Estimating the market power within two cheese PDO supply chains in France

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Paper prepared for presentation at the 8^{th} INRA-SFER-CIRAD congress,
Grenoble(France), 11-12 December 2014

Abstract

This paper measured the extend of market power exert by the Protected Designation of Origin (PDO) supply chains, with a focus on Cantal and Comté fluid milk market. Using a non linear three stage least square (3sls), over monthly data from January 2006 to December 2013, we found that the estimated point of market power are not statistically significant for both Comté and Cantal. Further, we conduct a set of unilateral test to investigate whether farmers are charging monopoly price or not. While the test clearly rejects the hypothesis of monopoly at 1% level, its fails to reject the perfect competition. Therefore, we conclude that Cantal and Comté PDO supply chain do not exert market power, at least at dairy farmers' level. These findings appear to be robust to the generalized method of moment(gmm) estimator.

JEL-classification: C36 L13 L41 Q18

Keywords: Dairy sector, market power, supply chain, PDO, NEIO

1 Introduction

The European Union's quality policies, in particular the Protected Designation of Origin (PDO) and the Protected Geographical Indications (PGI), are designed to increase farmers' incomes, to balance supply and demand and to sustain rural development. The effectiveness of PDO/PGI labeling policies to achieve these goals have been widely documented in the agricultural and economic literature (see, Bouamra-Mechemache and Chaaban, 2010 for a broad review). Nevertheless, according to an OCDE (2000) report, some European PDO/PGI supply chains have created news intra-chain mechanisms to get market power. Indeed, some of them are often tempting to operate a supply control which can lead to market distortions. The Organization for Economic Co-operation and Development (OCDE) has expressed concern about the risks of anti-competitive practices of certain PDO supply chains in Europe. In France particularly, the Cantal PDO supply chain implemented a mechanism of control supply in 1987 and had to discard it due to the decision of French Competition Authority. On the other hand, for 20 years, PDO comté supply chain had implemented a mechanism to control supply with some restrictions. Numerous critics have been formulated to the Comté supply regulation, especially about the potential non-competitive effects of this specific policy. Face with these criticisms, the actors concerned by these practices develop three lines of defense. On the one hand, they assume that these mechanisms of supply control are legal since they are approved by government. On the other hand, they argue that producing quality require output control. Finally, they pointed to the exceptions which some competition regulations allow to the general ban on understandings to restrict competition. Though, if evidences are found that supply control leads to significant market power, the PDO supply chain can be deprived of its label. Then, it becomes interesting to investigate whether the PDO supply chains exert a market power or not.

Some works have used the New Empirical Industrial Organization (NEIO) approach to estimate market. The NEIO approach introduced by Appelbaum (1979) and Appelbaum (1982), Bresnehan (1982) and Lau (1982) have been widely used to measure the degree of competitiveness in food processing and marketing at one stage (e.g., Azzam, 1997; Sexton and Lavoie, 2001) in a horizontal approach. However, few studies exist on the market power of PDO supply chain. Merel (2008) estimates the degree of competitiveness in French Comté PDO market. The estimation was conducted at the wholesale stage of the supply chain from ripeners to suppliers (at the cheese ripening stage), over the period 1985-2005, but not at the dairy production stage. He found that sellers' market power is small and statistically insignificant. Thus, he concluded that the Comté market was perfectly competitive from 1985 to 2005. Sckokai et al. (2013) analyzed the extend of market power in the two most famous Italian PDO quality cheeses, Parmigiano Reggiano and Grana Padano. They performed generalized method of moments (gmm) to jointly estimate market power parameters with a structural system of demand, supply and price transmission equations. The authors found evidences of downstream market power by retailers (towards final consumers) only for Parmigiano Reggiano, but no evidence of upstream market power (towards processors/ripeners). Barjolle and Jeanneaux (2012) mobilized the Raising Rivals' Costs (RRC) theory to explain the price gap between PDO Cantal in France and PDO Swiss Gruyère. While the former has developed an industrial model where the production is controlled by few large dairies, the latter's strategy is based on the strategy of differentiation linked to the geographical origin and specificity. They pointed out three factors that explain the price gap and to understand more what factors could explain a potential market power. The first factor is the ability of the supply chain of a localized agro-food chain to set up a collective level of governance. Along the value building process, the collective organizations decides the use of specific territorial resources and take control over quality (quality segmentation, grading and clearing of low quality cheese towards the reprocessing industry). The second factor refers to the legal framework and its implementation. The setting-up and enforcement of strict production rules empower the collective structure, and allow structuring the relation between dairy farmers, cheese-makers and ripeners. Thirdly, the price gap is explained by the dynamic of the market power between firms within the supply chain over time and their capacity to distribute the value among stakeholders by taking into account the real enhanced market value at the retailers' stages.

The present paper aims at discuss if PDO regulation gives a market power to farmers and can be non competitive organization, especially when farmers control the production. To discuss these points we have carried out an analysis on two French cheeses PDO:One is the Cantal case without supply control; the other is the Comté case, which has implemented a supply control mechanism over a long time.

The reminder of the paper is organized as follow. The next section briefly presents the characteristics of Cantal and Comté PDO supply chains. Section 3 outlines the theoretical model. Section 4 presents the estimation method used in the paper. Section 5 describes the data, section 6 presents the estimation results. The last section concludes.

2 Cantal and Comté PDO supply chain

Agricultural in the mountains areas of France is strongly dedicated to milk production that feeds into cheese supply chains benefiting from a legal recognition through an official quality label in the Cantal department within Auvergne Region (several PDOs: Cantal, Saint-Nectaire, Bleu d'Auvergne, Fourme d'Ambert, Salers) and in Doubs and Jura Departments within the Jura Mountain (Several PDOs: Comté, Mont d'Or, Morbier, Gruyère, Bleu de Gex).

The products originate from the Auvergne region gathered in 2010, around 8000 dairy farmers producing more than 1200 million liters of milk. Among them, 2800 farmers produce milk necessary for PDO Cantal. For two decades, from 1990 to 2010, the PDO Cantal production has been stabilized around 18000 tons, but since 2010 the production is decreasing and was around 13000 tons in 2013.

Three steps mark the construction process for obtaining the protected designation of origin. The first step aimed at obtaining the exclusivity for the product. The Cantal indeed benefits from a PDOs protection with a ruling of Magistrates Court of Saint-Flour in 1956. The second step consisted in collectively setting the production standards defining the production system. Large industrial dairy groups mostly set up their processing plants within the Cantal department. Under the influence of industrial dairy processors, the agents together fixed the requirements for the dairy farmers of the land zone who were included in the initial PDO zone. The code of practices successively evolved towards fewer requirements to promote intensive agriculture practices based on corn silage feed for the Prim Holstein breed, leading toward to exclude linkage to the *terroir*. Farmers became standard dairy suppliers and had the same price of their non-specific milk as French standard milk. At the same time, all the rulings of the codes of practices focused on promoting large-scale dairy-processors units (heating treatment for the milk and robot for the processing activities were allowed). Therefore, it forced small dairy processors involved in the supply chain to reduce their costs at dairy stage by increasing the production, and numerous of them couldn't accept and disappeared. Large industrial dairy groups realized vertical integration of suppliers (and horizontal integration of competitors) to impose a production system mostly based on cost leadership strategy. The third step for dairy farmers faced an induced industrial and market power, and see their milk prices being continually low consisted to change the production conditions. Since 2007, thanks to a new code of practices, the dairy farmers are able to highlight again their contribution to the product quality and specific link to the geographical origin. The implementation of the code of practices (GMOs prohibition, land load limitation ratio of one hectare fodder per milking cow, cows grazing mandatory) impacts the production costs and excludes from the production system the milk producers adopting intensive agricultural practices. The barriers to entry, which are raised by the code of practices for milk processing, are protecting the specificity and link to the *terroir* founding the competitive advantage of the product. But in spite of these modifications, the creation of values is not effective because the cheese-makers do not agree on crucial elements determining quality differentiation, identity, image and long-term reputation at the consumer's level. This value results also of the capacity to control the volume of production to avoid cheese shortage, over production and price volatility. But for the Cantal PDO, it is not possible to control the supply contrary to PDO Comté.

From a historical perspective, the PDO Comté was the most important vector to the organizational development of the cheese production system in the Jura Mountain, based on specific technical and social division of labor (Perrier-Cornet, 1986). The Comté benefits from a PDO's protection with a ruling of the Magistrates' Court of Dijon in 1952. Almost 50 years later, the PDO zone was scaled down in 1998, matching with its effective production's territory and preventing the late and opportunistic development of the production periphery of the historical area. The 3000 dairy farmers, on the one side, are organized in collective cheese-making units (140 cheese-making cooperatives in 2010). They control the processing from milk to fresh cheese (not ripened) and do not have market access. The cheese- ripeners (around 10 units in 2010), on the other side, have the quasi-exclusive access to market without being involved in the first processing stage. Since 1990, the Comté production have significantly increased by more than 25000 tons. The labor division is still present and generates a long-lasting collective value that is safe-guarded by the successful setting of the Protection Designation of Origin Comté. The Comté supply chain shaped the agro-food sector in this mountain region and supported the selling price of that cheese. In 2007, the average price was 10.20 €/kg compared to 7.10€/kg for French Emmental[1], that is to say a positive price difference of 47% in favour of the Comté[2]. The milk price at farm gate depends as well on the bargaining skills of the dairy farmers (as they also control most of cheese-making cooperatives) when discussing within the collective organization about the calculation ratio for fresh cheeses they sell to the ripeners. Until today, the supply chain organized the surplus' distribution between production and market. The system's efficiency was based on the regulated distribution of the collective surplus that allowed dairy farmers, over the last 15 years, excepted 2007, to reached a 25% higher price for milk compared to national average (Jeanneaux and Perrier-Cornet, 2011). The milk price at farm gate depends also to the collective action which sets a powerful organization and gives extended authority for bargaining and implementing Comté supply control measures. Indeed, the interprofessional Comté PDO organization controls its supply through a mechanism of "campaign plain" since 1977. This interprofessional organization defines the volume of production every year to avoid cheese shortage, overproduction and price volatility.

3 The model

In this section, we use the model developed by Bresnehan (1982) to identify the market power in the wholesale of fluid milk market. In this model, the market price and the quantity of milk is determined by the intersection of demand function and a supply relation. The demand function assumed price taking buyers while the supply relation presumes that sellers may have some market power.

Let milks buyers have a typical demand function.

$$Q = D(P, X, \alpha) + \epsilon_d \tag{1}$$

Where Q is quantity of milk, P milk price, X a vector of exogenous demand shifters, α a parameters of the demand system to be estimated and ϵ_d is the econometric error term of the demand system.

Turning to the supply relation, Bresnehan (1982) proposed a general supply relation of the form

$$P = c(Q, Y, \beta) - \lambda h(Q, X, \alpha) + \epsilon_s \tag{2}$$

[1]source: syndidat français des pâtes pressées cuites 2007

[2]source CIGC: http://www.comte.come/le-marche-du-comte,4,0,8,1.html

Where c(.) is the marginal cost, Y exogenous variables in the supply side, β the supply-function parameters and ϵ_s the supply-error term. λ is a new parameter indexing the degree of market power. Depending on the value of λ, there are three cases that can prevail from equation (2). When $\lambda = 0$, market is perfectly competitive since price equals marginal cost, $P = c(.)$. When $\lambda = 1$, sellers are charging monopoly price since marginal revenue equals marginal cost, $P + h(.) = c(.)$. An intermediate λ's correspond to monopolistic competition.

Now, let us assume a linear demand function. The demand function is defined as follow:

$$Q = \alpha_0 + \alpha_1 P + \alpha_2 P_{juices} + \alpha_3 Income + \alpha_4 P * P_{juices} + \epsilon_d \tag{3}$$

Where P_{juices} is the price index of juices. According to previous studies on the milk sector (Braga and Scalco, 2012), we consider the index price of juices as a substitute to the fluid milk. Naturally, the price of the substitute interact with the milk price. Most important, the interactive term ($\alpha_4 P * P_{juices}$) is included to ensure that system of demand and supply is identified. As clearly explained by Bresnehan (1982), the interactive term ($\alpha_4 P * P_{juices}$) allows the demand curve rotates- not only shifts- due to a change in exogenous variable (here P_{juices}). The interactive term is necessary to the identification of the degree of market power, measured by λ in the supply relation [3] .

Similarly, we assume a linear marginal cost in the supply side. Under the assumption of linear marginal cost, the supply relation is defined as

$$P = \left(\frac{-\lambda}{\alpha_1 + \alpha_4 P_{juices}}\right) * Q + \beta_0 + \beta_1 Q + \beta_2 P_{feed} + \epsilon_s \tag{4}$$

Where P_{feed} is the animal feed price index. For more details on the derivation of the supply relation, see Appendix A.

The equation (3) and (4) will be simultaneously estimated. Our parameter of interest is λ. When $\lambda = 0$, the fluid milk market is perfectly competitive. When $\lambda = 1$, milk sellers' are charging monopoly price. Finally, a value of $\lambda \in]0;1[$ indicates monopolistic competition. Turning to others parameters, α_1 is expected to be negative since a price increasing will decrease the demand quantity. In contrast, we expect α_2 to be positive since an increase in the substitute price will lead to an increasing demand. Conventionally, α_3 is positive while the interactive parameter α_4 should be negative. On the supply side, β_1 is expected to be negative while β_2 is conventionally positive since an increase of input price should increase the output price.

In the next section, we present the method used to estimate the system of equations (3) and (4).

4 Estimation methods

Traditionally, we use the two stage least square (2sls), three stage least square (3sls) or maximum likelihood (ml) in the estimation of industrial organization model. However in this paper, we used the nonlinear generalized methods of moments (nonlinear gmm) to estimate the system of equations (3) and (4). This choice is guided by three reasons. Firstly, the gmm method includes 2sls, 3sls and the ml in certain cases. In order words, the three methods (2sls, 3sls and ml) are particular cases of generalized method of moments (gmm), we illustrate that later in the paper. In that, we do not completely break with usual methods. Secondly, the gmm estimators and the respective standards errors are consistent irrespective to heteroskedasticity and/or autocorrelation. Finally, unlike to the maximum likelihood, the gmm estimator does not require assumption on the distribution process or normality.

The generalized methods of moments is based on the principle of analogy, which means that we can derive a parameter by replacing a population moment condition with its sample analogy.

[3]For more details on this point, see Bresnehan (1982)

The gmm estimator $\hat{\theta}$ is defined as a solution that minimize a quadratic function of moments condition

$$\hat{\theta} \equiv argmin_{\theta} \left\{ \frac{1}{N} \sum_i Z_i \epsilon_i(\theta) \right\}' W \left\{ \frac{1}{N} \sum_i Z_i \epsilon_i(\theta) \right\} \tag{5}$$

Where Z is a k-vector of instrumental variables including the exogenous variables present in the model, which are assumed to satisfy the orthogonality condition $E(Z\epsilon(\theta)) = 0$; $\epsilon(\theta)$ the econometric error term and W a symmetric positive-definite matrix commonly called weight matrix. A key element of the gmm estimator is the computation of the weight matrix. Note that we can easily compute the gmm estimators θ if W is known. A simple way is to assume that W is an identity matrix ($\hat{W} = I$). However, Hansen (1982) seminal paper shows that the optimal GMM estimator is the one that approximates the weight matrix by the inverse of the moment covariance matrix. The moment covariance matrix denoted by S is defined as $S = Cov(Zu)$. Then, the weight matrix is given by $W = S^{-1}$. But we can not calculate S since ϵ is unobserved. We need at least in a first time, to make assumption on ϵ in order to compute S.

Let us assume that $\epsilon \sim i.i.d$ (independent and identically distributed), then $S = Cov(Z\epsilon) = E(\epsilon^2 ZZ') = \sigma^2 E(ZZ')$, where σ^2 is the variance of the error term ϵ .

We can keep out σ^2 in solving (5) since it is a scalar, and easily compute the weight matrix as

$$\hat{W_1} = S^{-1} = \left(\frac{1}{N} \sum_i Z_i Z_i' \right)$$

The computed weight matrix $\hat{W_1}$ is identical to 2sls weight matrix. So, under the hypothesis of independent and identically distributed error term ($\epsilon \sim i.i.d$), the gmm estimator is equivalent to 2sls. Knowing $\hat{W_1}$, we can solve (5) to obtain consistent parameters $\hat{\theta_1}$. Making the assumption of $\epsilon \sim i.i.d$ allow us to compute consistent parameter in one-step. But remember that we have assumed ($\epsilon \sim i.i.d$) because the error term is not an observed variable. But now, given $\hat{\theta_1}$ we can predict the error term, $\hat{\epsilon_1}$. We can now partially relax the previous hypothesis. Let us assume that residuals are independent but not identically distributed. Put differently, we assume that the variance of residuals are no longer constant. So we can recompute the weight matrix as

$$\hat{W_2} = S^{-1} = \left(\frac{1}{N} \sum_i \hat{\epsilon_i}^2 Z_i Z_i' \right)$$

Given $\hat{W_2}$, we can solve (5) to obtain a new consistent gmm estimators $\hat{\theta_2}$. This approach is known as two-step gmm estimator. It is so called because we proceed in two-step. In the first-step, we make assumption on the error term ($\epsilon \sim i.i.d$) to compute the weight matrix $\hat{W_1}$ and then solve (5) to obtain consistent gmm estimators $\hat{\theta_1}$. In the second step , we partially relax the previous assumption to recompute consistent estimators $\hat{\theta_2}$, using the weight matrix $\hat{W_2}$.

We may continue this procedure until the difference between two estimators ($\hat{\theta}_{p-1}$,$\hat{\theta_p}$) keep unchanged from iteration $p-1$ to p. If the estimator at the p^{th} iteration is identical to the $p-1$ estimator, we say that estimator convergence is achieved. This procedure is known as the iterative gmm estimator.

Turning back to our system of equations (3) and (4), we presume that data follow the model defined by

$$\begin{cases} Q &= \alpha_0 + \alpha_1 P + \alpha_2 P_{juices} + \alpha_3 Income + \alpha_4 P * P_{juices} + \epsilon_d \\ P &= \left(\frac{-\lambda}{\alpha_1 + \alpha_4 P_{juices}} \right) * Q + \beta_0 + \beta_1 Q + \beta_2 P_{feed} + \epsilon_s \end{cases} \tag{6}$$

In model(6), we have two endogenous variables, the quantity of PDO milk (Q) and the PDO milk price (P). All others variables are assumed to be exogenous. To deal with the endogeneity of supply and demand of milk, we need instruments. A good instrument should be correlated with the endogenous variable but not be with the error term. The second condition, known as the condition of orthogonality, corresponds to the following moment conditions.

$$E\left\{\begin{array}{c} Z_d\epsilon_d \\ Z_s\epsilon_s \end{array}\right\} = 0$$

Where Z_d and Z_s correspond to the demand and supply instruments, respectively. In this study, we use international dairy price index, natural gaz price and the price of domestic fuel as external instruments for milk demand and supply. In France, the antitrust authority does not allow farmers to fix price. However, the CNIEL (Centre National Interprofessionel de l'Economie Laitière) provides farmers some indicators to help them determining the milk price. Among those indicators, we have the evolution of international dairy price index and the evolution of energy price. So, sellers milk price calculated based based on the evolution of these indicators. As mentioned earlier, Z_d and Z_s also include all others exogenous variables in (6). The corresponding covariance matrix is defined as

$$S = E\left[\left\{\begin{array}{c} Z_d\epsilon_d \\ Z_s\epsilon_s \end{array}\right\}\left\{Z_d'\epsilon_d \quad Z_s'\epsilon_s\right\}\right] = \begin{bmatrix} \sigma_{dd}E(Z_dZ_d') & \sigma_{ds}E(Z_dZ_s') \\ \sigma_{sd}E(Z_sZ_d') & \sigma_{ss}E(Z_sZ_s') \end{bmatrix}$$

Where $\sigma_{i,j} = cov(\epsilon_i, \epsilon_j)$. One can not compute the weight matrix since ϵ_d and ϵ_s are unobserved variable. As in single-equation gmm case ,we have to adopt the two-step procedure. In the first step, we assume that ϵ is independent and identically distributed. The independent hypothesis implies that the demand and supply relation can be treated separtly i.e ($\sigma_{ds} = \sigma_{sd} = 0$). The error terms are assumed to be identically distributed when its variance is constant i.e ($\sigma_{dd} = \sigma_{ss} = \sigma^2$) [4]. Since $\sigma_{dd} = \sigma_{ss}$ are both assumed to be constant, we can consider them as scalar and compute the weight matrix. Based on this weiht matrix, we solve equation (5) to get initial gmm estimator. This two-step gmm procedure is equivalent to traditional three-stage least square. The 2sls is applied to each single equation in order to compute the weight matrix. And we use this weight matrix to obtain estimator by solving (5). The traditional 3sls is guided by two rules. Firstly, as mentioned above, it assumes conditional homoskedasticity. In other words, the 3sls assumes that the variance of error terms conditional to instruments, $\sigma_{ss}E(Z_sZ_s')$ and $\sigma_{dd}E(Z_dZ_d')$, are constant. Secondly, the 3sls does not discern the list of instruments between the two moments equations. Put differtly, the 3sls used the same list of instruments in the supply and demand function i.e $Z_d = Z_s$. The GMM 3sls introduced by Wooldridge (2010) generalizes the 3sls in two ways. Firstly, the GMM 3sls relaxes the hypothesis of conditional homoskedastciy and allows the covariance matrix to be heterskedastic. Secondly, in contrast to traditional 3sls, the GMM 3sls may assign different instruments to the moments equations i.e the instruments of the demand equation may be different of the instruments used in the supply relation. Further, the GMM 3sls allows to take into account the non linearity of our parameters in the supply relation. In practice, the GMM 3sls is a two-step procedure. The first step consist in estimating the initial estimator by the traditional 3sls described above. Given the initial estimator, we predict the error terms for each of moment equation [5]. In the second step, we solve (5) using a weight matrix that allows for heteroskedasticity

$$\hat{W} = \frac{1}{N}\sum_i Z_i'\hat{\epsilon}_i\hat{\epsilon}_i{}'Z_i$$

As in the single-equation GMM, this procedure can continued until convergence achieved. In the empirical part of this paper, we use both 3sls and GMM 3sls. In the next section, we describe the data used to estimate the model.

[4] without subscript ϵ refers to the two moment equation

[5] $\epsilon = Y - \theta X$

5 Data and descriptive statistics

Monthly data from January 2006 to December 2013 for PDO Cantal and Comté are used to estimate the structural model of demand and supply (6). All variables are provided by the Direction of Statistics of French Ministry of Agricultural (SSP-Agreste, Enquête Mensuelle Laitière) except the international dairy price index obtained from the Food and Agriculture Organization of the United Nations (FAO, UN).

Descriptive statistics of the variables are reported in table 1. The quantity of milk (Q) and milk price (P) at farm gate are measured in million of liter and euro per liter, respectively. The price index of Juices (P_{juices}) does not require unit since it is an index. Similarly, the animal food price (P_{feed}) is an index. Income is measured in thousand of euros per head. Turning to additional instruments, the natural gas price and domestic fuel price are expressed in euro per kw and euro per liter, respectively. While the international dairy price index does not require unit.

Table 1: Descriptive statistics of used variables

Variable	**Mean**	**Std. Dev.**	**N**
Cantal milk price (Euro per liter)	0.32	0.036	96
Comté milk price (Euro per liter)	0.413	0.044	96
Production of Cantal milk (in million liters)	29.976	2.883	96
Production of Comté milk (in million liters)	47.139	5.350	96
income per head (in thousand euros)	2.154	0.054	96
Index price of juices	111.9	8.757	96
Index price of animal food	144.407	35.7	96
Natural gas price (Euro per kw)	3.384	0.605	96
Domestic fuel price (Euro per liter)	0.775	0.149	96
International dairy price index	157.431	32.709	96

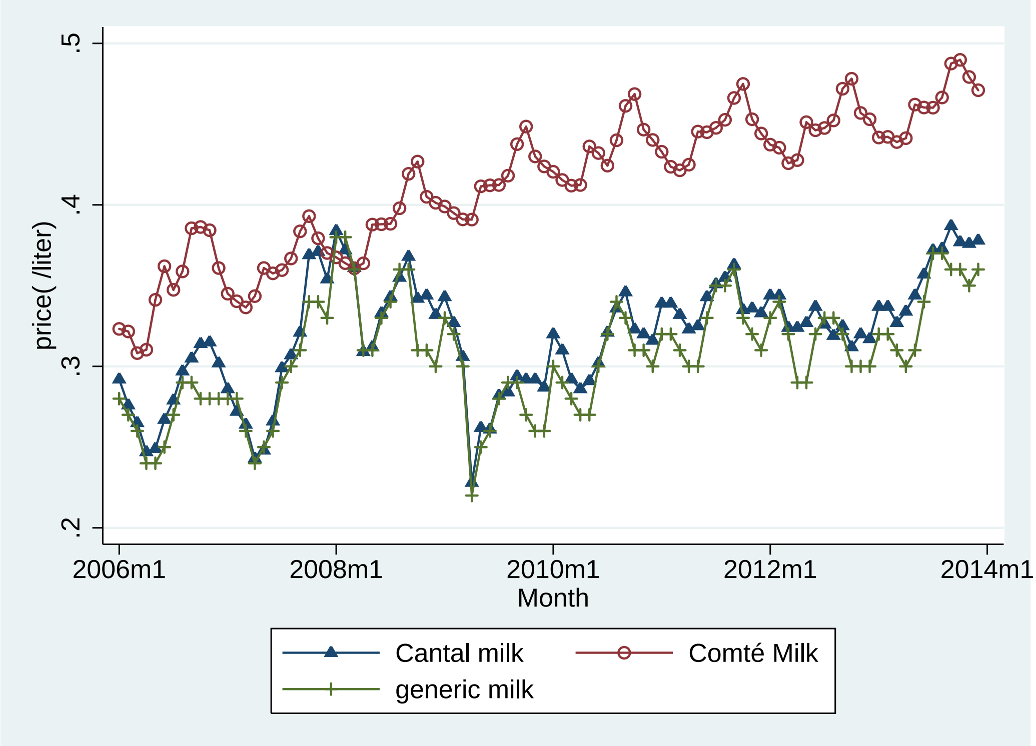
Figure 1 displays the evolution of Comté, Cantal and generic milk price, over January 2006 to December 2013. The difference between Comté and Cantal milk price is high. The difference in January 2006 was around 0.03 euro per liter and has been increasing over time to reach 0.09 euro per liter. The difference between Comté and Cantal milk price has been multiple by three, how can one explain this difference? Is it determined by the bairgaining power of Comté farmers or simply hided a market power due to supply control practices in Comté but not in Cantal? An initial answer to these questions may be found by looking to quantity of milk produced by the two PDO supply chain. Figure 2, in appendix, shows the evolution of quantity produced by each supply chain. One can note that the Comté milk production has significantly increased over perid. Also, in table 1, one can see that the quantity of Comté milk averaged 47 millions of liter, while the average production of Cantal is 30 millions of liters. This indicates that the difference between Comté and Cantal price is not due to supply control since the former has increased its production over time. If we consider standard deviation as a measure of volatiliy, we can see that the prices are relatively stable over time. There is not significant difference between Comté and Cantal milk price in term of volatility.

In the next section, we further investigate the existence of market power at farmers' level in Cantal and Comté supply chain. We estimate the degree of competitiveness between farmers and formally test whether there is market power or not?

6 Estimation results

We first estimate our system (6) using the 3sls described in the previous section. The results are reported in the first two columns of table 2.

Figure 1: Dynamic of the price of Comé, Cantal and generic milk at farm gate



Firstly, concerning the demand, as expected, the milk price has negative effect on the demand in the Cantal case, which is unfortunaly not statistically significant. In Comté, the price has positive and highly significant effect on demand. This result is unexpected and we can see on figure 3 in appendix that the price of Comté and the production increase at the same time. This result may be explained by the high penetration rate of market characterize by the fact that Comté faced new customers every year. The juices price used as substitute product to milk has positive and significant effect on demand in Comté. This result is expected since an increase in substitute price leads to an increasing demand of milk. As expected, the income has positive and highly significant effect on the Cantal milk demand. This effect is negative in Comté but not significant at 1% level.

Secondly and most important results concern the estimation point of the degree of competitiveness since the aim of this paper is to measure the extend of market power exert by Comté and Cantal farmers. As exposed in the theoretical model, $\lambda \in [0;1]$. An estimated point of $\lambda = 0$ means that the PDO milk market is perfectly competitive, while a value of $\lambda = 1$ indicates that farmers charged monopoly price. When the estimated point of $\lambda \in]0;1[$, we have monopolistic competition. Keep in mind these three scenarios, let us see what happened on the Cantal and Comté milk market. First of all, note that the estimated point of λ, reported in table 2, lies in the appropriate interval. According to our estimation ,the degree of competitiveness λ varies between 0.02 to 0.1 indicating that the estimated point belong to right interval. More precisely, the estimated points of λ are 0.023 and 0.14 for Comté and Cantal, respectively. In term of comparison, this result indicates that Comté market is more competitive than Cantal one. However, the parameter of market power are not statistically significant at the conventional level of 5%, indicating that farmers in both supply chains do not introduce distorsions into market. Further, we conduct unilateral test to characterize the Comté and Cantal milk market. We successively test the hypothesis of monopoly (H_0:$\lambda = 1$ vs H_1: $\lambda < 1$) and perfect competition (H_0:$\lambda = 0$ vs H_1:$\lambda > 0$). The results are reported at the bottom of table 2. While the test clearly rejects the hypothesis of monopoly at 1% level, it fails to reject the perfect competition. Therefore, we conclude that Cantal PDO and Comté PDO farmers do not exercise market power. Similar results were found by Merel (2008) at the ripeners stage of supply chains. He found that sellers' market power is small and statistically insignificant and concludes that the Comté market was perfectly competitive from 1985 to 2005.

Finally, in order to check the robustness of our results, we also employ gmm estimator introduced by Hansen (1982). This method allow us to correct for autocorrelation and heteroskedasticity through the Newey and West (1987) procedure. Overall, the gmm estimator results reported in the last two columns corroborate the results obtain by 3sls.

Table 2: Estimation of market power

	3SLS		GMM	
	Comté	Cantal	Comté	Cantal
α_0	-364.4***	-6.911	-174.2	14.41
	(0.000)	(0.868)	(0.104)	(0.719)
α_1	1152.3***	-261.5	595.5	-265.3
	(0.000)	(0.078)	(0.066)	(0.061)
α_2	3.832***	-0.372	1.862	-0.488
	(0.000)	(0.330)	(0.098)	(0.189)
α_3	-8.948***	1.185	-4.279	1.612
	(0.000)	(0.336)	(0.110)	(0.181)
α_4	-37.68*	55.53***	-16.82	45.33***
	(0.045)	(0.000)	(0.362)	(0.000)
λ	0.0233	0.143	0.0914	0.0452
	(0.415)	(0.487)	(0.184)	(0.400)
β_0	0.0324	0.334***	0.0485	0.262***
	(0.441)	(0.000)	(0.254)	(0.000)
β_1	0.00712***	-0.00452	0.00740***	-0.00196
	(0.000)	(0.082)	(0.000)	(0.308)
β_2	0.000408***	0.000603***	0.000405***	0.000708***
	(0.000)	(0.000)	(0.000)	(0.000)
$\lambda = 0$ vs $\lambda > 0$	0.66	0.48	1.77	0.71
	(0.415)	(0.487)	(0.184)	(0.399)
$\lambda = 1$ vs $\lambda < 1$	1162.08***	17.31***	174.94***	316.10***
	(0.000)	(0.000)	(0.000)	(0.000)

p-values in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

7 Conclusion

In this paper we have estimated the extend of the market power exert by the Protected Designation of Origin (PDO) supply chains, with a focus on Cantal and Comté milk market. The market power is measured by a conduct parameter derived from a New Empirical Industrial Organization (NEIO) approach. According to NEIO approach, the PDO milk market is perfectly competitive when the conduct paramater is equal to zero, monopoly when the conduct parameter equal one. and between zero and one, we have monopolistic competition. The market power measured by conduct parameter was estimated using a nonlinear three stage least square through January 2006 to December 2013. The estimated parameter of market power are not statistically significant at the conventional level indicating that farmers in Comté and Cantal do not introduce distorsions into milk market. Further, we formally test the hypothesis of monopoly and perfect competition. While the test clearly rejects the hypothesis that farmers charged monopoly price at 1% level, it fails to reject the perfect competition. Therefore, we conclude that Cantal PDO and Comté PDO do not exert market power, at least at farmers' level.

A Derivation of supply relation

Let us consider a representative farmer (i), who maximizes its profit, denoted by π_i

$$Max\pi_i = Pq_i - c_i$$

Subject to $P = P(Q)$; $Q = q_i + \sum_{i \neq j} q_j$; $\sum_{i \neq j} q_j = f(q_i)$; $c_i = c_i(q_i)$.

Where P represents the milk price, q_i the quantity of milk produced by the farmer (i), $\sum_{i \neq j} q_j$ the quantity of milk produced by other farmers, Q the total quantity and c_i the cost function of farmer (i). The derivative profit π_i with respect to the quantity q_i produced by farmer (i) is given by

$$\frac{\partial \pi_i}{\partial q_i} = P + \left(\frac{dP}{dQ}\right)\left(\frac{dQ}{dq_i}\right) q_i - \frac{dc_i}{dq_i}$$

Given the definition of demand elasticity, $\eta = -\left(\frac{dQ}{dP}\right)\left(\frac{P}{Q}\right)$, we obtain

$$\frac{\partial \pi_i}{\partial q_i} = P - \frac{1}{\eta}\left(\frac{dQ}{dq_i}\frac{q_i}{Q}\right) P - \frac{dc_i}{dq_i}$$

The first order condition implies to equalize the RHS of the previous equation to zero. So the first order condition implies

$$P\left(1 - \frac{\lambda_i}{\eta}\right) = mc_i$$

Where mc_i is the marginal cost and $\lambda_i = \left(\frac{dQ}{dq_i}\frac{q_i}{Q}\right)$, measures the degree of horizontal competition among farmers. $\lambda_i \in [0; 1]$ is known as conjectural variation or conduct parameter. When $\lambda_i = 0$, there is perfect competition since that each farmer charged a price that equalizes its marginal cost ($P = mc_i$). When $\lambda_i = 1$, farmers are charging monopoly price, and a value of λ_i between 0 and 1 indicates monopolistic competition.

Multiplying the previous equation by the share market of each farmer and summing up on all farmers, we obtain the degree of competitiveness at mean value

$$P\left(1 - \frac{\lambda}{\eta}\right) = MC \tag{7}$$

There are two different ways to estimate the degree of competitiveness λ. The first method is to estimate λ as residual. If demand elasticity η is known and given the marginal cost (MC), we can compute the value of λ for each year. The second way to determine the degree of competitiveness consists in estimating simultaneously a system of demand and supply relation. Let us assume a linear demand function, specify as follow

$$Q = \alpha_0 + \alpha_1 P + \alpha_2 P_{juices} + \alpha_3 Income + \alpha_4 P * P_{juices} + \epsilon_d$$

The demand of elasticity defined as

$$\eta = -\left(\frac{dQ}{dP}\right)\left(\frac{P}{Q}\right)$$

Since from the demand equation $\frac{dQ}{dP} = \alpha_1 + \alpha_4 P_{juices}$, the demand elasticity becomes

$$\eta = -\left(\alpha_1 + \alpha_4 P_{juices}\right)\left(\frac{P}{Q}\right) \tag{8}$$

Now let us assume a linear marginal cost, defined as

$$MC = \beta_0 + \beta_1 Q + \beta_2 P_{feed} + \epsilon_s \tag{9}$$

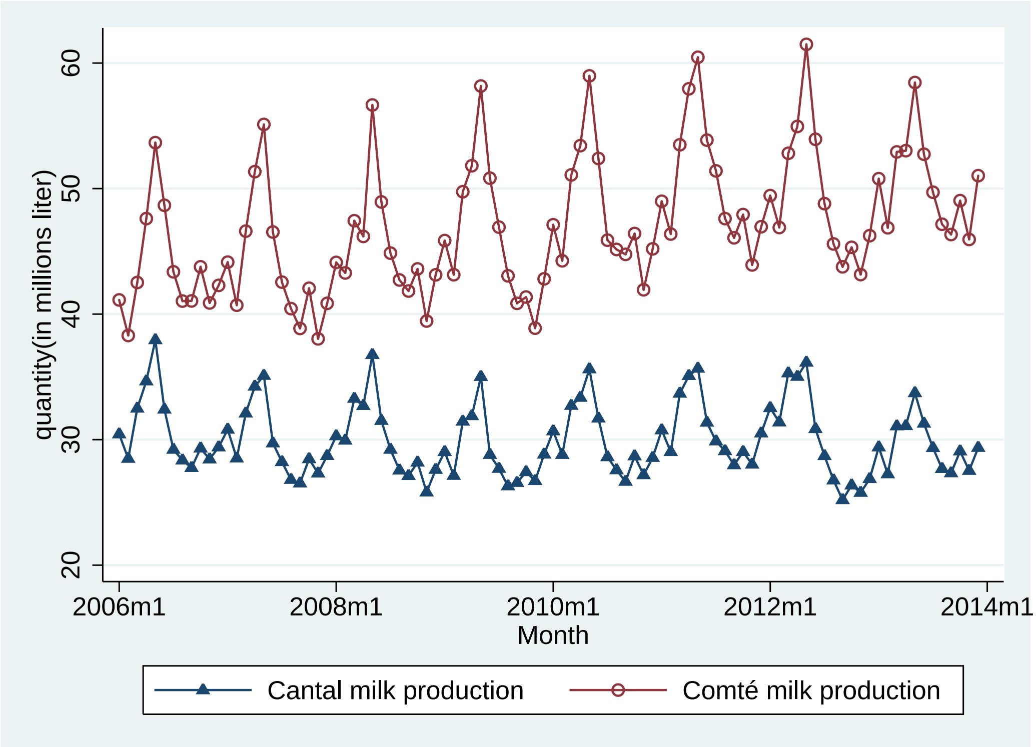
Then replacing the demand elasticity (8) and marginal cost (9) into the supply relation (7), we obtain after simplification the following supply relation.

$$P = \left(\frac{-\lambda}{\alpha_1 + \alpha_4 P_{juices}} \right) * Q + \beta_0 + \beta_1 Q + \beta_2 P_{feed} + \epsilon_s \quad (10)$$

which is jointly estimated with the demand function.

B Descriptive statistics

Figure 2: Evolution of Cantal and Comté milk production over 2006-2013



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