ESTIMATING MARKET POWER BY RETAILERS IN THE ITALIAN PARMIGIANO REGGIANO AND GRANA PADANO CHEESE MARKET

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Abstract

In this paper, we evaluate the role of market power by retailers within the supply chain of Parmigiano Reggiano and Grana Padano, the two most famous Italian quality cheeses. Market power is analysed in the context of an imperfect competition model of the supply chain, in which retailers are allowed to exercise market power both downstream and upstream. We jointly estimate market power parameters together with supply and demand elasticities, by means of a structural system of demand, supply and price transmission equations, estimated using the Generalised Method of Moments. We find clear evidences of downstream market power by retailers (toward final consumers), and no evidences of upstream market power (toward processors/ripeners). These results may be justified by the structure of the supply chain and by the peculiar characteristics of the two cheeses.

Keywords: *Market power; Imperfect competition; PDO cheese (J.E.L. Q13)*

1. Introduction

The supply chain of the “grana” cheese sector is extremely relevant for the Italian dairy system: about one third of Italian milk production is processed to obtain grana, mainly Grana Padano (GP) and Parmigiano Reggiano (PR), two PDO (Protected Denomination of Origin) cheeses. Their supply chains have very peculiar characteristics: a large number of farms in the production area produce for the two cheeses; the production process takes a long time, due to a long aging phase; after the minimum aging period, the ripening phase is mainly conducted by specialised ripening firms, not by milk dairies. The two products have a high degree of penetration in households’ consumption, since more than 90% of Italian households regularly consume one of the two cheeses. Prices show a strong cyclical pattern through the years (6/8-year cycle), and researchers do not agree on possible explanations; wholesale prices seem to drive the dynamics of retail prices (a sort of price-leadership or causal relationship), although the role of market power through the chain has not been analysed yet and therefore such findings are still questionable.

For the above reasons, PR and GP are very peculiar PDO products. Given their widespread consumption, they are among the very few PDO products that can be considered mass market goods rather than niche goods. As most generic food products, they reach final consumers mainly through super and hypermarket chains, rather than through specialised channels, and, given their incidence on food retail sales, they are a key element of the assortment of large retailers. For these reasons, it is interesting to explore the retailers' behaviour with respect to these products, especially in terms of their ability to exercise market power both on the wholesale market, toward processors/ripeners, and on the final market, toward consumers. For example, one of the key question is whether the presence of the PDO collective brand, together with the fact that all retail chains operating in Italy are forced to have PR and GP on their shelves, may influence retailer buying strategies. Moreover, on the consumer side, it is interesting to analyse whether demand characteristics allow retailers to implement marketing policies that increase their margins, for example through a limited transmission of the wholesale price cyclical fluctuations on the final market.

In this context, the present paper aims to evaluate the role of market power within the supply chain of PR and GP, trying to fill a gap in applied research. In the supply chain, retailers have been progressively playing a major role. The Italian food retail sector has undergone a dramatic change in the last 10 years: the share of the first five buying groups of retailers was 26% in 1996 and it is now over 70%, while modern retailers cover about 60% of total food sales. Retailers benefit from high margins in the PR and GP chains: statistical data show that they are producing the highest share of the total value added, from 50 to 75% for PR and around 80% for GP. Furthermore, there is a very low degree of implementation of own-brand policies by dairy processors and ripeners, such that retailers are increasingly adopting private label strategies for these products.

Market power is analysed in the context of an imperfect competition model of the supply chain. The modelling framework refers to the oligopsonistic/oligopolistic paradigm, following the approach in Appelbaum (1982) and Azzam and Pagoulatos (1990), where firms account for strategic interrelationships by means of conjectural elasticities, which measure the total effect on the market due to firms' choices (the firm's direct effect and the indirect effect following the strategic response of the competing firms). The firm behaviour can be extended to a sector framework by aggregating across competing firms. Aggregation is a central issue in order to evaluate imperfect competition at the sector/market level. Work on aggregation can be found in Appelbaum (1982), Azzam and Pagoulatos (1990), Schroeter and Azzam (1990), Wann and Sexton (1992) and Muth and Wohlgenant (1999), based on conditions and/or restrictions on marginal productivity and/or oligopolistic/oligopsonistic behaviour, thus providing conjectural elasticities at the sector level.

A second important issue is based on the identification of the relevant model parameters, especially those related to imperfect competition. Assumptions on strategic behaviour can simplify the measurement of these parameters (i.e. for example, an assumption of Cournot behaviour among firms makes conjectural elasticities at the sector level equal to the Herfindhal concentration index). As an alternative, model parameters can be jointly estimated within structural models of supply/demand and price transmission equations, following Schroeter (1988), Hyde and Perloff (1998) and Gohin and Guyomard (2000). Depending on the specific condition of aggregation in the model, and assuming a quantity setting behaviour, the market power parameter can be interpreted as conjectural elasticities or as a measure of the departure from marginal cost pricing, in line with the interpretations proposed by Bresnahan (1982) and Hyde and Perloff (1998).

Our modelling framework extends the general framework developed in Hyde and Perloff (1998) and Gohin and Guyomard (2000), focusing on the role of the retail sector. In our model, retailers sell PR and GP to final consumers and buy the grana cheese from ripeners. The key element of the model is that they are allowed to exercise market power both downstream to consumers and upstream to ripeners. Thus, we concentrate only on one step of the supply chain, which is one of the possible approaches suggested by the literature. In fact, one important aspect emerging from the literature is the relevance of the definition of the vertical chain for which imperfect competition is evaluated: some studies focus on the wholesale-retail level (Gohin and Guyomard, 2000), others on the farm-processing level (Suzuki and Kaiser, 1997; Liu *et al.*, 1995), and others consider jointly the processing/retailing phase (Chidmi et al., 2003; Bhuyan and Lopez, 1997). Market power can emerge at different levels of the vertical chain and one has to choose the appropriate setting in order to correctly identify the source of imperfectly competitive behaviour.

The paper is organised as follows. Some basic elements of the PR and GP supply chain are presented in section 2, while in the following section the estimated model is presented. Data and estimation techniques are described in section 4, while in section 5 the estimation results are discussed. Finally, some concluding remarks close the paper.

2. The grana cheese sector in Italy

Parmigiano Reggiano (PR) and Grana Padano (GP) are two Italian hard cheeses made of raw milk and with a maturing period of at least 12 months for PR and 9 months for GP, although they are usually sold at a longer age (PR is sold up to 28-30 months of aging, GP up to 24 months). They are two regional specialties, which have been granted the PDO status by the European Union (EU).

Both PR and GP production has grown steadily in recent years and in 2006 reached 117,000 and 150,000 tons, respectively.

In 2006 there were about 4,500 dairy farmers producing more than 1.6 million tons of milk channelled into the PR supply chain as well as 8,000 farmers producing 2.2 million tons of milk processed into GP. PR processing is carried out by about 450 dairies, mainly farmer cooperatives processing 77% of PR milk; despite a strong concentration process in the last period, dairies are still quite small (the average size is about 3,000 tons). On the contrary, the GP chain is characterised by higher levels of concentration in the production phase (170 dairies), with larger cooperatives, whose share is about 57% of total milk. Furthermore, GP dairies tend to be more flexible, since in periods of market crisis due to oversupply they can use milk to produce other types of hard and semi-hard cheese (Asiago or Provolone) and even soft cheese, thus being less exposed to potential financial crises deriving by low cheese prices.

After the first 12 months for PR, and 9 months for GP, ripening is mainly carried out by specialised firms: there are about 60-80 cheese ripeners/wholesalers in the grana cheese market trading either PR or GP or both, and several of them are not involved in production, especially in the PR chain. The top 10 ripening firms cover 33% of the market; hence, concentration in the wholesale market is reasonably strong. Nevertheless, only few traders have adopted adequate marketing strategy to face large modern retailers and/or the export market.

In terms of destination of the final product, around 70% of both PR and GP goes to household domestic consumption, while the remaining 30% goes either to export or to away from home consumption and food industry use.

In 2006, the market value of grana cheese was about 2.5 billion €; retail sales accounted for about 70% of the total. About 76% of total retail sales takes place in super/hypermarkets, superettes, and hard discounts, while the share of traditional and specialty shops is declining. In terms of product types, around 60% of grana cheese is still sold as whole natural wheels, freshly cut in the sales outlet (either traditional shops or specialty corners in super/hypermarkets); the remaining 40% is sold with a specific packaging.

In recent years, the market trends of the two cheeses have been strongly different. The GP sales have shown a clear increasing trend in volume terms (+18% from 2002 to 2006), while PR has shown a marked decline (-11% in the same period). This diverging trend has strongly modified the market shares of the two cheeses (42% for PR and 58% for GP in value term in 2006), since in the '90s both cheeses were fluctuating around 50%.

Price formation along the PR and GP chain is quite complex. At the farm level, milk price for PR is higher than that for GP (on average a 20% price premium), due to more stringent production rules. Given that raw milk has virtually no alternative use in the PR area and cooperatives are the dominant organisational form in the processing sector, the milk price tends to be driven by the trend in the cooperatives' net revenues. At the wholesale level, there are different prices for different levels of aging, since the product is sold at different ripening stages: consequently, prices are sensitive to market expectations, volume of unsold stocks, signals from operators and purchasing policies by large retailers.

Retail prices are likely to be influenced by the increasing bargaining power of retailers in the grana cheese chain and in the whole Italian food system. In fact, thanks to the weaknesses of most of the PR and GP chain actors in setting up a set of coherent marketing strategies, retailers have become the main players in the area of pricing and promotion strategies, thanks also to the increasing role of their private labels in packaged products (vacuum packed pieces, snacks and ready grated cheese), where they account for 25% of the market. The role of promotions is becoming crucial, especially for PR, since the higher PR price (an average 40% price premium) represents an important barrier for consumers, such that a recent survey shows that more than 50% of PR is sold in promotion. This is not surprising, since modern retailers tend to implement massive promotion activities on both grana cheeses, in order to exploit their attractiveness for potential customers and boost retail sales also on other food products.

3. Model description

In order to measure the degree of oligopoly and oligopsony power exercised by retailers in the Italian grana cheese sector, we simultaneously estimate a system of demand, supply and price transmission equations, extending the general framework developed in Hyde and Perloff (1998) and Gohin and Guyomard (2000). As mentioned before, in our model we emphasise the role of retailers, which sell PR and GP to final consumers and buy the same grana cheese from ripeners. The key element of the model is that retailers are assumed to potentially exercise market power both downstream and upstream.

The demand side of our model considers home consumption of PR and GP by Italian households, which represents the main use of the two grana cheeses (around 70% of total aged production for both PR and GP).

As explained earlier, only a few large grana cheese processors carry out both the processing and the ripening phases. Therefore, ripeners normally manage the cheese aging phase but not the processing phase, The supply side of our model considers ripeners as price takers, since the 60-80 firms acting in the Italian grana cheese market have limited flexibility in deciding when and how to sell their product. In fact, based on the official EU product specifications, the length of the aging phase is fixed: the standard aged GP is sold at 18 months and the standard aged PR is sold at 24 months. Italian consumers can actually find cheese of different ages in the final market, but the range is quite limited (15-20 months for GP and 22-27 months for PR, with some very limited exceptions). Moreover, retailers are increasingly selling products that indicate on their label the exact number of months of the aging phase and consumers are becoming increasingly aware of the relationship between age and quality of grana cheese. Apart from selling to retailers operating in the domestic market, the main alternative destination of aged PR and GP is export (around 16% of total production for PR and 22% for GP). However, this is possible only for those ripeners that have developed adequate export marketing strategies, and their experience shows that any expansion of the export market requires a considerable amount of time and effort. For these reasons, we believe that the assumption of price-taking behaviour by ripeners is reasonable.

To model the final consumption level we adopt the standard almost ideal demand system (AIDS) conditional specification (Deaton and Muellbauer, 1980), assuming multistage budgeting and weak separability between the two grana cheeses and all the other purchased goods:

$$(1) \qquad w_i = \alpha_i + \sum_{j=1}^{N} \gamma_{ij} \ln p_j + \beta_i \ln\left(X / P\right) \qquad i = 1,2$$

where $w_i = p_i q_i / X$ is the budget share of the i^{th} good, with q_i being the quantity purchased of either PR or GP, p_i the corresponding retail price and X total consumer expenditure on grana cheeses, while α_i, γ_{ij} and β_i are parameters to be estimated. P is a general price index that in the so-called "Linear Version" of the AIDS (LAIDS) is approximated by the Stone price index $\left(\ln P = \sum_i w_i \ln p_i\right)$[1]. In order to avoid the unit of measurement problem implied by this last index, we scale retail prices and total expenditure at their sample mean (Moschini, 1995).

On the ripeners' supply side, we employ a Normalised Quadratic functional form for the underlined profit function, which implies the following specification for the two supply equations of PR and GP:

$$(2) \qquad q_i = \lambda_i + \sum_{j=1}^{N} \delta_{ij} \frac{v_j(-t_i)}{v_{inp}(-t_i)} + \sum_{k=1}^{M} \rho_{ik} z_k(-t_{ik}) \qquad i = 1,2$$

[1] The theoretical properties of homogeneity, symmetry and adding-up can be maintained through the following parametric restrictions $\gamma_{ij} = \gamma_{ji}, \sum_i \gamma_{ij} = \sum_j \gamma_{ij} = \sum_i \beta_i = 0, \sum_i \alpha_i = 1$.

where q_i is the quantity of PR or GP supplied by ripeners, v_j is the corresponding wholesale price, v_{inp} is an input price index used as numeraire, t is a time lag expressed in months, since the model is estimated on monthly data, while the vector z includes a set of additional supply shifters[2]. We assume that the supply level q_i coincides with the quantities of PR and GP demanded by final consumers, since we do not consider any storage activity carried out by retailers[3]. In our model, the vector z includes the normalised export price (the main alternative destination of grana cheeses), the interest rate (which is a proxy of storage costs) and the level of stocks of both PR and GP. As numeraire input price index, we employ the wage index of the dairy industry, since labour represents one of the main cost components for ripeners.

All supply independent variables are lagged by t months, where t is specific to the supplied cheese and/or to each supply shifter: t = 15 for all right hand side variables of PR supply, with the exception of the export price, for which t = 1; t = 9 for GP supply, with the same exception for the export price. Thus, supply at time t depends on previous storage decisions, which are based on contemporary output and input prices, stock levels and interest rates. Only the export price is a short term variable, since one can assume that, for ripeners having the adequate know-how, the choice of selling on the export market can be a short term decision. Note that the different lags for the two cheeses are linked to the different aging lengths, even though they are shorter than the standard aging period. In fact, for large processors carrying out also the aging phase the time horizon coincides with the standard aging period (24 months for PR and 18 months for GP), while for specialised ripeners the time horizon is much shorter. Thus, the above lags represent an approximate weighted average of these two different time horizons.

Price transmission equations between wholesale and retail prices of PR and GP are derived under the assumption that, in the Italian grana cheese market, retailers may exercise some form of market power both downstream and upstream. Thus, profit maximisation by the k^{th} retailer can be specified as follows:

$$(3) \qquad \max_{q^k} \quad \pi^k = \sum_{i=1}^{N} p_i\left(q\left(q^k\right)\right)q_i^k - \sum_{i=1}^{N} v_i\left(q\left(q^k\right)\right)q_i^k - C^k\left(q^k\right)$$

where *p(.)* is the (market) inverse demand function by final consumers, *v(.)* is the (market) inverse supply function by ripeners, C(.) is the cost of retailing (excluding the cost of purchasing PR and GP) and q is a vector of $N=2$ grana cheeses.

[2] The theoretical property of homogeneity and adding-up are satisfied by construction, while symmetry can be maintained imposing $\delta_{ij} = \delta_{ji}$.

[3] This assumption seems quite reasonable, since all major retailers are increasingly implementing a set of strategies that aim to minimise the average storage time of their products.

After same rearrangements, the first order conditions for the above problem take the following form:

(4) $$\left(p_h - v_h\right) + \frac{1}{q_h^k}\left(\sum_{i=1}^{N}\sum_{j=1}^{N} p_i q_i^k f_{ij}\theta_{jh}^k - \sum_{i=1}^{N}\sum_{j=1}^{N} v_i q_i^k g_{ij}\psi_{jh}^k\right) - \frac{\partial C^k\left(q^k\right)}{\partial q_h^k} = 0 \qquad h = 1,2$$

where $f_{ij} = \dfrac{\partial p_i}{\partial q_j}\dfrac{q_j}{p_i}$ is the own/cross flexibility of the inverse demand of grana cheese i in the final market, g_{ij} is the own/cross flexibility of the corresponding inverse supply in the wholesale market, $\theta_{ih}^k = \dfrac{\partial q_i}{\partial q_h^k}\dfrac{q_h^k}{q_i}$ is the own/cross conjectural elasticity of retailer k on the final market and ψ_{ih}^k is the corresponding own/cross conjectural elasticity on the wholesale market.

As discussed in Appelbaum (1982) and Azzam and Pagoulatos (1990), the conjectural elasticities θ_{ih}^k and ψ_{ih}^k play a crucial role. In fact, on both sides of the supply chain, when their value is zero we have the perfect competition case, while when their value is one we have the monopoly/monopsony case. Values between zero and one reflect different levels of the k^{th} retailer's market power on both the final market and the wholesale market.

As in most studies of this type, we work with aggregate data; thus aggregation over the retailing firms is required in order to obtain an estimable form of (4). Here we adopt the following empirical specification:

(5) $$p_h = v_h + \left(\mu_{0h} + \mu_{1h}v_{en} + \mu_{2h}v_{lab} + \mu_{3h}q_h\right) - \frac{1}{q_h}\left(\sum_{i=1}^{N}\sum_{j=1}^{N} p_i q_i f_{ij}\theta_{jh} - \sum_{i=1}^{N}\sum_{j=1}^{N} v_i q_i g_{ij}\psi_{jh}\right) \qquad h = 1,2$$

where the parametric form of the demand flexibilities f_{ij} is obtained inverting the Marshallian price elasticity matrix of the AIDS model (Anderson, 1980), and, by analogy, the parametric form of the supply flexibilities g_{ij} is obtained inverting the elasticity matrix of the Normalised Quadratic functional form, while θ_{jh}, ψ_{jh}, and μ_{sh} are additional parameters to be estimated[4]. To our knowledge, this approach (flexible specification of a system of direct demand equations on the final market and of direct supply equations on the wholesale market, modified by the introduction of the parametric form of the demand and supply flexibilities obtained through matrix inversion) has not been applied in similar studies[5].

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[4] Note that our demand specification is similar to Hyde and Perloff (1998), but they adopt a simple inverse of each LAIDS elasticity as parametric form of the corresponding flexibility. Our use of full matrix inversion for both the demand and the supply side of the model implies a considerable burden in the estimation phase, due to the non-linearities introduced by the complex parametric form of the flexibilities.

[5] Azzam and Pagoulatos (1990) deal with both oligopoly and oligopsony power, but they use external information sources to introduce a constant elasticity value in their model. Schroeter and Azzam (1990) develop the multioutput oligopoly case, but using again exogenous values for the demand elasticity matrix. Schroeter (1988) estimates simultaneously the market power parameters and the demand/supply elasticities, but he employs a constant elasticity

As it is clear from equation (5), we have adopted a quantity-dependent specification for our product-specific aggregate marginal cost: this allows marginal costs to be different across firms in a way that it is consistent with nonlinear aggregation of output [6]. Since we allow this differentiation, the estimated θ_{jh} and ψ_{jh} should not be interpreted as the common conjectural elasticities of all firms in the industry, but simply as a measure of the departure from marginal cost pricing, in line with the interpretations proposed by Bresnahan (1982) and Hyde and Perloff (1998)[7]. In our specification, marginal costs depend on the quantity of grana cheese and on some key input prices (the price of energy v_{en} and the price of labor in the retail sector v_{lab}).

Appending an error term to the two demand equations in (1), the two supply equations in (2) and the two price transmission equations in (5) we obtain a six-equation system with six endogenous variables: the two retail prices, the two wholesale prices and two quantities exchanged of PR and GP. This system can be estimated simultaneously, since all parameters are identified.

4. Data and estimation

All of the data required to estimate the empirical version of the model are available on a monthly frequency for the period January 2002 - December 2006 (60 observations). The short period of time (5 years) allows to work on a set of relatively homogeneous data from the point of view of estimating market power parameters. In fact, in the 2002-06 period, the structure of the food retail sector has been relatively stable, since most of the big mergers and acquisitions took place at the end of the '90s. The same can be said on the structure of the grana cheese ripeners/wholesalers, since most of the major players, both among cooperatives and among private firms, have maintained their market shares during the period.

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functional form. Hyde and Perloff (1998) develop the multioutput oligopoly case using a flexible specification for their demand systems, without considering the issue of oligopsony power. Gohin and Guyomard (2000) choose to estimate a flexible inverse (price-dependent) demand system, but we believe that this last hypothesis is not suitable for the grana cheese case.

[6] Any quantity-dependent specification of marginal costs is not consistent with linear aggregation of industry output. Linear aggregation of output over firms (i.e. $q_h = \sum_k q_h^k$) requires that firm-level cost functions are quasi-homothetic. This implies that technical differences across firms are restricted to the level of fixed costs, while marginal costs are constant and identical across firms. This is of course a very restrictive assumption, that can be relaxed assuming some more general form of nonlinear aggregation of output (i.e $q_h = f\left(q_h^1,...,q_h^K\right)$) (Chambers, 1988, Chapter 5).

[7] This interpretation implies that nothing can be said on the type of strategic game that is behind the estimated θ_{jh} and ψ_{jh}. Moreover, this assumption is needed if we want to distinguish θ_{jh} from ψ_{jh}. In fact, as it is explained in Gohin and Guyomard (2000), under fixed proportion and constant marginal costs across retail firms, we have that $\theta_{jh}^k = \psi_{jh}^k$. On the contrary, under our assumption, we allow different degrees of market power on the wholesale and retail market.

Information on PR and GP home consumption has been retrieved from a representative panel of 6,000 consumers managed by CRPA-SIPR (2006). This survey registers domestic consumption (that is consumption at home through purchases at the retail level) both in value and in quantity terms, such that monthly average retail prices can be obtained taking the ratio between the corresponding values and quantities. Wholesale prices of the two grana cheese are regularly collected by public institutions such as the local Chambers of Commerce. Data on input prices (energy price index, wage index in both the retail and the dairy industries) are available from the National Institute of Statistics (ISTAT). Data on private stocks of PR and GP are regularly collected, since grana cheese can enjoy a special payment for private storage in the context of the Common Agricultural Policy (CAP). As interest rate, we have used the average interest rate for medium-term loans to non-financial firms provided by the Central European Bank, while the average export price of grana cheese has been computed using official ISTAT data on export of grana cheese in value and quantity terms. Trade data on grana cheese do not distinguish between PR and GP; thus, we have only one export price for the two cheeses.

Since the estimation of a simultaneous system of equations, like the one described in the previous section, requires the adoption of an instrumental variable estimator, we have collected another set of variables available on a monthly basis that may be used as instruments. This set of variables includes both variables related to the grana cheese sector (production of fresh PR and GP), to the dairy sector (wholesale prices of butter and other Italian PDO cheeses; farm level price of milk) and to the general economy (total food sales; consumer price index).

The model is estimated using the Generalised Method of Moments (GMM). The advantage of GMM over traditional estimation methods, such as maximum likelihood, is that GMM does not require strong assumptions on the underlying data generating process and has the ability to generate heteroscedasticity and autocorrelation robust standard errors (Greene, 2003). In the case of simultaneous estimation of a system of g equation, GMM starts from a vector of M function $\mathbf{m}(.)$ satisfying the following moment conditions:

(6) $$E\left(m_l(\mathbf{x_i}, \varphi)\right) = 0 \quad l = 1, ..., M$$

where $\mathbf{x_i}$ is the set of random variables (both endogenous and exogenous) appearing in the model and φ is the vector of the K parameter to be estimated, with $M \geq K$. Sample moments are computed taking the sample means of each moment condition:

(7) $$\overline{m}_l(\varphi) = \frac{1}{T}\sum_{i=1}^{T} m_l(\mathbf{x_i}, \varphi) \quad l = 1, ..., M$$

where T is the number of observations. Under the assumption that:

(8) $$\text{plim}\, \overline{\mathbf{m}}(\varphi) = E\left(\overline{\mathbf{m}}(\varphi)\right) = 0$$

where $\overline{m}$ is the vector of sample moment conditions, a consistent, and possibly efficient, estimator of φ is obtained minimizing the following criterion function:

(9) $$Q = \overline{\mathbf{m}}(\varphi)'\mathbf{W}\overline{\mathbf{m}}(\varphi)$$

where **W** is a symmetric positive definite weighting matrix (Greene, 2003). The choice of **W** is arbitrary[8], but its optimal form requires that the weights used in the estimation are inversely proportional to the variances of the moments. Thus, if $\mathbf{\Omega} = Asy.Var\left[\sqrt{T}\overline{\mathbf{m}}\right]$, the optimal asymptotic covariance matrix of the GMM estimator is the following:

(10) $$\mathbf{V}_{GMM} = \frac{1}{T}\left[\mathbf{\Gamma}'\mathbf{W}\mathbf{\Gamma}\right]^{-1} = \frac{1}{T}\left[\mathbf{\Gamma}'\mathbf{\Omega}^{-1}\mathbf{\Gamma}\right]^{-1}$$

where $\mathbf{\Gamma}$ is the matrix of the first derivatives of the moment conditions with respect to the parameter vector φ.

In our case, we adopt a standard set of instrumental variable moment conditions, where the instruments are orthogonal to the residuals in each equation. Thus, since we adopt the same set of L instruments for each equation, in our case the number of moment conditions is $M=gL$.

The estimated version of the model includes five equations: one of the two demand share equations[9] in (1), in which we have added a trend variable and a set of monthly dummies, in order to control for seasonality of consumption, the two supply equations in (2) and the two price transmission equations in (5). The final set of instruments include all the exogenous variables in the system (constant, eleven monthly dummies, time trend, expenditure on grana cheeses, price of energy, wage index in the retail sector, and, with the opportune lags, stocks of PR, stocks of GP, interest rate, export price of grana cheeses, wage index in the dairy industry) and a set of additional instruments (production of fresh PR, production of fresh GP, farm level price of milk, wholesale price of butter, wholesale price of Provolone, wholesale price of Gorgonzola, consumer price index, food sales' index, and, with 16 months lag, retail and wholesale prices of GP).

Since the model is highly non-linear and convergence is difficult to achieve, starting values for GMM estimation have been constructed in three stages: first estimating the demand share equation only, then the two supply equations only and finally the two price transmission equation, holding the supply and demand parameters constant at the values estimated in the first two stages. The covariance matrix of the moment conditions defined in (10) was then constructed from these starting values, and during the estimation procedure was iterated in order to obtain its optimal form. This optimal matrix was constructed taking into account the presence of serial correlation, since we

[8] Many popular estimation methods (non linear least squares, instrumental variables, maximum likelihood) can be interpreted as special cases of GMM, depending upon the number and type of moment conditions considered, as well as the form of the **W** weighting matrix.

[9] The second share equation is omitted in order to avoid singularity of the system.

are using monthly time series data. Standard errors are also computed correcting for serial correlation.

To see whether the structure of the model is correct, we use a *J*-test of overidentifying restrictions (Greene, 2003). If there are *M=gL* moment conditions and *K* parameters, there are *M-K* over-identifying restrictions and it can be shown that the following statistics:

(11) $$TQ = \sqrt{T}\,\overline{\mathbf{m}}(\hat{\varphi})'\hat{\Omega}^{-1}\overline{\mathbf{m}}(\hat{\varphi})\sqrt{T}$$

has a χ^2_{M-K} distribution. The null hypothesis of the *J*-test is that the over-identifying restrictions hold and then the structure of the model is correct. The set of instruments described above was not rejected by the test[10].

5. Results and discussion

Parameter estimates of the simultaneous system of six equations are reported in Table 1. Since the model is non-linear in the endogenous variables, it has been estimated in its implicit form as written in (1), (2) and (5). Thus, goodness-of-fit statistics, such as R^2, could not be computed. However, most of the estimated parameter (almost 66%) are statistically significant, and this is a signal that the GMM estimation technique performed well. Results are also globally robust to the arbitrary choice of the set of instruments, which is a further signal of good estimation performance.

The key results of our analysis are of course the estimated market power parameters. All oligopoly power coefficients are statistically significant and own parameters (*i=h*) fall in the 0-1 range, as predicted by the theory. The estimated parameters confirm the existence of downstream market power by retailers (toward final consumers), while the wholesale market (toward ripeners) appears to be competitive.

Focusing our attention on the own parameters, the estimated degree of oligopoly power (i.e. the departure from marginal cost pricing) is stronger for PR than for GP (0.87 vs 0.52). This may be due to the different reputation of the two grana cheeses, which reflects in different demand characteristics. PR is clearly perceived as the highest quality grana cheese by Italian consumers, with a higher retail price premiums; furthermore, while the demand for GP is sensitive to the price of PR, the reverse is not true. Therefore, the empirical evidence of a more stable pattern of the retail price for PR with respect to GP, that is a lower sensitivity to cyclical patterns in the wholesale market, may be partly explained by the objective of keeping volume sales for the two cheeses more stable.

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[10] The P-value of our J-test is 0.99 with 136 degrees of freedom.

The results concerning the wholesale market do not seem to reflect a common claim by PR and GP processors/ripeners, that often highlight their low bargaining power toward retailers buying groups. Our model does not allow to explore the causes of this absence of upstream market power by retailers. However, one may note that the number of ripeners operating in the market (trading either PR or GP or both) is rather small, with some of them carrying a relevant market share. In addition, both collective PDO brands (PR and GP) are very well known to Italian consumers and have a strong reputation, such that all Italian retail chains must have grana cheese in their assortment. Both these elements may make more difficult for retailers to exercise their market power..

Marginal costs of retailing turn out to be constant, since for both PR and GP the estimated parameter related to the corresponding quantity is not statistically significant. Marginal costs are also positively related to the energy and the labour price for both PR and GP.

Marshallian demand elasticities are computed at the mean point of the sample and are reported in Table 2. The two demand functions are well-behaved and both own-price and expenditure elasticities have the expected signs. The difference between PR and GP price elasticities (1.37 vs. 0.94) is rather large, but the average price level is also much higher for PR (13.4 €/kg vs. 9.6 €/kg in our sample), and this may explain such a difference.

The demand for PR is also very sensitive to the amount spent by consumers in this cheese category. Since we are evaluating conditional elasticities, it is incorrect to classify PR as a luxury, but for sure it is more sensitive to a change in consumer income as compared to GP. In fact, GP demand is inelastic with respect to total expenditure, thus it can be classified as a necessity, since for food items income elasticity is normally lower than group expenditure elasticity. This seems to confirm the competitive position of the two PDO cheeses, with PR targeted to medium and high-income households and GP playing a role of "mass product".

Looking at cross-price effects, consumption of GP reacts to price changes of PR with a cross-price elasticity of 0.3, while the opposite is not true, since the corresponding cross-price elasticity is not significantly different from 0. Thus, in the last few years it seems that the degree of substitutability between the two PDO cheeses has been quite low, at least for home consumption. This may imply some degree of loyalty of groups of Italian consumer to each of the two PDO cheeses, especially to PR, while the level of consumption strongly depend on own-price and consumer income.

Another important element of the analysis is the significant negative trend parameter for PR (to which, by construction, corresponds a positive trend for GP), which confirms the long-term trend observed in recent years.

Finally, the supply of grana cheese by ripeners is also well behaved, showing positive and inelastic own price elasticities for both PR and GP. Moreover, the two cheeses appear as substitues in the ripening decision, which seems to imply some sort of flexibility by ripeners in deciding which cheese to enter in their aging stores. PR and GP supply are both positively influenced by the aggregate export price of grana cheese. Therefore, export opportunities influence ripeners' decisions. PR supply is also positively related to the lagged level of PR stocks, while GP supply is negatively related to the lagged interest rate. Thus, the higher opportunity cost of ripening seems to penalize the lower quality product.

6. Concluding remarks

In this paper, we have evaluated the role of market power by retailers within the supply chain of Parmigiano Reggiano (PR) and Grana Padano (GP), the two most famous Italian PDO cheeses. We focus on the role of retailers, because they are becoming increasingly important in the grana cheese supply chain. This is because PR and GP are very peculiar PDO products. Given their widespread consumption, they are among the very few PDO products that can be considered mass market goods rather than niche goods. Thus, as most generic food products, they reach final consumers mainly through super and hypermarket chains, rather than through specialised channels, and, given their incidence on food retail sales, they are a key element of the assortment of large retailers.

Market power is analysed in the context of an imperfect competition model of the supply chain. The modelling framework refers to the oligopsonistic/oligopolistic paradigm, where firms account for strategic interrelationships by means of conjectural elasticities. In our model, retailers sell PR and GP to final consumers and buy the grana cheese from ripeners, and they are allowed to exercise market power both downstream and upstream.

In terms of estimation strategy, we extend the general framework developed in Hyde and Perloff (1998) and Gohin and Guyomard (2000), in order to jointly estimate market power parameters together with supply and demand elasticities, by means of a structural system of demand, supply and price transmission equations. Based on our estimation results, we find clear evidences of downstream market power by retailers (i.e. toward final consumers) and no evidences of upstream market power (i.e. toward processors/ripeners).

The results concerning the final market, where the degree of market power is much stronger for PR as compared to GP, may be interpreted in light of the different reputation of the two grana cheeses. In fact, PR is clearly perceived as the highest quality grana cheese by Italian consumers, with a higher retail price premiums; furthermore, while the demand for GP is sensitive to the price of PR, the reverse is not true. Therefore, the empirical evidence of a more stable pattern of the retail price for PR with respect to GP, that is a lower sensitivity to cyclical patterns in the wholesale market, may be partly explained by the objective of keeping volume sales for the two cheeses more stable. This interpretation seems to be reinforced by the estimated own-price and expenditure demand elasticities.

The results concerning the wholesale market do not confirm the frequent claim by PR and GP processors/ripeners that often highlight their low bargaining power toward retailers. However, the concentration of ripeners and the reputation of the two PDO brands for Italian consumers may make more difficult for retailers to exercise their market power,

Starting from the results of this paper, further improvements of the model may lead to more conclusive evidences. Given the complex price formation mechanisms of the two PDO cheeses, some additional effort may be devoted to a more sophisticated modelling of the dynamics of supply decisions by ripeners, both in terms of storage choices and of price expectation formation. However, to pursue this objective one has to face the lack of detailed data and has to consider the difficulties in estimating a simultaneous highly nonlinear system of equations, which make any extension of the model quite challenging.

Table 1: GMM estimated parameters of the 5-equation system[(a)]

	Coefficient	t-stat		Coefficient	t-stat
Demand			*Supply*		
γ_{11}	-0.0781**	-2.392	λ_1	976.2	0.550
α_1	0.4739***	68.667	δ_{11}	22965.2***	2.871
β_1	0.1967***	6.332	δ_{12}	-58869.4***	-3.186
τ1	-0.0492***	-11.139	ρ_{11}	0.0599***	3.591
η_1	0.0513***	5.885	ρ_{12}	-0.0120	-1.515
η_2	0.0013	0.184	ρ_{13}	-135.4	-0.738
η_3	-0.0244***	-4.373	ρ_{14}	39685.9***	3.120
η_4	0.0300**	2.527	λ_2	5985.5**	2.423
η_5	0.0142	1.329	δ_{22}	82131.3*	1.685
η_6	-0.0114*	-1.823	ρ_{21}	0.0348*	1.665
η_7	0.0296**	2.153	ρ_{22}	0.0132	1.086
η_8	0.0307**	2.133	ρ_{23}	-663.5**	-2.530
η_9	-0.0182***	-2.676	ρ_{24}	44683.8**	2.357
η_{10}	0.0641***	5.408			
η_{11}	0.0701***	7.589	*Oligopoly Power*		
			θ_{11}	0.8660***	7.761
Marginal costs			θ_{21}	0.2308***	3.087
μ_{10}	-19.2563***	-10.548	θ_{12}	-0.2329***	-2.627
μ_{11}	0.0247***	3.866	θ_{22}	0.5191***	6.362
μ_{12}	0.0790***	4.626			
μ_{13}	0.0000	0.010	*Oligopsony Power*		
μ_{20}	-7.2905***	-5.372	ψ_{11}	-0.0427*	-1.736
μ_{21}	0.0078**	2.091	ψ_{21}	0.0612	1.244
μ_{22}	0.0476***	4.408	ψ_{12}	0.0489	1.367
μ_{23}	0.0001*	1.665	ψ_{22}	-0.0246	-1.176

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels.
[(a)] *i=1* for Parmigiano Reggiano and *i=2* for Grana Padano; τ_1 = time trend; η_1-η_{11} = monthly dummies.

Table 2: Demand and supply elasticities at the mean point of the sample[(a)]

	p1	p2	y
Demand			
Parmigiano Reggiano (q1)	-1.372***	-0.070	1.441***
	(-16.147)	(-0.916)	(20.676)
Grana Padano (q2)	0.299***	-0.944***	0.645***
	(4.378)	(-15.478)	(11.517)
Supply			
Parmigiano Reggiano (q1)	0.398***	-0.671***	
	(2.871)	(-3.186)	
Grana Padano (q2)	-0.587***	0.539*	
	(-3.186)	(1.685)	

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels.
[(a)]asymptotic t-statistics in parenthesis

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