Quantitative Literature Review", *Journal of Economic Perspectives* 15, 131-150.

Von Cramon-Taubadel, S., Loy, J.-P., Meyer, J. (2003), "The impact of data aggregation on the measurement of vertical price transmission: Evidence from German food prices", paper presented at the AAEA conference in Montreal, Canada, July 27-30, 2003.

Wohlgenant, M.K. (1985), "Competitive Storage, Rational Expectations, and Short-Run Food Price Determination", *American Journal of Agricultural Economics*, Vol. 67, pp. 739-748.

Annex

Pre-cointegration asymmetry analysis uses the following Ward (1982) specification, based on the earlier Woffram (1971) and Houck (1977) specification:

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

Here, the first differences of the producer prices are split into increasing and decreasing phases by the D^- and D^+ dummy variables. Asymmetry is tested using a standard F-test to determine whether β_j^+ and β_j^- are significantly different.

These approaches do not pay attention to the time series properties of the data and many of them suffer serial autocorrelation that usually suggests spurious regression.

With the development of cointegration techniques, attempts were made to test asymmetry in a cointegration framework. Von Cramon-Taubadel (2002) demonstrated that the Wolffram-Houck type specifications are fundamentally inconsistent with cointegration and proposed the use of cointegration techniques, followed by the estimation of an (potentially asymmetric) vector error correction model (VECM). The underlying data generation process may assume several linear and non-linear cointegration test procedures that ultimately define the empirical methodology of asymmetrical price transmission analysis. We briefly cover some of the cointegration techniques used (see table 3. for a methodological overview of papers analysed).

Johansen et al. (2000) generalised the Johansen (1988) maximum likelihood cointegration test in order to include up to two breaks. The procedure estimates the following model:

$$\Delta Y_t = \alpha \begin{pmatrix} \beta \\ \mu \end{pmatrix}' \begin{pmatrix} Y_{t-1} \\ tE_t \end{pmatrix} + \gamma E_t + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \sum_{i=1}^{p} \sum_{j=2}^{q} \kappa_{j,i} D_{j,t-i} + u_t \tag{2}$$

where Y_t is a vector of non-stationary variables, p is the lag number, $E_t = (E_{1t}\, E_{2t} \ldots E_{qt})'$ is a matrix of q dummy variables, where $E_{j,t} = 1$ if observation t belongs to the j^{th} period and 0 otherwise, $D_{j,t-i}$ is an impulse dummy that equals 1 if observation t is the i^{th} observation of the j^{th} period, meant to render the corresponding residuals to zero. Γ_i and $K_{j,i}$ are short run matrices, α is the speed of adjustment parameter matrix, β are the long run cointegration coefficients and μ are the long run drift parameters. The u_t residuals are supposed to be independently and identically distributed with zero mean and symmetric and positive definite variance-covariance matrix Ω. Restrictions on the model can be tested using likelihood ratio tests.

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:

$$y_{1t} = \mu_1 + \mu_2 \varphi_{t\tau} + \alpha^{\mathrm{T}} y_{2t} + e_t \quad , \mathrm{t} = 1,\ldots,\mathrm{n}. \tag{3}$$

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

$$y_{1t} = \mu_1 + \mu_2 \varphi_{t\tau} + \beta t + \alpha^{\mathrm{T}} y_{2t} + e_t \quad , \mathrm{t} = 1,\ldots,\mathrm{n}. \tag{4}$$

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

$$y_{1t} = \mu_1 + \mu_2 \varphi_{t\tau} + \alpha_1^T y_{2t} + \alpha_2^T y_{2t} \varphi_{t\tau} + e_t \quad \mathrm{t} = 1,\ldots,\mathrm{n}. \tag{5}$$

Because usually the time of the break in not known *a priori*, models (3) – (5) are estimated recursively allowing T to vary between the middle 70% of the sample:

$$\lfloor 0.15n \rfloor \le T \le \lfloor 0.85n \rfloor .$$

A more flexible, yet slightly more complicated approach is to allow the price equation system parameters to vary according to the possible shifts in the data generating process. Threshold

models allow defining two or more regimes with regime dependent short-run parameters and adjustment coefficients. Threshold models (e.g. Balky and Fomby 1997, Goodwin and Holt 1999, Hansen and Seo, 2002) are often used to test price transmission and integration, since the threshold may be interpreted as transaction costs. The Hansen and Seo (2002) procedure employs bi-dimensional Maximum Likelihood grid search to simultaneously test for the threshold and estimate the cointegrating vector ($\boldsymbol{\beta}$). The following model is estimated:

$$\Delta x_t = \begin{cases} A'_1 X_{t-1}(\beta) + u_t, & ha \quad w_{t-1}(\beta) \le \gamma \\ A'_2 X_{t-1}(\beta) + u_t, & ha \quad w_{t-1}(\beta) > \gamma, \end{cases} \tag{6}$$

where X_{t-1} are p dimension I(1) time series, cointegrated with vector β, $w_t(\beta)=\beta' x_t$ being the I(0) error correction term. The significance of the estimated threshold value is tested with an LM type statistic, with bootstrapped critical values.

Hamilton (1989) developed the Markov-switching vector autoregressive model. The advantage of Markov-switching (MS) class models is that it allows time series analysis with different regimes, when the corresponding state variable is not known. In this paper we apply Markov-switching error correction models, MSVECM, allowing shifts in the short-run parameters, intercept, and residual variance according to the state of the system:

$$\Delta Y_t = v(s_t) + \alpha(s_t)(\beta' Y_{t-1}) + \sum_{i=1}^{k} D_i(s_t)\Delta Y_{t-i} + u_t \tag{7}$$

where Y_t is the non-stationary price vector, v is the vector of intercept terms, α is the vector of the speed of adjustment coefficients, and β is the long-run cointegrating vector. D_i are the autoregressive, (short-run parameters) matrices. As before, u_t are assumed to have the usual properties. s_t is the state variable, where $s_t = 1,\ldots,M$ indicates in which of the M possible regimes the system might be in. The state of the system, however, is not directly observed. Generally, the probability of the system of being in state s_t might depend on the full history of the system. In MS modelling, the following simplifying assumption is made:

$$\Pr(s_t \mid S_{t-i}, \Delta Y_{t-1}, \beta' Y_{t-1}) = \Pr(s_t \mid s_{t-1,} \Pi)$$

where Π is the matrix of transition probabilities, i.e., the probability of today's state does functionally depend only on the state in the previous time period.