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Abstract

The paper assesses the degree of price cooperation between the main agricultural supply chain stakeholders in EU-27. The price transmission mechanism between producers and retailers is used for assessing cooperation. Cereals prices of EU-27 are used for the empirical analysis (January 1995 - April 2022). The price mechanism is modeled via the Co-Integrated Vector AutoRegressive (VAR) representation. The empirical analysis follows the usual drill of stationarity and co-integration tests followed by Granger Causality tests, Impulse Responses and Forecasts of Error Decomposition. The results show restricted cooperation between supply chain stakeholders.

JEL Classifications: Q13, Q18

Keywords: Price analysis, European Union - 27, supply chain management

1. Introduction

Each company in a supply chain usually attempts to maximize own profits. However, the interdependency of the companies states the need for collective optimization (Bechtel and Jayaram, 1997). When a link of the chain faces a shock, the chain is disrupted and the workload for the other companies reduces (Stevens, 1989). Forrester (1961) was the first to verify that a shock in one part of the chain can quickly become magnified as the effect spreads through the supply chain. This holds especially for food supply chains due to the perishability of agricultural products and the inherent uncertainty. The concerns of consumers for the safety of the food products and the production methods are major factors for exponential shocks in a food supply chain. Moreover, open markets policies facilitate the need for tighter cooperation among supply chain agents due to intensified competition. Older practices, like inventory accumulation, cope with uncertainty in a much costlier way than a current company or supply chain can withstand (Towill, 1997). Therefore, this paper set to investigate the degree of cooperation between producers and retailers in EU-27 cereals supply chain by taking into consideration the reaction of stakeholders to price shocks.

1.1 Characteristics of food supply chains

Food supply chains consist of set of companies that produce and distribute vegetable and animal products. Their main characteristic is the perishability of products. Production cycle is dependent on weather and biological factors resulting in seasonality. However, biotechnological advancements are reducing it. In the next stages of wholesalers, processors and retailers, the major issue is the variability in quality and quantity of agricultural inputs. Moreover, the complementarity of agricultural inputs increases the complexity of the capital-intensive procession process. According to Van Weele (1988), 70 % of production costs comes from raw materials; therefore, processors contract suppliers in order to achieve a constant flow of inputs. On the other hand, information technology benefits logistical and marketing activities by improving dissemination of information through supply chain resulting in better coordination of actors (Gattorna, Walters, 1996). However, these improvements are not equally beneficial for all actors due to competition issues. Another dimension of agricultural production is the need for quality and environmental controls throughout the supply chain resulting in a tight institutional framework and the development of certified products. In the macroeconomic environment, globalization was the standard (Cohen, Huchzermeier, 1999) however now increased trade barriers are common. Instead, the development of regional and multicounty economic zones is observed.

On the demand side, demographic changes in the developed economies of the European Union take place i.e., ageing population, increases in double-income families and in smaller households. Changing patterns in consumers' preferences result in increased demand for refined foods of foreign origin. Important for consumers is easy preparation and increased convenience (Hughes, 1994). That includes more snacks and ready-made meals. On the other hand, the trend for healthier meals that have less fat, sugar and meat is gaining popularity. Consequently, the demand for vegetarian meals is increasing while at the same time the need for diversity is gaining importance. Worth mentioning, is the need of consumers for more socializing during their food experiences. Finally yet importantly, the local needs of each neighborhood in urban territories are quite different due to the existence of many immigrants with different cultural references.

The rest of the paper continues with the presentation of supply chain literature review (section 2), the methodology utilized (section 3), the presentation of the price series and empirical analysis of price mechanisms (section 4). The paper concludes with section 5.

2. Literature review

2.1 Supply chain management and Business process redesign

In supply chain management the entire network from end consumer to inputs suppliers is managed in order to achieve the best outcome for everyone. The analysis includes inventories, flow of information through the chain and the activity taken for meeting customer demands (Ellram, Cooper, 1993). Business process redesign is a framework of actions that aims at improving the efficiency of a company and a supply chain through redesigning its processes (Hammer, Champy, 1993). Business redesign in order to be successful needs a strategic plan. More specifically, the management of the company and by extension of the supply chain initially should identify the current state of the company as seen from the point of view of customers. The results of this process then are used for the simplification of business activities and by extension for the reduction of waste and redundant surpluses. Thus, business redesign should stay focused on the interaction among business processes that add value to customer offerings and not to the individual business functions. More often than not, the redesign of business processes takes place when the pressure of competition surpasses a threshold where the company is in jeopardy of losing market share and eventually leave the market. The structural changes that follow affect the entire company and chain in tangible and non – tangible aspects.

2.2 Collaborating models in food supply chains

Vertical integration is a collaborating model in a supply chain that takes place when there is need for recurrent transactions while the production process requires specialized assets. Vertical integration reduces the chance for opportunistic behavior among the partners of the chain. Strategic partnership is a model that involves cooperation of independent companies. The partnership entails long run commitment to mutual goals by sharing the risks and the rewards. Partnering companies in order to achieve a competitive advantage, they focus on their core competencies. Each firm needs to devote on what it does best while at the same time shares risks with partners trough coordination and information sharing. However, even in the closest partnerships, there is always the risk of moral hazard (Lamming, 1993). Efficient consumer response model is an example of strategic partnership for food retailers and suppliers (Kurt, 1993). The efficient consumer response is based on the Just in Time concept. Retailer and supplier cooperate closely with the aim to quickly respond to customer needs based on information from points of sale. In the framework of efficient consumer response, information substitute surpluses.

2.3 Successful partnerships

Partnerships are not by default beneficial for a company and by extension for the supply chain. No matter how willing are partners to commit themselves into a partnership, there will always be a number of obstacles to overcome. The majority of companies are not willing to invest in proper managerial systems that will aim at integration with the rest of the chain. Their orientation stays locked to their own business activities. The reasons usually include the lack of trust among the members of the supply chain. Moreover, the members of the supply chain do not value the effect of overall efficiency in their individual efficiency. These obstacles conclude in making difficult for members of the supply chain to know what are the costs and the benefits of operating in a strategic partnership.

3. Methodology

The econometric analysis of the price mechanism of cereals is based on non-structural time series analysis. The Augmented Dickey – Fuller test is used for the assessment of the stationarity of price series. Co-integration testing takes place with Johansen tests (trace test and maximum eigenvalue). The existence of a co-integrating relationship between producer and retailer prices

results in the utilization of a co – integrated Vector AutoRegressive model (i.e. Vector Error Correction model). The co - integrated Vector AutoRegressive model in its reduced form is given by:

$$\Delta p_t = \Pi p_{t-1} + \Gamma_1 \Delta p_{t-1} + \dots + \Gamma_{j-1} \Delta p_{t-j+1} + u_t \quad (1)$$

where: $\Delta p_t = (\Delta p_{1t}, \dots, \Delta p_{Kt})'$ is a vector of K price series each including T observations, K = producer or consumer, $p_{t-1} = (p_{1t-1}, \dots, p_{Kt-1})'$ is a vector of K one-lagged prices, each $\Delta p_{t-j} = (\Delta p_{t-j}, \dots, \Delta p_{Kt-j})'$ is a vector of K j-lagged differenced prices, j = 1…J, Π is a (K x K) matrix of long-run coefficients, each Γ_j is a (K x K) matrix of short-run coefficients and $u_t = (u_{1t}, \dots, u_{Kt})'$ is a vector of K residual series.

The number of lags j to include in the model are determined by the multivariate Akaike Information Criterion (AIC) (Lütkepohl, 2004). The estimation process continues with the computation of Granger causality test, impulse responses and forecast error variance decomposition. These calculations assess the interdependencies between the series. The Granger causality test assesses the effect of past prices of consumer prices on current prices of producer and vice versa in the short run. The impulse responses show the behavior of each variable intertemporally when a price shock of a standard deviation affects the price mechanism. The response to the shock is examined by the Vector Moving Average (VMA) representation of the Vector AutoRegressive model. A Vector Moving Average model represents the price series as a function of current and past values of the shock:

$$\Delta p_t = \Phi_0 u_t + \Phi_1 u_{t-1} + \Phi_2 u_{t-2} + \dots , \quad (2)$$

Alternatively, the Vector Moving Average process can be expressed in terms of s periods in the future:

$$\Delta p_{t+s} = \Phi_0 u_{t+s} + \Phi_1 u_{t+s-1} + \Phi_2 u_{t+s-2} + \dots , \quad (3)$$

where $\Phi_0 = I_K$, $\Phi s = \Sigma \Phi s\text{-}j\ Aj$, s = 1, 2, ...,

Using a Choleski decomposition, the orthogonalized shocks are $\varepsilon_t = P^{-1} u_t$, where P is a lower triangular matrix such that $\Sigma u = PP'$. Equation (3) can now be re-written as,

$$\Delta p_{t+s} = \Psi_o\, \varepsilon_{t+s} + \Psi_1 \varepsilon_{t+s-1} + \Psi_2 \varepsilon_{t+s-2} + \dots, \quad (4)$$

where $\Psi_0 = P$, $\Psi_s = \Phi_s P$.

The off-diagonal elements of the matrix Ψ_s represent the response of the price of producer of an agricultural product to the innovations of consumer and vice verca. The orthogonal impulse response function (IRF) is presented by the plot of the elements of Ψ_s as a function of s. The ordering follows the most influential variable, i.e., consumer price, which is placed first. The forecast error variance

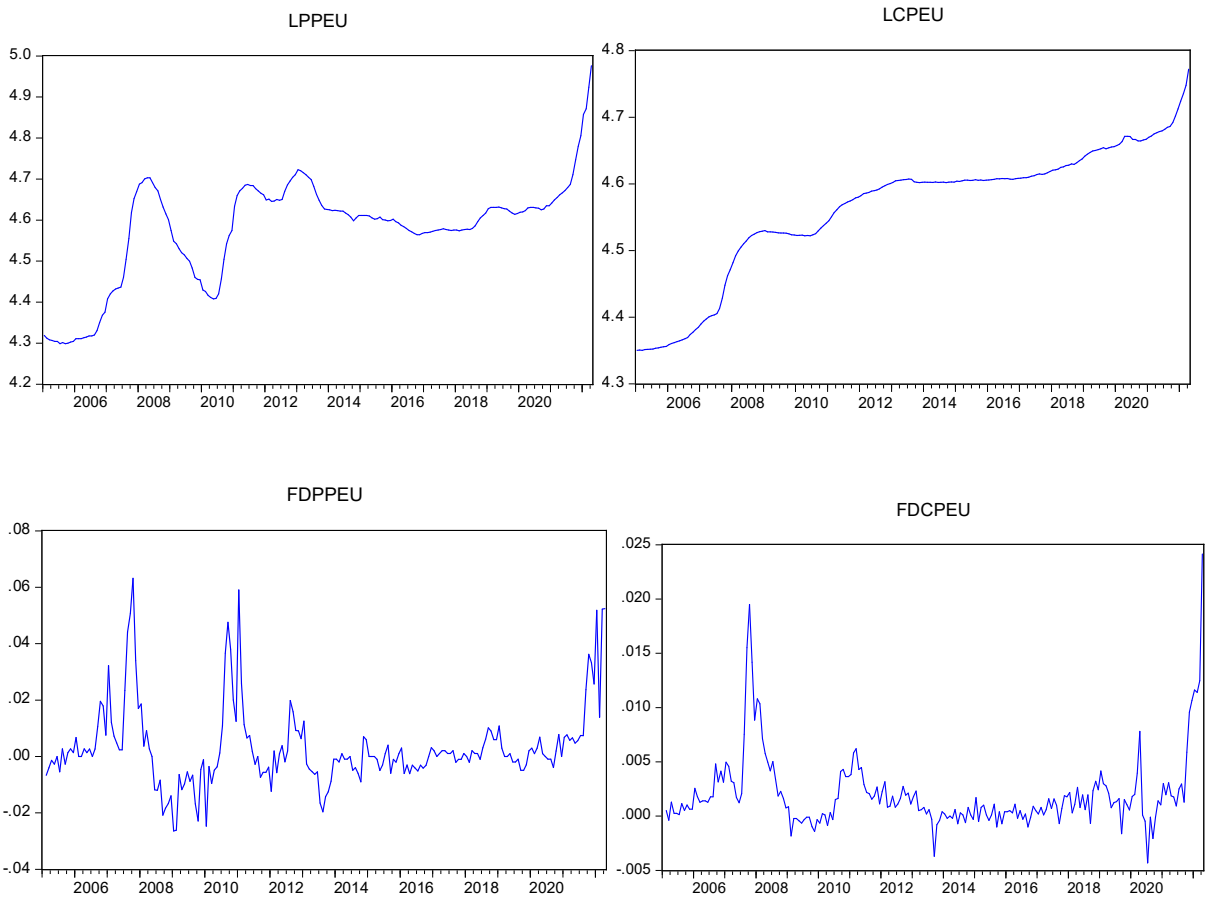
decomposition (FEVD) is the percentage contribution of variable i to the h-step forecast error variance of variable k. The Forecast Error Variance Decomposition k_i is the variance of the forecast error. All the computations were performed in Eviews 7.

4. Data and Empirical Analysis

4.1 Descriptive analysis of the cereals sector

The analysis is based on monthly prices indices extracted from the food monitoring tool of Eurostat for cereals in EU-27. The price series expand from January 2005 to April 2022 and include the 27 countries of the European Union. The presentation of the data takes place in plots of natural logarithms and first differences. Moreover, the descriptive statistics of the series are computed.

Diagram 4.1.1: Price indices of producer and consumer in log and first differences



The price indices of cereals in logarithms follow an upward trend that is more intense for retailers. Their first differences reveal that producers' prices are more volatile than retailers. This is evident

from the observation that the divergence of producers' prices is much stronger than consumers (-0.3, 0.6) vs (0.020, -0.005).

Table 4.1.1: Descriptive statistics of price indices of producer and retailer in log and first differences

	LCEREALSPP	LCEREALSCP	FDCEREALSPP	FDCEREALSCP
Mean	4.577	4.563	0.003	0.002
Std. Dev.	0.126	0.098	0.014	0.003

The table of descriptive statistics reveals a similar average price in logarithms and in first differences but a quite different standard deviation. Producers' standard deviation is larger in both logarithms and first differences verifying the optical inspection of the plots. Especially producers' standard deviation is almost five times the standard deviation of consumers in first differences.

4.2 Empirical analysis of cereals

The analysis of price mechanism of cereals between producer and retailer reveals that the series are not stationary while a co–integrating relationship between producer and retailer exists. Table 4.2.1 presents the coefficients of the Co-integrated Vector AutoRegressive model.

Table 4.2.1 Co-integrated Vector AutoRegressive (Error Correction) model

Cointegrating Equation	Coefficient	
Lcerealspp(-1)	1.000000	
Lcerealscp(-1)	-1.011 (-7.633)	
Constant	0.039	
Error Correction:	D(LcerealsPP)	D(LcerealsCP)
CointEq1	-0.028 (-2.383)	0.024 (2.237)
D(LcerealsPP(-1))	0.632 (8.304)	0.099 (6.874)
D(LcerealsPP(-2))	0.192 (2.326)	-0.029 (1.890)
D(LcerealsCP(-1))	0.565 (1.221)	0.588 (6.666)
D(LcerealsCP(-2))	-0.199 (-0.0464)	0.095 (1.162)
Constant	0.000 (0.150)	0.000 (3.094)
R-squared	0.632	0.772
F-statistic	64.48	134.8
Akaike AIC	-6.590	-9.906

In parenthesis t-statistics are presented

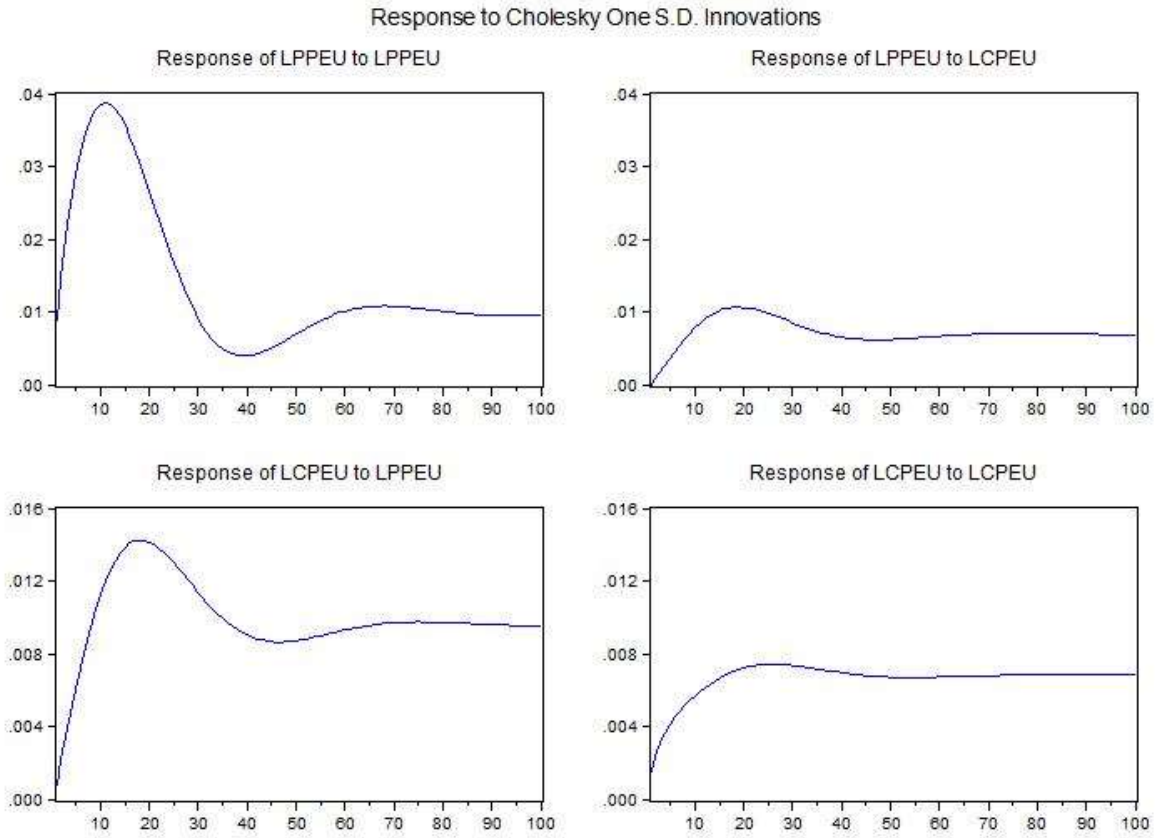
The price mechanism of cereals is a two lagged model according to Akaike Information Criterion. The coefficient of the co–integrating vector in the producer equation is negative and of small magnitude but significant. Likewise, the coefficient of the co–integrating vector in retailer's equation is positive and significant but still very small. Thus, in the long run, the co-integrating relationship formulates prices but at an imperceptible pace. In the short run, the lagged prices of retailer and producer reveal mixed results regarding statistical significance. The effect of lagged prices of producer and retailer is further evaluated with Granger Causality test.

Table 4.2.2 Granger Causality

	Statistic	Probability
D(Lcereals**PP)**		
D(LcerealsCP)	1.588	0.415
D(Lcereals**CP)**		
D(LcerealsPP)	51.30	0.0000

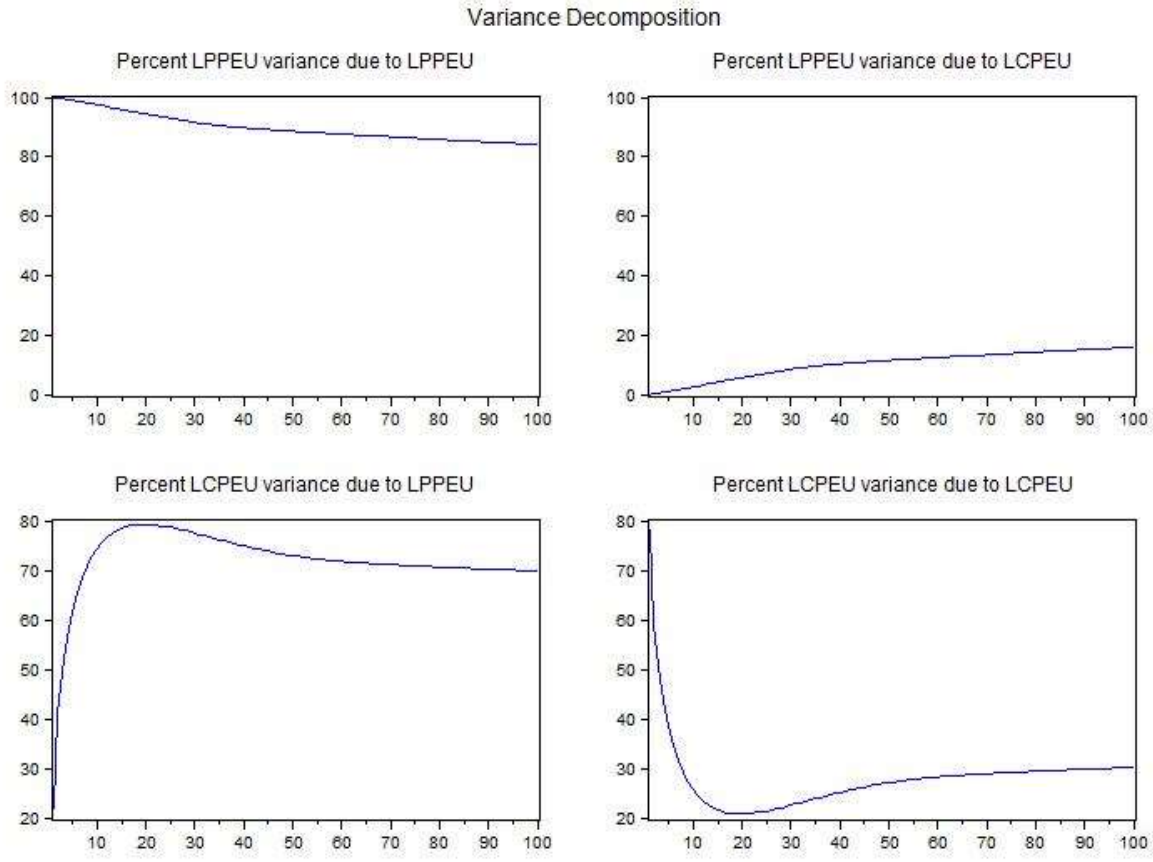
As is evident from the table, producer prices Granger cause retailer prices. That is producers' prices determine the price formation mechanism in cereals' sector of the European Union in the short run. Next, the reaction of supply chain members in shocks of one standard deviation is presented.

Diagram 4.2.1 Impulse responses



As is evident by the plots, a shock of one standard deviation to producer's price affects own price instantly (from the first month). The shock is permanent and stabilizes in about 40 months. The shock affects consumer's price instantly (from the first month). The effect of the shock gets steady after the 20th month and is permanent. A shock of one standard deviation to retailer's price affects producers' price more than own price. The shock affects prices from the 1st month for both producer and retailer but in the case of producer the price change is exponential while in the case of consumer the price change stabilizes much faster, in about 20 months. In both cases, the effect of the shock is permanent. The analysis of price shocks goes on with variance decomposition.

Diagram 4.2.2 Variance decomposition



As expected, the plots of forecast error variance decomposition verify the result of impulse responses analysis that producer bares the cost from a shock of a standard deviation. Producer absorbs own shock almost entirely even after many months (80%) while retailer's participation in the assimilation of the price change is a merely 20%. In the same fashion, a shock of a standard deviation in retailer's price affects producer's price almost instantly from the first month. The effect gets steady in the 50th month reaching a staggering 70%. On the other hand, the effect of the shock on own price decreases quickly so after 20 months reaches zero. These results strongly suggest that the supply chain of cereals in European Union suffers from lack of cooperation between producers and retailers.

6. Discussion and Conclusions

The paper examined the degree of cooperation between producer and retailer in the supply chain of cereals in the European Union of the 27 Member States. The price mechanism was used as a proxy for the degree of cooperation between the two main stakeholders of the supply chain. The time series span from January 2005 to April 2022 and the frequency was monthly. The methodology followed the path of the non-structural analysis of co-integrated Vector AutoRegressive models.

The empirical results revealed poor cooperation in price handling between producer and retailer. The results of Granger causality tests showed a uni – directional relatioship from producer to retailer in the short run while in the long run there was interaction. Impulse responses analysis and variance decomposition revealed a different pattern. That is producers bare shocks almost entirely without any transmissions to retailers. More specifically, a shock of a standrad deviation results in permanent effects on producer and retailer prices. The main part of the shock 70 - 80 % is born by producer while ratailers bare the rest in prolonged time horizons. The study of the European Union's cereals supply chain for the 27 Member States reveals that despite the long run price interaction between producer and retailer, in the case of shocks, the transmission is limited. In the short run, the retailer dominates the price relationship. Therefore, the food supply chain is characterized as inefficient, since it is not capable to fully transmit price signals in the case of price changes of one standard deviation. Supply chain as a conceptual framework state that producer and retailer are motivated to cooperate in facing price shocks. However, the empirical analysis of the cereals supply chain of EU-27 Member States shows the contrary. It is worth mentioning that managers of food supply chain companies have to overcome a series of circumstances that do not apply to other production sectors. Specifically, a food chain is restricted by exogenous factors such as biological and weather conditions. These exogenous factors make it more difficult for managers to adopt changes that will offer deeper cooperation among chain members. Long growing and breeding cycles for plant and animal products do not let any margins for flexibility. Achieving greater cooperation is even more restricted by the difficulty in raising inventories for a long time. Especially, since customers prefer the consumption of fresh products. Managers also have to overcome the risk that improved control over the partners of the supply chain would result in limited competition something that would trigger the intervention of competition authorities. The reason would be that companies that do not participate into the supply chain would be at a disadvantage since they would lack opportunities to grow. More importantly, the market mechanism would be further distorted since information will not be freely available to all, competitors and consumers. As is known from the competitive paradigm, companies aim at exercising market power on customers and suppliers in order to maximize profits. An important characteristic for partners is the willingness for sharing costs apart from rewards. The reasons usually include the lack of trust among the members of the supply chain. The members of the supply chain do not value high enough the effect of overall efficiency in comparison to their individual efficiency. These obstacles result in making difficult for members of the supply chain to know what are the costs and the benefits of operating in a strategic partnership. Thus, the cooperation in sharing the burden of price shock is subject to the moral hazard faced by partners.

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