Detecting Market Power Along Food Supply Chains: Evidence From the Fluid Milk Sector in Italy

Cavicchioli D. [1]

[1] Università degli Studi di Milano, Department of Agricultural. Food and Environmental Economics an Policy, Milano, Italy

PAPER PREPARED FOR THE 116TH EAAE SEMINAR "Spatial Dynamics in Agri-food Systems: Implications for Sustainability and Consumer Welfare".

Parma (Italy)
October 27th -30th, 2010

Detecting Market Power Along Food Supply Chains: Evidence From the Fluid Milk Sector in Italy

Cavicchioli D. [1]

[1] Università degli Studi di Milano, Department of Agricultural. Food and Environmental Economics an Policy, Milano, Italy

Abstract— **This paper applies to Italian milk supply chain a theoretically grounded methodology able to detect for the presence of market power along the supply chain itself using easily available data. The model, developed by Lloyd *et al.* brings to estimate a quasi-reduced form equation in which consumer price is regressed against producer price, marketing costs and demand and supply shifters. When market power is exerted along the supply chain both of the shifters are statistically significant and signed accordingly to model prescriptions, while with perfect competition none of the shifters is significant.**

29 time series have been used in the analysis, within three different dataset covering partially or totally overlapped time periods. Variables having the same order of integration have been used within an Error Correction Model framework. Among all the variables having one cointegrating vector, only those with statistically significant parameters and signed according to model prescriptions have brought to conclusive results, detecting market power exertion along the Italian milk supply chain during two over the three periods examined. The present methodology may be useful in competition policy analysis as a preliminary "fast" test on food supply chain conduct. For this purpose theoretical model validation is however necessary using Monte Carlo simulations. In this line, further improvements relates to explicitly modeling food processing-retailing relationships in order to detect for market power on each segment of the supply chain.

Keywords— **market power, cointegration, supply chain.**

I. INTRODUCTION

Food industry and food retailing have witnessed a continuous process of concentration in many European countries over the last decades [1]; such phenomenon has raised concerns among public authorities and governments for potential anti-competitive behaviors along food supply chains. Such deeds are represented, among others, by oligopoly and oligopsony power, that may be exerted within agrifood systems at food processing and retailing stages to the detriment of farmers (supplier of raw agricultural inputs) and consumers [2][3]. For these reasons a vast amount of researches have been carried out by agricultural (and non-agricultural) economists to analyse anti-competitive behaviors in agrifood markets using different methodological approaches that can be roughly classified into two broad categories: Price Transmission Asymmetry (PTA) studies and New Empirical Industrial Organization (NEIO) models.

Following the suggestion provided by Digal [4] on market power analysis in food retailing, the aim of this paper is to identify and apply a methodology able to put together advantages of aforementioned approaches in order to test conclusively for the exertion of market power along the whole food supply chain using easily available data. What seem the more appropriate theoretical background for this purpose has been started by McCorriston [5] [6] and then developed and adapted by Lloyd [7] [8] [9] for empirical application to some food supply chains in UK. The present work applies such methodology to Italian fluid milk supply chain, in so doing a threefold contribution is provided with respect to the existing literature. Firstly, starting from the available approaches for analyzing imperfect competition in agrifood systems, the importance and usefulness of the employed methodology is explicitly highlighted. Secondly, to the best knowledge of the writer, this is the first empirical application of the McCorrsiton-Lloyd approach in another Western European country. Lastly, a slightly different interpretation of the inter-face between theoretical model and empirical application is adopted and consequent suggestions for testing its validity and to extend and improve its adoption are made.

The paper is organized as follows: chapter II provide a brief treatment of existing methodologies for the analysis of imperfect competition in food chains, putting in evidence their strength and weaknesses in order to justify the choice of the adopted theoretical model. Section III describe the McCorrsiton-Lloyd approach, representing the reference framework for the empirical analysis, while in chapter IV the dataset construction and time series stationarity tests are illustrated. Section V show the econometric strategy employed in the empirical analysis and consequent results. Section VI draws main conclusion and provides suggestions for future researches.

II. LITERATURE REVIEW

This chapter is meant to give a brief illustration of principal approaches adopted to examine the presence and the extent of imperfect competition at different levels of analysis. In continuity with previous studies [4], the main objective is to highlight advantages and disadvantages in each group of methodologies rather than giving an exhaustive review of the relevant literature. The end of the chapter summarizes and compare the focal features of each approach, pointing out and proposing the McCorriston-Lloyd model [5] [6] [7] as a unifying framework to examine market power along food chains. Subchapter A rely heavily on the survey of Meyer and von Cramon-Taubadel [10] while subchapter B takes as reference point the book of Perloff [12].

A. Price transmission asymmetry studies

Economic theory recognize in the price mechanism a key role for carrying signals among economic agents about relative scarcity of goods and factors in a certain market, in order to assure an efficient resources allocation. It is also of paramount importance that price signals were correctly transmitted among markets related horizontally (same good or factor in different places or countries) and vertically (a good in a market is a factor in the subsequent one). An incorrect or incomplete transmission of prices along vertically related markets may rise a double concern, both for academics and consumers. On one hand imperfect price transmission may represent an inconsistency for economic theory [10], as shown by the exhaustive empirical work carried out by Peltzman [11] while, on the other side, it is often considered as an evidence of anti-competitive behavior. For this reason, a remarkable amount of work have been done on this topic, with particular reference to vertically related markets such as food supply chains.

The main part of these studies try to identify asymmetries between input (farm) and output (consumer) prices movements along vertically related markets; In this context there is asymmetry when input price increase (decrease) is fully passed on to output price while a decline (rise) in the former is transmitted incompletely to the latter. Asymmetries can be classified according to the nature of incomplete transmission [10] (incompleteness in rapidity or size of price adjustment) and to the direction of asymmetry [11]. According to the second criterion, there is *positive* PTA when (assuming a causality from input to output prices) food price adjust incompletely to farm price increase (*positive* variation) than to their fall. In the reverse case, *negative* PTA takes place when the imperfect transmission from input to output price pertain only farm price decrease *(negative* variation). Considering the marketing margin [13] [14] as the difference between output and input prices, and taking into account that exogenous shocks may reverse the causality pricing so far assumed (flowing from farm to food price), a more general and appropriate definition would be that positive PTA allows for a complete transmission of margin-reducing price movements, while negative PTA happens when margin-stretching price signals are fully passed through the marketing chain [10].

What is more important, for competition policy purposes, is to establish unambiguously what causes ATP in vertical marketing chains; in spite of the vast amount of work done on the topic, different determinants are suggested by many authors, without a unique reference framework able to unify contrasting explanations [10] [15]. Market power exertion in one or more intermediate stages of food marketing chain is pointed out to be a cause of ATP [15] [16] [17] [18] [19] to the detriment of suppliers of raw agricultural product and food consumers. However the causal relationship between imperfect competition and ATP is not theoretically grounded [4] [10] [15] [20] [21]. According to Meyer [10] testing such kind of relationship is not easily feasible as it would require a meta-analysis using evidence from previous studies on different supply chains in different countries in order to catch the treatment effect of imperfect competition on price transmission. Anyway lack of homogeneity among econometric techniques employed in each empirical research would make data and results incomparable. The only empirical work that overcome such limitation is by Peltzmann [11] that analyzed price transmission in a wide range of vertically related markets using the same econometric methodology; however market power exertion in each vertical chain has been proxyed using a market concentration index (Hirschman-Herfindal) to gather cross-sectional evidence on the effect of imperfect competition on PTA. Such approach rely on the Structure-Conduct-Performance paradigm that has been criticized since it assumes a one way relationship from structure to performance not taking into account simultaneity bias and endogeneity of market structure [10] [22] [23] [24]. It seems, once again, that causation of APT by imperfect competition are not reliably testable. On the theoretical side, Gardner [13] developed a a farm-retail supply chain equilibrium displacement model, assuming perfect competition in intermediate stage and constant return to scale; its model indicates an higher effect of food demand compared to farm supply shifter on the marketing margin. Using numerical simulations based on the same model, Kinnukan and Forker [16] found that elasticity of price transmission differs according to the side of shift, suggesting that this could lead to PTA. This would mean that PTA can take place without imperfect competition in intermediate stages of supply chain, even if von Cramon [25] suggests that in this context PTA would only be apparent. Following the Gardner framework, McCorriston has shown that imperfect competition can reduce price transmission elasticity, but different conditions in elasticity of substitution [5] and return to scale [6] may either amplify or offset the market power effect. This implies that if processing and retailing markets are imperfectly competitive but show high elasticity of substitution and increasing return to scale such technology and cost conditions can compensate the market power effect yielding symmetric price transmission along the marketing chain. In this case the presence of PTA would not be a viable tool for detecting market power exertion along food chains.

In addition to aforesaid criticisms against the market power-PTA hypothesis, other causes of asymmetric adjustment of price movements are found in the literature, like menu-repricing costs [11] [26] [27] [28], [29] inventory costs [30] (especially at retail level), inflation [31] [32] and policy intervention on farm prices [16]. Even if part of these causes may lead to short run PTA, that would be harmless for social welfare, [10] rise the idea that imperfect competition cannot be the only determinant of PTA.

To summarize what reported so far, PTA approach presents the advantage of using easily available data on farm and consumer price movements to examine and get insights on the dynamics of the whole food supply chain. In so doing all the vertically related stages within the marketing (farming, processing, wholesaling and retailing) chain are analyzed. However, for a number of theoretical and empirical reasons, the presence of PTA cannot represent a conclusive evidence of market power exertion in one or more stages of the marketing chain being analyzed.

B. New Empirical Industrial Organization (NEIO) structural models

Such broad category of models was born as a consequence of the dissatisfaction with the Structure-Conduct Performance paradigm [24]. NEIO models are aimed to test for the presence or to estimate the extent of market power exertion at *market level*. To do that it is often adopt a conjectural variation approach, setting a simultaneous equation system (demand and profit function) to estimate the extent of oligopoly or oligopsony represented by a conduct parameter [12]. Since NEIO models are grounded on economic theory their findings of market power are more conclusive and reliable than those of PTA studies [4] [12] [20]; However they are demanding in term of data (qualitatively and quantitatively) and econometric sophistication while their estimation are focused and confined to a single market rather than to the entire food supply chain.

The two groups of models (PTA and NEIO) share in some way the same objective - test or estimate market power exertion, even if PTA are not conclusive- but operates at different levels, using different kinds of data, carrying out different findings; in order to make the detection on market power exertion in agrifood systems more effective for competition policies purposes, it would be desirable to integrate such approaches [4]. As previously said, such objective would require a methodology that unifies advantages and fix limitations of PTA and NEIO models in order to test conclusively for the exertion of market power along the whole food supply chain. The research for such kind of methodology starts from the first model describing explicitly the functioning of a vertical related supply chain (by Gardner [13]) even if assuming perfect competition in the intermediate stage. McCorriston adapted the model, allowing for market power exertion within the marketing chain, variable elasticity of substitution [5] and non constant return to scale [6] in order to derive the elasticity of price transmission under different conditions. Lloyd [7][8][9] built on such framework deriving (and applying) a theoretical model able to detect for market power exertion along the food chain. Such contribution are not unique, in fact also Holloway [33], following Wohlgenant [34] modify Gardner model relaxing the assumption of perfectly competitive behaviour to test the effect on the farm-retail price spread (an then to check for market power exertion). Both Lloyd and Holloway use conduct parameters to allow for imperfect competition along the food chain, but only the latter consider new firms entrance explicitly. However the approach proposed by Holloway is more demanding in term of data for the empirical application, as it require time series of prices and quantities (of raw agricultural products) , while the McCorriston-Lloyd model needs time series of prices (or price indexes) supplemented by other easily available data (proxyes of marketing costs, demand and supply shifters). For a matter of data requirement the McCorriston-Lloyd approach [7][8][9] is more appropriate to detect for the presence of market power along food supply chains in Italy.

III. THEORETICAL MODEL

The theoretical model [7][8][9] used for the analysis can be considered as a modification of the Gardner [13] equilibrium displacement model; while Gardner considered the effect of various shifters (farm input supply and food retail demand) on the farm-retail price spread, assuming perfectly competitive markets, the framework presented here [7][8][9] relaxes such assumption and allows for imperfect competition along the food chain introducing two conduct parameters (ranging from 0 to 1) of oligopoly and oligopsony power. In so doing, a reduced for equation is derived in order to test for the presence of (and not to measure the extent) imperfect competition along the food chain; the variables included in such equation differs according the values of conduct parameters. While Gardner models explicitly the behavior of food processing sector (even in a perfectly competitive fashion), this framework put emphasis on the retail stage of the food chain as a higli probable source of market power. This represent obviously a restriction and limitation for a more general application of the model, as it does not account explicitly for anticompetitive behavior of the processing stage (food industry).For a matter of simplicity, in this paper the intermediate stage of food chain will be considered as an aggregate of food processing and retailing sectors.

The modeled food marketing faces, on the consumer side, an inverse demand function:

$$x = D(P_x, N) \tag{1}$$

Where x is the quantity of food product sold, P_x is consumer price, and N is an exogenous food demand shifter. At the beginning of the chain, raw agricultural product is sold according to a supply function:

$$Pa = h(a, W) \tag{2}$$

Where Pa is farm-gate price of raw agricultural product, a is the quantity sold and W is an exogenous shifter of farm supply function. As previously mentioned, the intermediate food processing and retailing stage is seen as the most probable source of market power and then its behaviour is explicitly modelled using a profit function of the i-th firm:

$$\pi_i = P_x(x)x_i - P_a(a)a_i - C_i(x_i) \tag{3}$$

Where π_i, x_i and a_i are, respectively, profit, quantity of food sold and quantity of raw agricultural product bought by the i-th firm and C_i are costs not associated to agricultural product. Furthermore for this stage of food chain, constant return to scale and fixed proportion technology are assumed; the latter assumption is represented by:

$$x_i = \frac{a_i}{\rho} \tag{4}$$

Where ρ is an input-output coefficient that equals one. Such assumption impose a limitation to the empirical application of the model. The profit maximising firs order conditions for the i-th firm are:

$$P_x + x_i \frac{\partial P_x}{\partial x}\frac{\partial x}{\partial x_i} = \frac{\partial C_i}{\partial x_i} + \rho P_a + \rho a_i \frac{\partial P_a}{\partial a}\frac{\partial a}{\partial a_i} \tag{5}$$

In order to get an explicit solution from (5) under previous assumptions, agricultural supply (2) and food demand (1) function are made linear as follows:

$$x = D - bP_x + cN \tag{6}$$

$$Pa = h + gS \tag{7}$$

In which S is the food product supplied in a country, that is in turn composed by:

$$S = x_i + W \tag{8}$$

With the exogenous shifter W that appear in (2) is the level of exports. Using (6) – (8) the profit maximising conditions (5) can be rewrote allowing for oligopoly and oligopsony power exertion by the intermediate stage of the food chain:

$$P_x - \frac{\theta}{b} x = M + P_a + \mu g x \tag{9}$$

With θ and μ representing respectively oligopoly and oligopsony conduct parameters ranging from 0 (perfect competition) to 1 (monopoly – monopsony behaviour), the former represents the behaviour of the processing-retailing stage in the in the product (food) market, while the latter embodies its conduct in buying (raw agricultural) factor. When the food supply chain is perfectly competitive both of parameters equal 0, while departure from such benchmark are associated to increasing values, till 1. Assuming n firms operating in the processing-retailing stage, both of parameters can be identified by average conjectural elasticities. The oligopoly conduct parameter is represented as:

$$\theta = \frac{\sum_i \left(\frac{\partial x}{\partial x_i} \frac{x_i}{x} \right)}{n} \tag{10}$$

While the oligopsony conduct parameter is represented as:

$$\mu = \frac{\sum_i \left(\frac{\partial a}{\partial a_i} \frac{a_i}{a} \right)}{n} \tag{11}$$

Even if such parameters are widely used in the NEIO conjectural variations literature to estimate the extent of imperfect competition, in this context they are used only as instruments to signal collusive behaviour.

The variable M, that appears in equation (9), represents all the non-agricultural costs that determine the extent of marketing margin (P_x-P_a). M then contains both fix and variable components:

$$M = y + zE \tag{12}$$

Where y is a fix cost component and zE represents variable costs associated to non-agricultural inputs (Eg. Labour costs in processing and retailing). The set of previous equations (6) (7) (9) and (12) is employed to represent endogenous variables in explicit form:

$$x = \frac{(D - by - bh) + cN - bzE - bgW}{(1 + \theta) + bg(1 + \mu)} \tag{13}$$

$$P_x = \frac{D + [(1+\theta) + (bg(1+\mu)] \cdot [(1-b)(y+h+gW) + (1-bz)E + cN]}{(1+\theta) + bg(1+\mu)} \tag{14}$$

$$P_a = \frac{g[(k - by + cN - bzE] - g\{b - [(1+\theta) + bg(1+\mu)](h+W)\}}{(1+\theta) + bg(1+\mu)} \tag{15}$$

By subtracting equation (14) from equation (15) and rearranging it is possible to make explicit the marketing margin (Px-Pa):

$$P_x - P_a = \frac{D(\frac{\theta}{b} + g\mu) + (1+bg)(y+zE) + (\frac{\theta}{b} + g\mu)cN - (\theta + bg\mu)(h+gW)}{(1+\theta) + bg(1+\mu)} \tag{16}$$

Note that if the intermediate stage of supply chain does not exert neither oligopolistic (θ=0) nor oligopsonistic power (μ=0), equation (16) collapse in a simpler form representing marketing margin under perfect competition:

$$P_x - P_a = y + zE = M \tag{17}$$

According to the findings of the model, two important considerations can be made; first, under perfect competition along the food chain, price spread (P_x-P_a) is represented only by marketing costs (*M*) and, second, it does not depend on shifts in farm supply (*W*) and consumer demand (*N*) functions. However if oligopoly *or* oligopsony power is exerted along the food chain (i.e. θ *or* μ differ from zero) *both* of the exogenous shifters (*W* and *N*) affect the magnitude of price spread. In particular, under anticompetitive behavior, a shift in consumer demand (*N*) increase the margin while a shift in farm supply (*W*) reduce it. Note that if market power is exerted within the food chain, both of the shifters affect the margin *simultaneously*. The effect of exogenous shifter on the marketing margin is then "activated" by oligopoly or oligopsony exertion by intermediate stage of the chain; imperfect competition in one of the two related markets (agricultural input supply and food demand) to make the shifter to affect the spread.

To make a bridge from theoretical model (16)and its empirical implementation, it is used an unrestricted equation (comprising exogenous variables *W* and *N*) to test the (null) hypothesis of perfect competition against the alternative one of market power exertion:

$$P_x = \beta_0 + \beta_1 P_a + y\beta_2 M + \beta_3 N + \beta_4 W \qquad (18)$$

Under perfect competition along the food chain ($\theta = \mu$=0) none of the shifters affect the margin and then associated parameters are expected to be not significantly different to zero. Perfect competition, then, can be tested as follows:

$$H_0 : \beta_3 = \beta_4 = 0 \qquad (19)$$

Note that while accepting the null we can conclude that the supply chain is perfectly competitive, rejecting it is not a sufficient condition to deduce market power exertion (even if in conventional hypothesis testing this would be the case). To reach such conclusion some additional conditions are required; firstly, *both of the parameters* have to be significantly different from zero ($\beta_3 \neq 0; \beta_4 \neq 0$) and, secondly, the parameter of exogenous shifter N has to be positive ($\beta_3 > 0$) while the parameter of W has to be negative ($\beta_4 < 0$). The alternative hypothesis to be accepted in order to conclude that market power is exerted along the food chain is then the following:

$$H_1 : \beta_3 \succ 0; \beta_4 \prec 0 \qquad (20)$$

In the writer interpretation (that differs slightly from the version of Authors that developed and implemented the model), only empirical results falling under H_0 (perfect competition)or H_1(oligopoly and/or oligopsony power) can be considered plausible and conclusive. Alternative hypotheses (only one of the shifter significant and/or not signed according model prescriptions) would yield ambiguous and inconclusive results.

IV. DATASET AND TIME SERIES TESTS

The supply chain that has been detected for market power exertion is the Italian fluid milk sector; such choice has been partly determined by model restriction (input-output coefficient equal to one) and data availability. The first subchapter describes the dataset, while the second one treat test carried out on each time series.

A. Dataset description

To apply the theoretical model 29 time series have been employed, within three different *dataset* (called respectively A, B and AB) covering partially or totally overlapped time periods (1996.1 – 2003.10 for database A; 2000.1 – 2008.10 for database B ; 1996.1 – 2008.10 for database AB) using monthly data from publicly available databases: Istat, Conistat, Coeweb and Ismea. All the data are in index form (1995=100, 2000 =100) and refer to retail milk price, producer milk price (even proxyed by producer animal price and producer import milk price indexes), index of wages in dairy processing (as a proxy of marketing costs), retail price indexes all good, food, food and alcoholic beverages (as a proxy for demand shifter) and farm input price index (as a proxy for farm supply shifter). Variables' name, abbreviation, source and manipulations are reported in Table 1.

Some concerns may be raised for using producer and retail price indexes from different statistical sources (Istat and Ismea respectively) or in approximating producer price by index of a broader category (animal products). Unfortunately, available data do not allow for having producers and retail price indexes homogeneous both for statistical source and for level of aggregation; In order to exploit all the available statistical information, where possible, the original time series have been lengthened by re-basing the missing period of the same series having another basis. Such operation has been performed extending time series having both of the base indexes (1995=100 and 200=100) using one or more overlapping period between two series of the same variable (For instance producer milk price based on 1995 and 2000). In particular it has been chosen to maximize the number of re-based series, where possible, in order to increase the probability of finding a combination of variables fitting both model requirement (see end of previous chapter) and the restrictions imposed by the econometric estimation strategy (see next chapter about Error Correction Model). Obviously the extensive use of rebased time series allows, on one hand, to examine a longer period, but on the other side may rise concerns about the impact of data manipulations on the reliability of empirical results. In other words, re-based time series contain non-genuine information (at least in their re-based parts). To balance between such points it has been followed the strategy of separating the variables in two "genuine" datasets (A and B) containing mainly not re-based variables, confining re-based time series in another (longer) dataset (AB). In this line, re-based variables are denoted by the last letter that indicates their base (A for 1995 and B for 2000), preceded by a number indicating the overlapping period used for the re-basement (from 1 to 5), while "genuine" (not-rebased time series) are denoted only by the letter that identifies their basis. Demand and supply shifter variables are an exception to aforementioned rules. Dataset A contains the variables: RM1, PMA, PAPA, IPMA, MA, MB, MA1 DS1, DS2, DS3, SS1,SS2 and SS3. Dataset B contains the variables: RM1, PMB, PAPB, IPMB, MA, MB, DS1, DS2, DS3, SS1, SS2, SS4. Dataset AB contains the variables: RM1, PM1A, PM2A, PM3A, PM4A, PM5A, PM1B, PM2B, PM3B, PM4B, PM5B, PAP1A, PAP1B, IPMA, IPMB, MB, MA1, DS1,DS2,DS3, SS1 and SS2.

Table 1 variable used and data sources for the Italian milk supply chain

Variable	Abbrev	Data description	Source	Base	Period	Elaborations
Retail Milk price	RM1	Consumer Price Index: milk	Istat	1995	96.1 - 09.3	genuine data
Produc. Milk Price	PMA	Producer Price Index: cow milk	Ismea	1995	95.1 - 03.10	genuine data
Produc. Milk Price	PMB	Producer Price Index: cow milk	Ismea	2000	00.1 - 09.2	genuine data
Produc. Milk Price	PM1A	Producer Price Index: cow milk - rebased	Ismea	1995	95.1 - 09.2	rebas 00.1-03.10
Produc. Milk Price	PM2A	Producer Price Index: cow milk - rebased	Ismea	1995	95.1 - 09.2	rebas 00.1-00.12
Produc. Milk Price	PM3A	Producer Price Index: cow milk - rebased	Ismea	1995	95.1 - 09.2	rebas 01.1-01.12
Produc. Milk Price	PM4A	Producer Price Index: cow milk - rebased	Ismea	1995	95.1 - 09.2	rebas 02.1-02.12
Produc. Milk Price	PM5A	Producer Price Index: cow milk - rebased	Ismea	1995	95.1 - 09.2	rebas 03.1- 03.10
Produc. Milk Price	PM1B	Producer Price Index: cow milk - rebased	Ismea	2000	95.1 - 09.2	rebas 00.1-03.10
Produc. Milk Price	PM2B	Producer Price Index: cow milk - rebased	Ismea	2000	95.1 - 09.2	rebas 00.1-00.12
Produc. Milk Price	PM3B	Producer Price Index: cow milk - rebased	Ismea	2000	95.1 - 09.2	rebas 01.1-01.12
Produc. Milk Price	PM4B	Producer Price Index: cow milk - rebased	Ismea	2000	95.1 - 09.2	rebas 02.1-02.12
Produc. Milk Price	PM5B	Producer Price Index: cow milk - rebased	Ismea	2000	95.1 - 09.2	rebas 03.1-03.10
Produc. Anim Price	PAPA	Producer price Index: animal products	Istat	1995	95.1-04.12	genuine data
Produc. Anim Price	PAP1A	Produc. Pric. Ind.: animal products - rebas	Istat	1995	95.1-08.12	rebas 04.1-04.12
Produc. Anim Price	PAPB	Producer price Index - animal products	Istat	2000	00.1-08.12	genuine data
Produc. Anim Price	PAP1B	Produc. price Index: anim products, rebas	Istat	2000	95.1-08.12	rebas 04.1-04.12
Import Produc. Milk	IPMA	Index of milk import price from EU 25	Coeweb	1995	93.1 - 09.3	Indexed price €/kg
Import Produc. Milk	IPMB	Index of milk import price from EU 25	Coeweb	2000	93.1 - 09.3	Indexed price €/kg
Marketing Shifter	MA	Index of wages, dairy processing sector	Conistat	1995	96.1 - 02.12	genuine data
Marketing Shifter	MB	Index of wages, dairy processing sector	Conistat	2000	96.1 - 08.12	genuine data
Marketing Shifter	MA1	Index of wages, dairy processing sector	Conistat	1995	96.1 - 08.12	rebas 98.1-98.12
Demand Shifter	DS1	Consumer Price Index: general index	Istat	1995	96.1 - 09.03	genuine data
Demand Shifter	DS2	Consumer Price Ind: general index-no tobacco	Istat	1995	96.1 - 09.3	genuine data
Demand Shifter	DS3	Consumer Price Index: food, wines and spirits	Istat	1995	96.1 - 09.3	genuine data
Supply Shifter	SS1	producer price index for dairy farms	Ismea	1998	94.1 - 08.10	Correc techn progr
Supply Shifter	SS2	producer price index for dairy farms	Ismea	1995	94.1 - 08.10	Correc techn progr
Supply Shifter	SS3	producer price index for dairy farms	Ismea	1995	94.1 - 06.1	genuine data
Supply Shifter	SS4	producer price index for dairy farms	Ismea	2000	00.1 - 08.10	genuine data

B. Time series stationarity tests

The use of time series for the empirical analysis requires to perform some preliminary tests about their properties; equation (18), cannot be estimated using OLS unless all the time series employed enjoy a property called stationarity [15] [35] [36] that is, having constant statistical properties (mean, variance and covariance). According to Granger [37], running an OLS with non-stationary variables leads to unreliable estimates, resulting in spurious regression. A stationary variable, is said to be integrated of order zero, I(0); A nonstationary variable contains one or more unit roots;

when a nonstationary variable became stationary after differencing (subtracting by each value the previous one is said to contain a unit root, or to be integrated of order one, I(1). So, the test for market power exertion using OLS require that all the time series used are stationary in level, if such condition would not satisfied, other estimation procedures can be followed, provided that all the variables employed are I(1). Following such kind of requirements, all the time series in each dataset have been tested for stationarity in level and in firs difference to find their order of integration. Econometric package EViews 6 has been used for stationarity tests and for subsequent empirical estimation. Stationarity has been tested using Augmented Dickey-Fuller test, ADF [38] and Phillips-Perron test, PP[39] that takes nonstationarity (presence of a unit root) as a null hypothesis against the alternative one of stationarity. In order to complete the testing framework, variables in level and first difference have also been tested using Kwiatkowski-Phillips-Schmidt-Shin test, KPSS, [40] that assumes stationarity as a null against nonstationarity as alternative hypothesis. In each test has been assumed an underlying data generating process of the variable having, respectively, intercept and tend and intercept only. Judgments about order of integration of each variable have been drawn comparing t statistics (for ADF), adjusted t statistics (for PP) and Langrange Multiplier statistics (for KPSS) with critical values for each distribution (at 1%, 5% and 10%). For ADF an PP tests, estimation output provided also probabilities of unit roots. As results can differ among tests and can be sensible to functional form specification (intercept with or without trend) it has been chosen to consider stationary in level those variable having low probability ($p<5\%$) of accepting the null hypothesis in at least one specification of ADF and PP tests and, at the same time, a probability bigger than 5% of accepting the null in both of the KPSS test specifications. Stationarity tests have been performed separately on the 3 datasets, as results could change according time series length. According to the stated criteria, all the variable in dataset A are nonstationary in level (except for Import milk price IPMA) and stationary in first difference, dataset B has all the variables I(1) in level and I(0) in first difference, while dataset AB shows all variables with a unit root in level (except for IPMA and IPMB) and stationary in first difference. In complex, with the exception of import price index variables in datasets A and AB, all the time series result to be I(1) in level and I(0) in first difference. This means that OLS estimation is not a viable tool to perform the market power test, however as almost all variables have the same order of integration, I(1), another econometric strategy can be followed to detect for imperfect competition along the fluid milk chain.

V. ECONOMETRIC ANALISIS AND RESULTS

A. Econometric analysis

Giving the nonstationarity of time series, estimation strategies other than simple linear regression have to be used in order to avoid spurious results. According to the Engle-Granger representation theorem [41], if a set of nonstationary variables share the same order of integration, then can exist a variable, made by their difference or linear combination, that is stationary. If such condition holds, then the variables are said to be cointegrated and then they share a long run relationship, while difference among them are short term errors. When some variables are cointegrated, an Error Correction Model (ECM) can be estimated, establishing a relation between changes in one variable of the set (for our purposes the dependent variable) with respect to long run equilibrium with the other variables in the set. The ECM splits such changes (errors) in a short run component, that causes departure from long run equilibrium, and a long run component, called Error Correction Term (ECT) that brings the system back to the equilibrium. The ECM allows, then, to estimate separately long run and short run relationships among nonstationary cointegrated variables, providing that such relationships are not spurious and statistically significant. The cointegrating vector is the set of parameters estimates associated to long run component (ECT).

To estimate consistently equation (18) in the light of aforesaid econometric theory, for each dataset all the variables have been combined, looking for those combination having one and only one cointegrating vector according to Johansen cointegration test. EViews provides automatic selection of lags for this test, under five different assumptions about functional form of data and cointegration equation (CE):

1. No trend in data, no intercept and trend in CE
2. No trend in data, intercept and no trend in CE
3. Linear trend in data, no intercept and trend in CE
4. Linear trend in data, intercept and trend in CE
5. Quadratic trend in data, intercept and trend in CE

Those combinations of variables showing one and only one cointegrating vector, under one or more previously mentioned assumptions, have been tested for estimating an ECM. In so doing, all the necessary restrictions (number of lags for each variable and functional form) have been adopted for each selected combination of variables in order to assure one cointegrating vector only.

Of course such combinations of variables do satisfy only econometric conditions for consistent estimation of long run relationships among variable; in addition to this also theoretical requirements about significance and sign of parameters estimates have to be fulfilled.

B. Results

Before showing the econometric results of ECM estimation, it is useful recall the necessary conditions that parameter estimates of each variable should satisfy, according to economic theory and model prescriptions, in order to test conclusively about competitive behavior along the food chain:

- According to economic theory producer price and marketing costs parameters should be *always positive and significantly different from zero* ($\beta_1 > 0; \beta_2 > 0$);
- To infer perfect competition along the food chain, supply and demand shifter parameters have to be *simultaneously* not significantly different from zero ($\beta_3 = \beta_4 = 0$)
- To infer market power exertion along the food chain, demand shifter parameter has to be positive and significantly different from zero while, *simultaneously*, supply shifter parameter has to be negative and significantly different from zero ($\beta_3 > 0; \beta_4 < 0$).

Such conditions have to be fulfilled in order to get unambiguous conclusions in performing market power test, and will be then compared with sign and significance of the explanatory variables parameters estimates in the cointegrating vector. Such parameters describe the long run equilibrium relationships between dependent variable (retail milk price) and each explanatory variable in the theoretical model; According to econometric theory, the Error Correction Model used provides consistent and non spurious estimations of such relationships. Among all the combination of I(1) variables showing one cointegrating vector, will be presented, where possible, those having parameters statistically significant and signed according to model prescriptions, or at least those nearest to such requirements.

As the interest of the empirical estimation is mainly on sign and significance of parameters estimates (and not on their magnitude) t statistics only will be shown in the tables. For an algebraic matter, t values of explanatory variables have been multiplied by -1 to transform the cointegrating vector in equation (18), normalizing with respect to the dependent variable. In the following tables functional form of data and cointegration equation chosen for each combination of variables have been omitted, so different t values for the same combination are due to different functional forms.

Table 2 reports estimation results for dataset A (1996.1-2003.10) in which all the combinations presented are consistent with economic theory, indicating that consumer price is linked by a significantly positive relation to producer price and marketing costs (any other result would be meaningless, in the long run). Food demand shifter parameter is not significantly different from zero in the first four combinations, while is significantly negative in the last one, failing to satisfy model prescriptions. Farm supply shifter is always negative and significant, suggesting market power exertion during the period considered, however this is not sufficient to reach such conclusion as the same coherence is simultaneously needed for both of the shifters parameters.

Table 2 Dataset A, ECM cointegrating vectors parameters [t values] normalized respect to retail price (91 observations, 2 lags in variables). Different values for the same combination of variables depends on different assumptions

Producer price	Marketing costs	Demand shifters		Supply shifters	
PMA	MB	DS		SS2	SS3
Expected signs with market power exertion					
> 0	**> 0**	**> 0**		**< 0**	
Expected signs with perfect competition					
> 0	**> 0**	not signif. ≠0		not signif. ≠0	
[4,915]	[4,524]	DS2	[0,811]	[-3,55]	-
[5,166]	[4,655]	DS1	[0,268]	[-3,511]	-
[4,476]	[4,530]	DS2	[0,108]	[-3,411]	-
[5,03]	[4,69]	DS1	[0,060]	[-3,494]	-
[4,039]	[3,697]	DS3	[-2,27]	-	[-3,31]

t distribution critical values with 87 degree of freedom

1% 2,371 5% 1,663 10% 1,2915

Given the available data, for the period covered by dataset A, the test fails to detect any form of imperfect competition along the fluid milk supply chain. Note that this does not indicate prefect competition of the marketing chain in the same period, as relative requirements (not significant effects of both of the shifters on consumer price) are not achieved. In other words empirical results does not provide any clear evidence about the conduct (perfect or imperfect competition) in the food chain analyzed.

Table 3 shows parameter estimates t values for dataset B (2000.1 – 2008.10). It is worth remembering that apparently identical combination of variables differs for assumptions on data and cointegrating vector functional form (unreported in the table). In the first four combinations producer price is proxyed by import milk price; in such cases all the parameters are highly significant (at 1%) and signed as suggested by economic theory and theoretical model, detecting market power exertion along the supply chain during the examined period. Similar indications came from the last five combinations of variables using Ismea producer milk price index (PMA) and Istat producer animal price index (PAPB) as proxy. In the regression including PMA all parameters are significant at 1% except for MA1 (marketing costs) with 2,5% of significance.

Regressions with PAPB show still significant and "well signed" parameters, even if marketing costs significance falls at 5%.

Table 3 Dataset B, ECM cointegrating vectors parameters [t values] normalized respect to retail price (101 observations, 4 lags in variables). Different values for the same combination of variables depends on different assumptions

	Producer price	Marketing costs		Demand shifters	Supply shifters	
		MA1	MB	DS3	SS2	SS4
Expected signs with market power exertion						
	> 0	**> 0**		**> 0**	**< 0**	
Expected signs with perfect competition						
	> 0	**> 0**		not sign. ≠0	non signif. ≠0	
IPMB	[7,540]	[4,39]		[5,422]	[-6,90]	
IPMB	[7,514]		[4,35]	[5,342]	[-6,88]	
IPMB	[7,540]	[3,45]		[5,644]	[-7,11]	
IPMB	[7,497]		[3,43]	[5,612]	[-7,09]	
PMB	[3,423]	[2,14]		[14,657]		[-5,64]
PAPB	[3,128]		[1,92]	[11,671]		[-5,81]
PAPB	[3,081]	[1,91]		[11,701]		[-5,77]
PAPB	[2,997]		[1,88]	[11,457]		[-5,70]
PAPB	[2,947]	[1,86]		[11,481]		[-5,66]

t distribution critical values with 97 degree of freedom

1% 2,366 5% 1,661 10% 1,2905

In complex four over nine presented combination indicate with no doubt (1% significance) that over the period 2000.1 – 2008.10 the Italian fluid milk supply chain has been imperfectly competitive in one or more of their vertically related markets. The theoretical model adopted it is however unable to identify at what level, on which side (demand or supply) and to what extent market power have been exerted.

Table 4 reports cointegrating vectors t values obtained from dataset AB (1996.1 – 2008.10) that has been built up using longer time series obtained by re-basement of original ones. The first unexpected result is shown in the first four rows of the table, having, as a proxy of producer price, import price index for milk variables (IPMA and IPMB). ECM estimation using such variables yield the best results in term of sign and significance of long run parameter estimates, indicating then market power exertion.

Table 4 Dataset AB ECM cointegrating vectors parameters [t values] normalized respect to retail price (149 observations, 4 lags in variables). Different values for the same combination of variables depends on different assumptions

Producer price	marketing costs	Demand shifter	Supply shifter
	MB*	DS3	SS2*
Expected signs with market power exertion			
> 0	**> 0**	**> 0**	**< 0**
Expected signs with perfect competition			
> 0	**> 0**	not signif. ≠0	not signif. ≠0
IPMA	[7,474]	[5,477]	[5,897]	[-6,670]
IPMA	[7,440]	[5,399]	[5,706]	[-6,589]
IPMB	[7,474]	[5,477]	[5,897]	[-6,676]
IPMB	[7,439]	[5,399]	[5,706]	[-6,589]
PAP1A	[4,636]	[3,708]	[8,301]	[-4,878]
PAP1B	[4,313]	[3,635]	[7,958]	[-4,553]
PM3A	[1,597]	[1,149]	[15,56]	[-1,889]
PM4A	[1,464]	[0,934]	[15,47]	[-1,750]
PM2A	[1,435]	[0,890]	[15,45]	[-1,720]
PM5A	[1,340]	[0,743]	[15,38]	[-1,620]

t distribution critical values, more than 120 df

1%	2,326	5%	1,645
2,5%	1,960	10%	1,282

* MA1 and SS1 show the same t values

However, such variables had to be excluded from the set of time series used for empirical estimation, since they resulted stationary in level and in first difference, I(0), according to three different tests (ADF, PP and KPSS). Following relevant econometric theory, a cointegrating relationship can be searched only among series sharing the same order of integration and then results obtained using stationary variables may be spurious. Note that the same shorter and not-rebased variables employed in dataset A and B are I(1) and it is then plausible to infer some kind of modification in time series patterns induced by re-basement procedures. In any case, ECM estimations containing IPMA and IPMB are probably spurious and conclusions on market power detection based on them cannot be consider reliable.

Among the other I(1) variables, however, there are combinations providing conclusive results, according to model prescriptions. The two cointegrating vectors having PAP1A and PAP1B (index of animal product prices) as a proxy of producer price, yield parameters estimates fulfilling necessary conditions for presence of imperfect competition along the food chain. All the other combinations, having PM2A, PM3A PM4A PM5A for producer price, have marketing costs parameters not significantly different from zero. As such result is not plausible on the economic theory ground, no clear conclusions can be drawn from those combinations of variables. In complex only two cointegrating vectors have parameters estimates consistent, in sign and significance, with the evidence of anticompetitive behaviour at some stages of fluid milk supply chain during the period 1996.1 – 2008.10.

To sum up, empirical analysis detected market power exertion along the Italian fluid milk supply chain during two over the three periods examined (2000.1 – 2008.10 and 1996.1 – 2008.10). The strategy of using more time series as proxyes of each variable has been necessary to assure enough combination of variables having the same order of integration, one cointegrating vector and parameters estimates with sign and significance in line with theoretical model prescription.

VI. CONCLUDING COMMENTS

This paper has tried to give an empirical contribution to competition analysis along food supply chains, applying a theoretical framework that yields conclusive results on market power exertion using easily available data. For this reason, such approach can be used as a "first pass" test [9] to check for the presence of imperfect competition along the supply chain, before applying more complex and data requiring methods to measure the extent of market power in each vertically related market. Such combination and integration of methods can represent a useful tool for improving competition policy analysis efficiency [4]. In this context, empirical and theoretical issues emerged during the processing of the present work may provide useful hints and suggestions for improvement and future research.

The imperfect competition test pointed out the exercise of market power at some stage of the Italian fluid milk supply chain over the period 1996-2008, while no conclusive indications can be drawn for the period 1996-2003. Note that the absence of clear evidence of market power does not imply perfect competition, as in this case both demand and supply shifters should not affect the retail price.

A crucial point pertain the validation of the theoretical model employed in the analysis, indeed all the possible empirical outcomes (presence/absence of market power or inconclusive results) cannot confute or confirm the validity of underlying theoretical framework because of the lack of counterfactual evidence. There are two ways to get such evidence: analyzing each stage (market) of the supply chain using structural models, or setting up a Monte Carlo simulation experiments. The first way would be highly data demanding and counterfactual evidence would be confined to the supply chain analyzed, while the second one would give more general results (even if it is quite complex to set up) as it allows to simulate different kind of vertically related markets on which perform the market power test. The latter approach is the same used to validate some NEIO models [42] [43]. Once tested in its validity, the framework may be further improved by modelling explicitly and separately processing and retailing stages and, if possible, their complex relationships. Such model refinement would allow to look for the source of market power along two separate segments of the supply chain: from farm to food processing and from food processing to food retailing.

REFERENCES

1. Dobson P W, Waterson M, Davies S. (2003) The patterns and implications of increasing concentration in European food retailing. J Agr Econ 54:111–125
2. Dobson P W, Clarke R, Davies S et al. (2001) Retail power and its impact on competition in the food retail distribution sector of the European Union. J Ind Compet Trade 1:247-281
3. Dobson P W, Waterson M. (1999) Retail power : recent developments and policy implications. Econ Policy 28 :133-164
4. Digal L N, Ahmadi-Esfahani F Z (2002) Market power analysis in the food industry: a survey of methods. Aust J Agr Resour Ec. 46:4 559-584.
5. McCorriston S, Morgan C W, Rayner A J (1998) Processing technology, market power and price transmission. J Agr Econ 49:185-201.
6. McCorriston S, Morgan C W, Rayner A J (2001). Price transmission: the interaction between market power and returns to scale. Eur Rev Agric Econ 28:143-159
7. Lloyd T, McCorriston S, Morgan W et al. (2006). Food scares, market power and price transmission: the UK BSE crisis. Eur Rev Agric Econ 33: 119-147.
8. Lloyd T, McCorriston S, Morgan W et al. (2006). Market power in UK food retailing: theory and evidence from seven product groups, contrib paper prepared for the 24th IAAE Conference, Gold Coast, Australia 2006.
9. Lloyd T, McCorriston S, Morgan W et al. (2009) Buyer power in UK food retailing: a 'first-pass' test. J Agr Food Ind Organ Vol 7, Article 5.
10. Meyer J, von Cramon-Taubadel S (2004) Asymmetric price transmission: a survey. J Agr Econ. 55: 581-611
11. Peltzman S (2000). Prices rise faster than they fall. J Polit Econ 108: 466-502
12. Perloff J M, Karp L S, Golan A (2007) Estimating market power and strategies. Cambridge University Press, New York.
13. Gardner B L (1975) The farm-retail price spread in a competitive food industry, Am J Agr Econ, 76: 641-646.
14. Wohlgenant, M K (2001). Marketing margins: empirical analysis. In Gardner B L and Rausser G C (eds), Handbook of Agricultural Economics. Amsterdam: North-Holland.
15. Vavra P, Goodwin B K (2005) Analysis of price transmission along the food chain. OECD Food Agriculture and Fisheries Working Papers N°. 3, OECD Publishing, DOI 10.1787/752335872456
16. Kinnucan H W, Forker O D (1987). Asymmetry in farm-retail price transmission for major dairy products. Am J Agr Econ 69: 307-328.
17. Bernard J C, Schertz Willet L (1996). Asymmetric price relationships in the U.S. broiler industry. J Agric Appl Econ 28(2):279-289
18. Miller D J, Hayenga, M L (2001) Price cycles and asymmetric price transmission in the U.S. pork market. Am J Agr Econ 83:551-562
19. Ben-Kaabia M, Gil J M (2007) Asymmetric price transmission in the Spanish lamb sector. Eur Rev Agric Econ 34: 53-80
20. Hallam D, Rapsomanikis G (2006). Transmission of price signals and the distribution of revenues along the commodity supply chains: review and applications. Food and Agriculture Organization of the United Nations, Commodites and Trade Division.
21. Awokuse T O, Wang X. (2009) Threshold effects and asymmetric price adjustmentin U.S. dairy markets. Can J Agr Econ 57:269-286
22. Clarke R, Davies S W (1982) Market structure and price-cost margins. Economica 49: 277-287
23. Schmalensee R (1989). Inter-industry studies of structure and performance, in Schmalensee R, Willig R, Handbook of Industrial Organization 952-1009. Amsterdam.

24. Sheldon I, Sperling R (2003). Estimating the extent of imperfect competition in the food industry: what have we learned? J Agr Econ 54:1 89-109.
25. von Cramon-Taubadel S (1998) Estimating asymmetric price transmission with error correction representation: an application to German pork market. Eur Rev Agric Econ. 25: 1-18
26. Levy D, Bergen M, Dutta S, Venable R (1997) The magnitude of menu costs: direct evidence from large u.s. supermarket chains., Q J ECON 112(3):791-825.
27. Dutta S, Bergen M, Levy D, Venable R (1999) Menu costs, posted prices, and multiproduct retailers. J Money Credit Bank 31(4):683-703.
28. Bailey D, Brorsen B W (1989) Price asymmetry in spatial fed cattle markets, Western J Agr Econ 14:246-252
29. Ward R W (1982) Asymmetry in retail, wholesale and shipping point pricing for fresh vegetables, Am J Agr Econ 62:205-212
30. Blinder A.S. (1982). Inventories and sticky prices: more on the microfoundation of macroeconomics, Am Econ Rev 72(3):334-348
31. Ball L, Mankiw N G (1994) Asymmetric price adjustment and economic fluctuations, Econ J 104:247-261
32. Buckle R A, Carlson J A (2000) Inflation and asymmetric Price Adjustment. Rev Econ Stat 82(1):157-160
33. Holloway G J (1991) The farm-retail price spread in an imperfectly competitive food industry, Am J Agr Econ, 73: 979-99.
34. Wohlgenant, M K (1989) Demand for farm output in a complete system of demand equations. Am J Agr Econ 72: 241-52
35. Harris R, Sollis R (2003) Applied time series modelling and forecasting. John Wiley and Son, Chichester.
36. Enders W. (2004). Applied Econometric Time Series. John Wiley and Son, Chichester.
37. Granger C W J, Newbold P (1974). Spurious regressions in econometrics. J Econometrics 2:111-120.
38. Dickey D, Fuller W A (1979) Distribution of the estimates for autoregressive time series with a unit root. J Am Stat Assoc, 74: 427-431.
39. Phillips P C B, Perron P (1988) Testing for a unit root in time series regression. Biometrica 75:335-446
40. Kwiatkowski D, Phillips P C B, Schmidt P, Shin Y (1992) Testing the null of stationarity against the alternative of unit root. J Econometrics54 :159-178.
41. Engle R F, Granger C W J (1987) Co-integration and error correction: representation, estimation and testing. Econometrica 55: 251–276.
42. Hyde C E Perloff J M (1994) Can monopsony power be estimated? Am J Agr Econ 6276:1151-5
43. Hyde C E Perloff J M (1995) Can market power be estimated?, Rev Ind Organ, 10(4): 465- 85