Should we cry over the spilt milk?
Market power and structural change along dairy supply chains in EU Countries

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1. Introduction

The food supply chain plays a relevant role in the European economy connecting sectors such as agricultural, food processing industry and distribution. Along EU food supply chain farmers are more exposed to the influence of the market power of their trading partners, especially food retailers. The last decade has been characterized by a strong development of modern retail in the EU where modern retail's share of total grocery sales increased in 24 Member States (EC, 2014; Nicholson and Young, 2012). Top 10 large retailers control 40% of the European food market while in most Member States, 3-5 retailers hold over 65% of the market share (Nicholson and Young, 2012).

The value added for agriculture in the food chain is around 21% (in 1995 it was 31%) versus a value added of around 28% for the food industry and of 51% for food retail and food services taken together (EP, 2015). In order to balance power and the distribution of the value added along the agro-food supply chain, one of the objectives of the single Common Market Organisation Regulation (EU No 1308/2013) was to strengthen the role of farmers by fostering supply concentration through Producer Organisations (POs), associations and interbranch organisation recognized for all agricultural sectors. Before such EU CAP reform the role of private organisations was recognized and subsidized in fruit and vegetable sector and, more recently, in milk sector, within the so-called "Milk Package" which has been published on 30 March 2012. Such package provided for written contracts among milk producers and buyers and for the possibility to negotiate contract terms collectively via POs. It also sets out new specific EU rules for inter-branch organizations, allowing actors in the dairy supply chain to dialogue and carry out certain activities. The package also entails a series of measures enhancing transparency in the market. Although in some EU Member States recognized POs have conducted collective negotiations covering between 4 and 33% of national dairy production, we suppose that it is too early to evaluate the effect of the Milk Package on the milk sector (EU Milk Market Observatory, 2015). Nevertheless such political intervention points to a specific issue (competition and vertical relations along the dairy chain) that deserve attention.

Overall, the increasing process of concentration of food retailing has raised concerns regarding potential anti-competitive behaviours along food supply chains. Several works, using different methodological approaches, focused on oligopolistic and oligopsonistic power exerted within agrifood systems at food processing and retailing stages to the detriment of farmers (suppliers of raw agricultural inputs) and consumers. Some authors (Fałkowski, 2010; Bakucs et al., 2012; Serra and Goodwin, 2003; Rezitis and Reziti, 2011) have aimed at verifying the above mentioned view

by examining the mechanism of price transmission in some EU Countries, identifying both short-run and long-run asymmetries which are consistent with the use of market power by the downstream sector. Structural models (Grau and Hockmann, 2016; Zavelberg et al., 2015; Salhofer et al., 2012; Hockmann and Vöneki, 2009; De Mello and Brandao, 1999; Aalto-Setälä, 2002; Perekhozhuk et al., 2015), "first-pass" test proposed by Lloyd et al. (2009) (Cavicchioli, 2010; Fałkowski, 2010; Madau et al., 2016;) and, recently, the application of stochastic frontier methodology on a mark-up model (Cechura et al., 2015), have been employed to detect market power along EU milk and dairy supply chains, showing, in various cases, market power exertion of processors and retailers.

Also trends in price data along the dairy chain suggest that a systematic analysis of the topic would be appropriate. At EU level, the recent fall of milk prices at farm gate, (- 28% as UE weighted average from I semester 2015 to I semester 2016, Milk market observatory, 2016) seems not to have been transmitted to a limited extent downward, to processors-gate and consumers prices. For instance in Italy, over the same time span, farmer's prices has decreased of 24%, while dairy processor's prices have diminished by 6% and consumer's prices have fallen only of 0,8% (Pieri and Pretolani, 2015). Even if such differences may be due, in part, to the decreasing share of agricultural input value (milk) on the total value of dairy products, the imperfect competition along dairy supply chains may have a role. In this framework the present paper gives a twofold contribution to the analysis of the EU food supply chains. Firstly, by empirically estimating a "first-pass" test in order to detect the exertion of market power of processors and retailers in the EU dairy supply chains. Secondly, it tries to implicitly assess which structural characteristics across EU-25 food supply chains are correlated to the presence of imperfect competition. The remainder of the paper is organized as follows: section 2 explains the choice of the model adopted to isolate imperfect competition along EU dairy chains, data and econometric tools used for its empirical application and some relevant characteristics of the supply chains examined. Section 3 presents the results of the test of market power while Section 4 concludes.

2. Theoretical Framework and Methodology

The methodology used to detect the presence of market power along dairy chains has been defined by their inventors as a "first pass" test (Lloyd et al., 2009). In our opinion, such approach draws together the advantages of the two category of tools most used to analyse price relationships and imperfect competition and food markets: price transmission analysis and New Empirical Industrial Organization (NEIO) models. The former have the advantage of using easily available time series data (price or price index) to detect asymmetries in the transmission of price along food chains.

However, they lack of theoretical foundation and the asymmetries found may not be necessarily attributed to the exertion of market power (see Cavicchioli, 2010 for further details). The NEIO models, on the other side, are grounded in microeconomic theory and their empirical implementation allows to estimate the extent to which market power (oligopoly or oligopsony power) is exerted. Nevertheless, such models are demanding in terms of data and econometric tools. The model we use for our analysis has the advantage of using easily available data, getting conclusive results on the presence of market power along an entire supply chain.

2.1. Theoretical model

A way to detect market power exertion along food supply chain is represented by theoretical model introduced by McCorriston (2001) and adapted by Lloyd et al. (2006; 2009) for empirical application to some food supply chains. The authors built a theoretical model through a modification of Gardner model (1975) by releasing the assumption on perfectly competitive markets. This theoretical framework takes into consideration food supply chain by focusing on farm and marketing levels while, for simplicity, the intermediate stage is considered as an aggregate of the food processing and retailing sectors.

Specifically, retailers face the following demand function for the processed product:

$$x=D(Px,N) \quad (1)$$

where Px is the retail price of the good and N is a general demand shifter. The supply function of the agricultural raw material is given, in inverse form, from:

$$Pa=k(A,W) \quad (2)$$

where A is quantity of agricultural product supply by farmers to retailers and resold by retailers to consumers as x. W is the exogenous shifter in the farm supply equation. The source of power in the food chain is given to be at retail level in the form both of buyer power and of oligopoly power. Furthermore, the model takes into account a representative retail firm which has the following profit function:

$$\pi_i=Px(x)x_i-Pa(a)a_i-C_i(x_i) \quad (3)$$

where Ci is the other costs and, assuming a fixed proportion technology, xi=ai/ρ where ρ is the input-output coefficient. Then, constant returns to scale in distribution are assumed even if, as demonstrated by McCorriston et al. (2001), the release of this assumption would not affect the significance of market power test. The first-order condition for profit maximization is given by:

$$Px+x_i(\partial Px/\partial x)(\partial x/\partial x_i)=\partial C_i/\partial x_i \quad (4)$$

In order to get an explicit solution, we consider linear functional forms for equations (1) and (2) and assume ρ=1 which is consistent with the construction of the dataset in the empirical analysis. This leads us to consider the following equations:

$$x=D-bP_x+cN \quad (1.1)$$

$$P_a=k+g(A+W)=k+g(x+W) \text{ given that in equilibrium } A=x \quad (2.1)$$

From this it is possible to rewrite (4) as:

$$P_x-\frac{\theta}{b}x=M+P_a+\mu gx \quad (4.1)$$

Where

$$M=y+zE \quad (5)$$

is a composite variable that represents all other costs that affect the retail-farm price margin. From equation (4.1) derives the hypothesis of imperfect competition, where μ and θ are, respectively, the aggregate input and output conjectural elasticity such that with n firms in the retail sector:

$$\mu = \frac{\sum i \left(\frac{\partial a}{\partial ai}\frac{ai}{a}\right)}{n} \qquad \theta = \frac{\sum i \left(\frac{\partial x}{\partial xi}\frac{xi}{x}\right)}{n}$$

These parameters can be interpreted, respectively, as an index of oligopsonistic and oligopolistic power with μ,θ =0 representing competitive behaviour and μ,θ =1 representing market power exertion. Although these parameters are widely employed in the NEIO to estimate the extent of market power, in this case they are used as instrument to signal anti-competitive behaviour.
Using (1.1), (2.1), (4.1) and (5), we can derive an explicit solution for the endogenous variables:

$$x = \frac{(D-by-bh)+cN-bzE-bgW}{(1+\theta)+bg(1+\mu)} \quad (6)$$

$$Px = \frac{D+[(1+\theta)+bg(1+\mu)][(1-b)(y+h+gW)+(1-bz)E+cN]}{(1+\theta)+bg(1+\mu)} \quad (7)$$

$$Pa = \frac{g[(k-by+cN-bzE)]-g\{b-[(1+\theta)+bg(1+\mu)](h+W)\}}{(1+\theta)+bg(1+\mu)} \quad (8)$$

In order to derive the spread between retail and farm prices, we subtract (7) from (8) to give:

$$Px - Pa = \frac{D\left(\frac{\theta}{b} - g\mu\right) + (1+bg)(y+zE) + \left(\frac{\theta}{b} + g\mu\right)cN - (\theta + bg\mu)(h+gW)}{(1+\theta) + bg(1+\mu)} \quad (9)$$

It is useful note that if retailers exert neither oligopolistic power (θ=0) nor oligopsonistic power (μ=0) then, equation (9) collapse in a simpler form as following:

$$Px - Pa = y + zE \quad (10)$$

indicating that retail-farm price spread in a perfectly competitive market exclusively depends on marketing costs. In this case the exogenous shifters relating to demand and supply functions play no role in determining the spread. This does not mean that they do not affect any price along food supply chain but they have an equal effect on farm and retail prices no determining their spread. Conversely, when retailers exert market power, in oligopolistic and/or oligopsonistic form, each exogenous shifter affects farm and retail price differentially and, therefore, the margin changes. Specifically, in presence of market power the exogenous demand shifter increases retail-farm price while exogenous supply shifter decreases it as indicated by equation (9).

Based on the model findings, two important points can be made; first, under perfect competition along the food chain, the price spread (Px–Pa) is represented only by marketing costs (M) and second, it is not affected by shifts in farm supply (W) and consumer demand (N) functions. However, if oligopolistic or oligopsonistic power is exerted along the food chain (i.e. if θ or μ differ from zero), both of the exogenous shifters (W and N) affect the magnitude of price spread. In particular, under anticompetitive behaviour, a shift in consumer demand (N) increases the margin, whereas a shift in farm supply (W) reduces it. Note that if market power is exerted within the food chain, both of the shifters affect the margin simultaneously. The effect of the exogenous shifter on the marketing margin is then "activated" by the exertion of oligopolistic or oligopsonistic power in the intermediate stage of the chain.

Based on (9) and (10), we use the following unrestricted equation (including the exogenous variables W and N) to test two different (null) hypotheses of perfect competition or of market power exertion:

$$P_x = \beta_0 + \beta_1 P_a + y\beta_2 M + \beta_3 N + \beta_4 W \quad (11)$$

Under perfect competition along the food chain (θ=μ=0), none of the shifters affect the margin and the associated parameters are expected to be not significantly different from zero. An additional prerequisite, consistent with economic theory and with equations (9–10), is that the retail price has to be positively related to both the producer price (β1>0) and marketing cost (β2>0) in the long

term and the associated parameter estimates should be positive and statistically significant. Thus, perfect competition can be tested as follows:

$$H_{0pc}: \beta_1 \succ 0; \beta_2 \succ 0; \beta_3 = \beta_4 = 0 \quad (12)$$

Note that whereas by failing to reject the null hypothesis we can conclude that the supply chain is perfectly competitive, rejection of the null hypothesis is not a sufficient condition to deduce the exertion of market power (although in conventional hypothesis testing, this would be the case). To reach such a conclusion, some additional conditions are required; first, both of the parameters have to be significantly different from zero ($\beta3 \neq 0$; $\beta4 \neq 0$) and second, the parameter of exogenous shifter N has to be positive ($\beta3 > 0$) while the parameter of W has to be negative ($\beta4 < 0$). Similarly, market power exertion along the food chain is tested under a different null hypothesis:

$$H_{0mp}: \beta_1 \succ 0, \beta_2 \succ 0; \beta_3 \succ 0; \beta_4 \prec 0 \quad (13)$$

In the interpretation here (which differs slightly from the version of the authors who developed and implemented the model), only empirical results failing to reject H0pc (perfect competition) or H0mp (market power exertion) can be considered plausible and conclusive. Alternative hypotheses (only one of the shifters significant and/or not signed according model prescriptions) would yield ambiguous and inconclusive results.

2.2. Data used

Table 1 shows the data which were collected from the Eurostat public database (http://ec.europa.eu/eurostat/data/database), covering partially or totally from January 2000 to June 2016 for 25 EU Countries. All data are monthly or quarterly time series in index form (rescaled, when it was necessary, to base year 2010 and to monthly). Consumer price corresponds to the harmonized price index of milk, cheese and eggs purchased by consumers in the selected EU markets. Agricultural production price refers to nominal and real price indexes of milk, milk, cheese and eggs and whole milk sold by EU dairy farmers. We used various time series in order to proxy the marketing costs such as labour, transport and energy costs indexes at retail level. In order to incorporate the agricultural supply-side shocks (W), we employed the real and nominal price indexes of all goods and services purchased by farmers. Finally, the demand shifter (N) is represented by harmonized consumer price index for food and food and non-alcoholic beverages.
Table 2 shows the main structural characteristics of the diary sector in EU 25 Countries. The first two columns, which report the value of diary production and its percentage on total agricultural production, indicate that dairy sector, weighting between 15% and 30%, plays a relevant role in the

EU agriculture. Although in almost all Countries national farmers supply the majority of dairy products employed in the next stages of the national diary supply chains, dairy industry and retailers buy by other Countries a relevant share of raw materials.

Average size of the dairy farms, which ranges from 6,000 euros of Bulgaria to 435,000 euros of Denmark, shows the heterogeneity of the agricultural production among EU Countries. Another interesting characteristic reported in table 2 is the change, in terms of percentage, of farm size between 2005 and 2013. Finally, we included concentration rate, respectively, of standard output in dairy farms bigger than 250,000 euros and of the first 5 buyers in food retailing (CR5). The results indicate that the level of concentration is decidedly higher at retail stage compared to agricultural production.

We have included several characteristics of the dairy sector in EU 25 Countries in order to answer to two questions: i) How well the market power test works and how the structural characteristics are related to it?; ii) How the structural features of the national diary supply chain are related to market power and perfect competition in the selected chains?

Table 1. Description of variables used for the test on market power

VARIABLE CATEGORY	TYPOLOGY/GROUP OF PRODUCT	DESCRIPTION OF THE VARIABLE	ABBREVIATION PROPOSAL	FREQUENCY OF THE DATA	TIME COVERAGE	COUNTRY COVERAGE	BASE YEAR OF THE INDEX	DATA TRANSFORMATION
RETAIL PRICE	Milk, cheese and eggs	Harmonized index of consumer price	rp1	monthly	2000M01 - 2016M06	ALL EU (25)	2005 = 100	Rescaled from 2005 to 2010;
RETAIL PRICE	Milk, cheese and eggs	Consumer Price - Food Price Monitoring Tool	rp2	monthly	2005M01 - 2016M03	ALL EU (25)	2010 = 100	
AGRICULTURAL PRICE (FARMER PRICE)	Milk	Farm price index of milk, nominal index	fp1	quarterly	2000M01 - 2016M06 (11 Countries)	17 countries 2005 - 2016	2010 = 100	from quarterly to monthly
AGRICULTURAL PRICE (FARMER PRICE)	Milk	Farm price index of milk, real index	fp2	quarterly	2000M01 - 2016M06 (11 Countries)	17 countries 2005-2016	2010 = 100	from quarterly to monthly
AGRICULTURAL PRICE (FARMER PRICE)	Milk, cheese and eggs	Agricultural Commodity price - Food Price Monitoring Tool	fp3	monthly	2005M01 - 2015M06 (20 Countries)	20 Counties 2005-2015	2010 = 100	
AGRICULTURAL PRICE (FARMER PRICE)	Whole milk	Agricultural Commodity price - Food Price Monitoring Tool	fp4	monthly	2005M01 - 2015M06 (20 Countries)	20 Counties 2005-2015	2010 = 100	
MARKETING COST	Manifacturing	Labor Cost Index - Wages and salaries (total) - Calendar and seasonally adjusted data	lcman	quarterly	2000Q1 - 2016Q1	24 Countries (no Croatia)	2012 = 100	Rescaled from 2012 to 2010; from quarterly to monthly
MARKETING COST	Wholesale and Retail trade	Labor Cost Index - Wages and salaries (total) - Calendar and seasonally adjusted data	lcwr	quarterly	2000Q1 - 2016Q1	24 Countries (no Croatia)	2012 = 100	Rescaled from 2012 to 2010; from quarterly to monthly
MARKETING COST	Transport and storage	Labor Cost Index - Wages and salaries (total) - Calendar and seasonally adjusted data	lcts	quarterly	2000Q1 - 2016Q1	24 Countries (no Croatia)	2012 = 100	Rescaled from 2012 to 2010; from quarterly to monthly
MARKETING COST	Energy	Producer price index of energy in domestic market - unadjusted data	encost1	monthly	2000M1 - 2016M6	19 Countries	2010 = 100	
MARKETING COST	Energy	Harmonized Index of Consumer Prices	encost2	monthly	2000M01 - 2016M06	19 Countries	2015 = 100	Rescaled from 2015 to 2010;
MARKETING COST	Manifacture of food products	Gross wages and salaries - seasonally and calendar adjusted data	lc4	monthly	2000M01 - 2016M04 (7 Countries)	7 countries	2010 = 100	
DEMAND SHIFTER	HICP - All items	Harmonized Index of Consumer Prices	ds1	monthly	2000M01 - 2016M06	ALL EU (25)	2005 = 100	Rescaled from 2015 to 2010;
DEMAND SHIFTER	HICP -Overall excluding seasonal food	Harmonized Index of Consumer Prices	ds2	monthly	2001M01 - 2016M06	24 Countries (Croatia 2004-2016)	2005 = 100	Rescaled from 2015 to 2010;
DEMAND SHIFTER	HICP - food and nonalcholic beverages	Harmonized Index of Consumer Prices	ds3	monthly	2000M01 - 2016M06	ALL EU (25)	2005 = 100	Rescaled from 2015 to 2010;
DEMAND SHIFTER	HICP - food	Harmonized Index of Consumer Prices	ds4	monthly	2001M01 - 2016M06	24 Countries (Croatia 2004-2016)	2005 = 100	Rescaled from 2015 to 2010;
SUPPLY SHIFTER	Price index of the means of agricultural production - Goods and services currently consumed in agriculture	Nominal Index	ss1	quarterly	2000Q1 - 2016Q1	14 countries - 23 countries 2005-2016	2010 = 100	from quarterly to monthly
SUPPLY SHIFTER	Price index of the means of agricultural production - Goods and services currently consumed in agriculture	Real Index	ss2	quarterly	2000Q1 - 2016Q1	14 countries - 23 countries 2005-2016	2010 = 100	from quarterly to monthly

Table 2. Structural characteristics of the dairy sector in EU 25 Countries (average 2005-2015).

GEO	Value of dairy production* (mln €)	% of dairy on total agricultural production	Import of dairy products (mln €)	Share of Import on domestic production (dairy)	Share of trade (imp + exp) on domestic production (dairy)	Average size of Dairy farms (000 € Standart Output)	Change in dairy farm size between 2005* and 2013	Concentration Rate of Standard Ouput in Dairy farms bigger than 250,000 €	Concentration Rate of first 5 buyers in food retailing (CR5)
Austria	1,232	21%	625	0.51	1.30	42	67%	31%	94%
Belgium	1,175	15%	2,618	2.23	4.42	167	83%	6%	71%
Bulgaria	588	17%	125	0.21	0.38	6	128%	19%	67%
Croatia	368	15%	111	0.30	0.41	21	117%	31%	48%
Czech Republic	887	21%	439	0.49	1.15	198	161%	76%	46%
Denmark	1,744	19%	501	0.29	1.35	435	115%	57%	89%
Estonia	201	30%	50	0.25	0.97	84	316%	70%	79%
Finland	1,181	31%	275	0.23	0.58	99	90%	11%	92%
France	9,415	15%	2,688	0.29	0.86	120	63%	4%	65%
Germany (until 199	10,368	22%	5,636	0.54	1.24	155	49%	26%	89%
Greece	1,692	17%	762	0.45	0.65	63	60%	17%	50%
Hungary	700	11%	299	0.43	0.76	69	71%	69%	68%
Ireland	1,662	27%	475	0.29	1.19	106	54%	7%	65%
Italy	6,105	14%	3,405	0.56	0.88	126	36%	33%	40%
Latvia	246	26%	97	0.39	1.07	12	181%	25%	77%
Lithuania	458	21%	147	0.32	1.26	9	105%	19%	92%
Netherlands	4,836	22%	2,878	0.60	1.87	248	59%	15%	65%
Poland	4,151	21%	437	0.11	0.45	20	145%	36%	48%
Portugal	849	14%	488	0.57	0.91	79	113%	22%	65%
Romania	3,128	22%	209	0.07	0.09	4	66%	10%	23%
Slovakia	368	19%	245	0.67	1.36	32	182%	73%	48%
Slovenia	200	18%	113	0.56	1.15	30	99%	31%	82%
Spain	3,835	10%	1,707	0.45	0.69	89	81%	22%	70%
Sweden	1,219	25%	669	0.55	0.81	228	80%	28%	95%
United Kingdom	5,020	21%	2,800	0.56	0.81	278	92%	33%	78%
EU 25	**61,629**	**18%**	**27,801**	**0.80**	**1.02**	**66**	**76%**	**24%**	

2.3. Econometric analysis

In order to estimate the parameters of the Equation (11), a preliminary step is to test the order of integration and the stationarity properties of the univariated time series involved in the model. Following Lloyd et al. (2006, 2009), it is appropriate to apply empirical analysis in a vector autoregressive (VAR) framework. However, estimation of the parameters of the VAR models requires that the variables are covariance stationary. If the times series are not covariance

stationary, but their first differences are, a vector error-correction model (VECM) can be used (Enders, 2004).

A VAR model, written with exogenous variables, is given by:

$$x_t=\phi_1 x_{t-1}+\phi_2 x_{t-2}+....+\phi_p x_{t-p}+\Psi D_t+\varepsilon_t \quad (14)$$

where xt is a (m x 1) vector of jointly determined I(1) variables, Dt is a (q x 1) vector of deterministic and/or exogenous variables and each ϕi (i=1, …, p) and Ψ are (m x m) and (m x q) matrices of coefficients to be estimated by Johansen's (1988) maximum likelihood procedure. Finally, εt is a vector of n. i. d. disturbances with zero mean.

The Vector Error Correction Model (VECM) representation of (X), is given by:

$$\Delta x_t=\alpha\beta' x_{t-p}+\sum_{i=1}^{p-1} \Gamma\Delta x_{t-I}+\Psi D_t+\varepsilon_t \quad (14a)$$

where the attention is focused on (m x r) matrix of cointegrating vectors β that quantify the long-run relationships between the time series in the system and the (m x r) matrix of error correction coefficients, α, the elements of which load deviations from equilibrium into Δxt for correction. The Γi coefficients estimate the short-run effect of shock on Δxt, allowing the short-run and long-run response to differ.

As a consequence, before we run VAR or VECM models, we investigate on stationarity and cointegration of the employed time series. All the time series in each dataset were tested for stationarity in level and in first differences looking for their order of integration. Stationarity was tested using the augmented Dickey–Fuller (ADF) test (Dickey and Fuller 1979) which takes nonstationarity (presence of a unit root) as the null hypothesis against the alternative of stationarity. In each test, an underlying data generating process was assumed with the variable having, respectively, intercept and time trend and intercept only. Judgments about the order of integration of each variable were made comparing t-statistics (for ADF), with critical values for each distribution (at 1%, 5% and 10%).

Furthermore, since there may exist up to m-1 cointegrating relations among m variables in xt, the precise number is evaluated by Johansen's Trace test statistic (Johansen, 1988). In this test the null hypothesis is that there are at least r cointegrating relationships. Where a single cointegrating relationship among variables included in econometric equations is detected, our goal is to verify the significance of the supply and demand shocks in VECM estimations[1] in order to investigate whether market power is present along the selected food chain.

[1] An important issue about ECM concerns the restrictions on trend terms. This leads to 5 different cases: i) Unrestricted trend: if no restrictions are placed on the trend parameters, implies that there are quadratic trends in the levels of the variable and that the cointegrating equations are stationary around time trends; ii) Restricted trend: we assume that trends in the levels of the data are linear but not quadratic. This specification allows the cointegrating equations to be trend

Therefore, our strategy is to check those combinations of variables showing one cointegrating vector, under one or more mentioned assumptions, and proceed to VECM estimates of the more parsimonious models.

3. Results and discussion

The analysis to detect the exertion of market power described in Section 2.1 has been applied to the dairy chains of 25 selected EU Countries using the variables listed in table 1. The results are presented in table 3.

stationarity; iii) Unrestricted constant: in this case we restrict the cointegrating equations to be stationary around constant means. This specification puts a linear trend in the level of the data; iv) Restricted constant: by adding the restriction on the constant, we assume there are no linear trends in the levels of the data. This specification allows the cointegrating equations to be stationary around a constant mean, but it allows no other trends or constant terms; v) No trend: this specification assumes that there are no nonzero means or trends. It also assumes that the cointegrating equations are stationary with means of zero and that the differences and the levels of the data have means of zero.

Table 3: Results of market power test on dairy supply chains in EU -25 Countries

Country	Results of the market power test on the dairy supply chains
Austria	Market power
Belgium	Non conclusive
Bulgaria	Perfect competition
Croatia	Market power
Czech Republic	Perfect competition
Denmark	Perfect competition
Estonia	Non conclusive
Finland	Non conclusive
France	Non conclusive
Germany	Non conclusive
Greece	Non conclusive
Hungary	Market power
Ireland	Non conclusive
Italy	Non conclusive
Latvia	Non conclusive
Lithuania	Non conclusive
Netherlands	Non conclusive
Poland	Non conclusive
Portugal	Market power
Romania	Non conclusive
Slovakia	Market power
Slovenia	Non conclusive
Spain	Perfect competition
Sweden	Perfect competition
United Kingdom	Perfect competition
CONCLUSIVE RESULTS	11
NON COCNLUSIVE RESULTS	14
% CONCLUSIVE/ TOTAL CASES	44%

As explained in previous section, to test for market power may yield non conclusive results, due to the strict requirements to be fulfilled, both on the econometric estimation side (section 2.3) and from theoretical model (section 2.1). The former require that all the variable involved in the estimation (retail price, producer price, marketing cost, demand and supply shifters) are cointegrated, in order to estimate their long run relationship; the theoretical model prescriptions suggest that in the estimated equation (11) parameters associated to farmer price and marketing cost should exert a positive effect on retail price ($\beta 1$and $\beta 2>0$). All the estimated equations lacking this conditions have not been considered as in contrast to model pre-requisites. The remaining combinations of variables have been considered conclusive only in case of

i) Perfect competition along the dairy chain if both of the shifters parameters were not significantly different to zero

ii) Market power exertion along the dairy chain when both of the shifters parameters were different to zero, with the demand shifter parameter positive ($\beta 3>0$) and, at the same time, the supply shifter parameter negative ($\beta 4<0$)

All the other combinations of variables with different signs and significance in shifter parameters have been considered meaningless for the market power test. As appears from table 3, the test has been conclusive in 11 Countries and non-conclusive in 14 ones, with a share of 44%. It seems that the test performance in dairy chains is lower if compared to a similar analysis carried out by the Authors (Cacchiarelli et al, 2016) in Fruit and Vegetable sectors, with share of success of 67% and 56%, respectively. The reason for such a lower performance of the test in the dairy sector may be found in its peculiar characteristics, that differ with respect to the model assumption of the input/output coefficient. To better understand possible causes that may influence the discriminant power of the test, we have correlated our results (using a dummy variable on test conclusiveness: 1 = conclusive, 0 = non conclusive) with the main features of the European dairy chains, reported in Table 2. The results of such correlation are shown in table 4.

Table 4 - Correlation between conclusiveness of the market power test and structural characteristics of dairy supply chains

		Value of dairy production (mln €)	% of dairy on total agricultural production	Share of Import on domestic productio n (dairy)	Share of trade (imp + exp) on domestic production (dairy)	Average size of Dairy farms (000 € Standart Output)	Change in dairy farm size between 2005 and 2013	Concentrati on Rate of Standard Ouput in Dairy farms bigger than 250,000 €	Concentrati on Rate of first 5 buyers in food retailing (CR5)
CORRELATION WITH CONCLUSIVENESS (1 = conclusive, 0 = non conclusive)		***-0.302***	***-0.365***	***-0.044***	***-0.183***	***0.221***	***0.079***	***0.464***	***0.075***

From the table appears that the discriminant power of the test is negatively related to the economic dimension of the dairy sector in the Country, both in absolute and in relative terms. Surprisingly the relative importance of trade with respect to domestic production it is low correlated with test performance, while we expected higher values, since the underlying model does not incorporate the effect of trade on imperfect competition. On the other hand, this result could be interpreted as negligible impact of trade on the national dynamics along diary supply chain. Also the change in average size of farm and the concentration rate of top 5 food retailers are not correlated to the

performance of the test. Finally, the success of the market power test is positively related at 22% with the average farm size and at 46% with farm concentration rate.

Moving on to the conclusive results of the test (Table 5), among 11 cases where test was conclusive, we found 6 Countries in which markets are perfectly competitive while the remainders show the exertion of market power at the retail level. Perfect competition characterizes Countries such as Spain and UK whose dairy supply chains are relevant in absolute terms, Denmark which presents, on average, bigger farms and Czech Republic showing high concentration rate in the biggest dairy farms. The exercise of market power, instead, is observed in Austria where retail industry shows a remarkable consolidation but, also, in Portugal whose retailers are less concentrated and in some of EU-13 (Slovakia and Hungary) where the concentration at farm level is slightly higher compared to retail stage.

It is interesting to note that our results are consistent with the findings of other works. For instance, Checkura et al. (2015) find as processors in Bulgaria, UK and Sweden exercise a lower degree of non-competitive behaviour (close to perfect competition), on average, as compared to processors in Austria, Hungary and Portugal. Moreover, market power exertion at retail level is showed by Salhofer et al. (2012) in Austria and by Hockmann and Vöneki (2009) and De Mello and Brandao (1999) at industry level, respectively, in Hungary and Portugal.

Overall, results showed in first column in table 5 do not exhibit clearly which determinants seem to facilitate the exercise of market power. For this reason, we have put in relation the absence and presence of market power with structural characteristics of dairy chain examined (table 5).

The use of correlations rather than regression analysis (using the result of market power test as a dependent variable) is due to the simultaneous nature of the relationships among structure, conduct and performance. For this reason, even if the use of the binary conduct variable (market power or perfect competition) as a dependent and of structural characteristics of the dairy chain as explanatory variables seem useful to explore the determinants of imperfect competition, the estimated relationship would be biased for the above mentioned endogenous relationships. For this reason we limit our analysis to correlation, leaving the causal analysis as a future development. Before commenting such results it is worth pointing out that the correlations presented are computed on a subsample of Countries on which the market power test has given a result. Unfortunately it does not include some Countries whose dairy supply chains are important, both in absolute (Germany, France, Italy) and in relative terms (Finland, Estonia, Ireland). For this reason the validity of the following results and subsequent discussion is limited to the subsample examined.

Table 5 - Conclusive results of buyer power test and correlation with structural features of dairy supply chains in EU Countries

Country	Result of buyer power test	Value of dairy production (mln €)	% of dairy on total agricultural production	Share of Import on domestic production (dairy)	Share of trade (imp + exp) on domestic production (dairy)	Average size of Dairy farms (000 € Standart Output)	Change in dairy farm size between 2005* and 2013	Conc. Rate of Standard Ouput in Dairy farms bigger than 250,000 €	Conc. Rate of first 5 buyers in food retailing (CR5)
Austria	Market Power	1,232	21%	0.51	1.30	42	67%	31%	94%
Bulgaria	Perfect Competition	588	17%	0.21	0.38	6	128%	19%	67%
Croatia	Market Power	368	15%	0.30	0.41	21	117%	31%	48%
Czech Republic	Perfect Competition	887	21%	0.49	1.15	198	161%	76%	46%
Denmark	Perfect Competition	1,744	19%	0.29	1.35	435	115%	57%	89%
Hungary	Market Power	700	11%	0.43	0.76	69	71%	69%	68%
Portugal	Market Power	849	14%	0.57	0.91	79	113%	22%	65%
Slovakia	Market Power	368	19%	0.67	1.36	32	182%	73%	48%
Spain	Perfect Competition	3,835	10%	0.45	0.69	89	81%	22%	70%
Sweden	Perfect Competition	1,219	25%	0.55	0.81	228	80%	28%	95%
UK	Perfect Competition	5,020	21%	0.56	0.81	278	92%	33%	78%
CORRELATION WITH MARKET POWER TEST 0= PERFECT COMPETITION		***-0.522***	***-0.326***	***0.267***	***0.125***	***-0.609***	***0.004***	***0.145***	***-0.279***

The variables with the highest (>50%) inverse correlation with market power exertion are the value of dairy production in a Country (-52%) and the average size of dairy farms (-61%). The latter result is of particular interest in the relationship between structural change and imperfect competition. According to such evidence farm size and imperfect competition along the chain are inversely related, while no or limited relations are observed with the change in farm size over time and with the concentration rate of farms (in terms of production value). These three results taken together are of particular interest; a possible explanation (remembering that correlation is not necessarily causation) may be that in Countries with bigger farms it is easier to implement all that tools to foster supply concentration (POs, Cooperatives) balancing the power relationships along the dairy chain. It this hypothesis is true, the inverse relation between market power and farm size may reflect the concentration in dairy farm supply. To confirm such hypothesis would be useful data on concentration of dairy cooperatives in UE Countries; unfortunately such data are not homogeneous and comparable as those on farm size and concentration. In any case the hypothesis of farm size-supply concentration is in part indirectly confirmed by the lack of correlation among market power, change in farm size and concentration rate of the farms. Having more concentrated farms the increase their size over time has no relation with market power on the chain. This may be explained, again, in terms of supply concentration: both of the mentioned features may be seen

as alternatives to supply concentration in counterbalancing market power along the chain. It is self-evident the relevance of this issue that deserve further investigation. Finally, the relationship between imperfect competition in the chain and concentration rate of top 5 food retailers is quite unexpected even though not strong (-28%). As the absolute value of such correlation is lower than 50% the two variables are weakly related, nevertheless the sign of correlation is quite surprising as points to a (weak) negative association between retailers concentration and market power.

4. Conclusions, implications and future research developments

Although the literature regarding market power along milk and dairy supply chain includes various paper, this work represents one of the first attempts to empirically estimate market power exertion along EU-25 dairy chains, linking such evidence to the observable structural characteristics of the different stages of the supply chains in the Countries examined.

The analysis has been able to draw consistent conclusions on the conduct (market power or perfect competition) of 11 dairy chains over the 25 examined, with a discriminant power of 44%. Such result is lower than those of similar analysis and points to an improvement of the discriminant power of the test adopted to detect imperfect competition along the food chains. The results show that in some EU Countries (Austria, Portugal, Slovakia, Hungary and Croatia) the downstream sector exert market power. On the other hand, other EU Countries (Spain, UK, Denmark, Czech Republic, Bulgaria and Sweden) are characterized by perfect competitive markets. Such results are in line with the findings found in previous works.

Moreover, in the sub-sample of Countries where the test reached a conclusion, the presence or absence of market power has been related to various structural feature of the dairy chain. Even if the correlation analysis does not uncover necessarily causal relationships, some meaningful results are worth to be highlighted. In particular, the significant inverse correlation between average farm size and market power and, at the same time, the lack of correlation with farm size increase and farm concentration rate, may be explained by the (unobserved) role played by farm supply concentration reached, probably, through the various kind of organisations (POs, APOs and Cooperative) supported by the recent CAP reforms. In fact, without falling in the causality trap, a plausible explanation (to be tested in further analysis) may be that the supply concentration (that counterbalance market power along the chain), is the unobserved variable (due to a lack of available data) inversely related to imperfect competition; while the average size of farms makes supply concentration easier to implement through POs and Cooperatives, the alternative strategies such as increase of farm size over time or more concentrated farms do not have any significant relationship with the imperfect competition along the dairy chain. This hypothesis and the relationship among

farm structure, supply concentration and market power along food chains deserve to be examined in more depth. In this context, gathering comparable data on dairy supply concentration in European Countries would shed light on these relationships, allowing to test the effectiveness of this category of EU policy intervention aimed at strength the position of farmers within the EU supply chains.

References

Aalto-Setälä, V. (2002). The effect of concentration and market power on food prices: evidence from Finland. *Journal of Retailing*, *78*(3), 207-216.

Bakucs, Zoltán, Jan Fałkowski, and Imre Fertő. "Price transmission in the milk sectors of Poland and Hungary." *Post-communist economies* 24.3 (2012): 419-432

Cacchiarelli, L., Cavicchioli D., Sorrentino A. (2016), Has the Force awakened? Producer Organizations, supply concentration and buyer power in Fruit and Vegetable sector, Paper prepared for the 153 EAAE meeting, New dimensions of market power and bargaining in the agri-food sector: organisations, policies and models, Gaeta, Italy, June 9-10, 2016.

Cavicchioli, D., (2010). Detecting Market Power Along Food Supply Chains: Evidence From the Fluid Milk Sector in Italy. In 116th EAAE seminar "Spatial Dynamics in Agri-food Systems: Implications for Sustainability and Consumer Welfare", Parma.

Cechura, L., Kroupová, Z. Z., & Hockmann, H. (2015). Market Power in the European Dairy Industry. AGRIS On-line Papers in Economics and Informatics,7(4), 39.

De Mello, M., & Brandao, A. (1999). Measuring the market power of the Portuguese milk industry. *International Journal of the Economics of Business*,*6*(2), 209-222.

Dickey D. & Fuller W. A. (1979). Distribution of the estimates for autoregressive time series with a unit root. *Journal of the American Statistical Association*, *74*, 427-431.

Enders W. (2004). Applied Econometric Time Series. John Wiley and Son, Chichester.

EU, Milk Market Observatory, http://ec.europa.eu/agriculture/market-observatory/milk/index_en.htm

European Union (2013). Regulation (EU) No 1308/2013 of the European Parliament and of the Council of 17 December 2013 establishing a common organisation of the markets in agricultural products.

European Union (2013), Milk Package Implementation, DG Agriculture European Commission update 22 May 2015

European Parliament - Policy Department B based on data from European Commission (2015), 'Parliamentary Questions, Question for written answer to the Commission (E-000251/15 of 15.1.2015) on the Food Supply Chain' (and answer of 27.2.2015).

Fałkowski, Jan. "Price transmission and market power in a transition context: evidence from the Polish fluid milk sector." *Post-communist economies* 22.4 (2010): 513-529.

Gardner B. L. (1975) The farm-retail price spread in a competitive food industry, *American Journal of Agricultural Economics*, 76: 641-646.

Grau A.,, H., Hockman (2016), A new approach to identify market power along agri-food supply chains – the German dairy supply chain, Selected Paper prepared for presentation at the 2016 Agricultural & Applied Eco-nomics Association Annual Meeting, Boston, Massachusetts, July 31-August 2.

Hockmann, H., & Vöneki, É. (2009). Collusion in the Hungarian market for raw milk. *Outlook on agriculture*, 38(1), 39-45.

Johansen S. (1988), Statistical Analysis of Cointegration Vectors, Journal of Economic Dynam-ics and Control, 12 (2/3): 231-254.

Lloyd T., McCorriston S., Morgan W. & Rayner A. (2006a). Food scares, market power and price transmission: the UK BSE crisis. *European Review of Agricultural Economics, 33*, 119-147.

Lloyd T., McCorriston S., Morgan W., Rayner A. & Weldegebriel H. (2009) Buyer power in UK food retailing: a 'first-pass' test, *Journal of Agricultural & Food Industrial Organization*, 7:1.

Madau, F. A., Furesi, R., & Pulina, P. (2016). The existence of buyer power in the Italian fresh milk supply chain. *British Food Journal*, 118(1), 70-82.

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*: 143-159.

Nicholson, C., & Young, B. (2012). The relationship between supermarkets and suppliers: What are the implications for consumers. Consumers International, London, http://www. consumersinternational. org/media/1035301/consumer% 20detriment% 20briefing% 20paper% 20sept2012. pdf, acedido a, 10.

Perekhozhuk, O., Glauben, T., Teuber, R., & Grings, M. (2015). Regional-Level Analysis of Oligopsony Power in the Ukrainian Dairy Industry. Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie, 63(1), 43-76.

Pieri R., Pretolani R. (eds.) 2015. Il sistema agro-alimentare della Lombardia, Rapporto 2015. FrancoAngeli, Milano. ISBN 978-88917-2929-3

Rezitis, A. N., & Reziti, I. (2011). Threshold cointegration in the Greek milk market. *Journal of International Food & Agribusiness Marketing*, *23*(3), 231-246.

Salhofer, K., Tribl, C., & Sinabell, F. (2012). Market power in Austrian food retailing: the case of milk products. *Empirica*, *39*(1), 109-122.

Serra, T., & Goodwin, B. K. (2003). Price transmission and asymmetric adjustment in the Spanish dairy sector. *Applied economics*, 35(18), 1889-1899.