European Dairy Industry Model

IMPERFECT COMPETITION IN A SPATIAL MODEL OF THE EUROPEAN DAIRY INDUSTRY

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Abstract: This paper analyses imperfect competition in a spatial model that is applied to the European dairy industry. We show how imperfect competition can be introduced within the dairy industry model developed by Bouamra et al. (2002). We then simulate four scenarios that differ in the assumptions on competition. We show that the existence of market power significantly modifies the implicit price of milk components, may lead to an increase in EU exports and that domestic prices are not adequate indicators of competitiveness in the presence of market power. Distribution in surplus among agents is changed and large welfare losses may be generated.

Keywords: spatial model, imperfect competition, milk and dairy products, agricultural policy, milk quota.

Introduction

Most models used to analyze the economic impact of agricultural policies consider that agricultural markets work in a perfectly competitive framework. If this assumption seems reasonable as long as one deal with agricultural raw products at a country level (or at the EU level), this assumption is more questionable when analysing international trade and/or food markets (that is processed product markets). It is particularly the case for the analysis of dairy policies which directly act on processed product markets. Thus, it is important to develop analysis of agricultural policy that integrates some aspects of imperfect competition. The aim of this contribution is to focus on the introduction of imperfect competition in spatial models applied to the dairy sector.

A short review of literature defines where we stand. Then, we provide some evidence of imperfect competition in the dairy sector. In the third section, we develop a simplified model for the dairy industry in the EU that integrates imperfect competition. The fourth section presents and discusses the simulation results for different competitive framework. And finally, we summarize the main findings in the concluding part.

1. A brief review of the literature on imperfect competition in spatial models

Most of spatial equilibrium models assume perfect competition. Thus, they do not take into account the non competitive effects that may arise because of the existence of oligopolies on markets. The existence of oligopolistic behaviour on markets may influence market equilibrium and qualifies the existing models results.

However, there exist few spatial oligopolistic market models. A first attempt has been developed by Takayama and Judge (1971) who considered a spatial monopoly market model and analyse how market equilibrium was modified compared to the perfectly competitive spatial model. In their setting, they assumed that the same firm operates in all the regions. When resale among regions is not possible, then the monopolist discriminates price among regions. They showed that when there is trade from region i to region j then the marginal revenue of the firm in market j is exactly equal to the marginal cost of the firm in region i plus the transportation cost from i to j. Note that in the perfect competition framework, the equality is between the price in market j and the marginal cost of the firm in region i plus the transportation cost from i to j. Obviously, in the monopoly case, prices are higher and productions are lower than in the perfect competition case. Takayama and Judge also explored monopoly pricing rule when resale among regions is possible (that is assuming that arbitrage is possible). This imposes additional constraint for the monopoly, namely prices among regions cannot differ more than the transportation cost between the considered regions. Hashimoto (1984) has extended the model proposed by Takayama and Judge and developed a spatial Nash non cooperative equilibrium model. He considered that there is one firm per region which competes à la Cournot with the other firms. A comparison of the Nash equilibrium model with the perfect competitive and the monopoly models shows that the differentials in interregional prices in the Nash equilibrium are greater than in the perfect equilibrium framework and lower than in the monopoly case. Hashimoto also showed that market equilibriums (demand, supply, prices) are modified and that the trade flows may differ from one framework to the other. In the non competitive setting, trade between regions depends not only on transportation costs but also on additional margins that are proportional to the level of imports.

Nelson and McCarl (1984) proposed a modified version of the spatial equilibrium model to analyse an oligopoly model. They discussed how to integrate different market structures (Cournot, Stackelberg and conjectural variations). The methodology consists in modifying the perfect equilibrium framework by adding a condition of maximisation of firms' profits that take into account the strategic interactions between firms. However, they assumed that all firms (one firm in each region) have identical costs and that transportation costs are zero. This considerably reduces the empirical attractiveness of their model. More recently, Yang, Hwang and Sohng (2002) have extended the symmetric spatial Cournot competition model developed in the literature to heterogeneous demand and cost functions. In particular, they defined necessary conditions for the uniqueness of solution. They applied it to the US coal market.

However, the implementation of imperfect competitive framework in applied models is still not well studied. In the food sector, Kawaguchi, Suzuki and Kaiser (1997) have applied an imperfectly competitive spatial equilibrium model to the dairy industry in Japan using the general methodology developed by Nelson and McCarl (1984) and Hasimoto (1984). They took into account the specificities of the Japan milk market organization. In particular, they distinguished the fluid milk market from manufacturing milk market. Market power on the fluid milk market is analysed while quota and guaranteed price prevails on the manufacturing milk market. Moreover, they integrated the pooled price policy used in this country. They found that the Cournot-Nash equilibrium solutions were more similar to actual observations compared to the monopoly case or to the perfectly competitive framework.

It should be stressed that under a perfect competition framework, trade between regions is always one-way trade. On the contrary, with an imperfect competition framework (and homogenous products), two-way trade occurs in numerous cases. This framework is thus one of the possible explanations of two-way trade frequently observed. Note that another important explanation is related to product differentiation. Numerous empirical models are built upon the seminal work of Armington (1969).
As shown by Brander and Krugman (1983), from a theoretical point of view, different situations may occur from no trade to bilateral trade given the market structure, the production and trade costs, and the pattern of demand in each country as well as policy instruments.

2. Some evidence of imperfect competition in the EU dairy sector

The concentration of the dairy industry in the European Union is diverse. It depends on the country as well as on the product. We provide in Table 1 some ratio of concentration for some EU countries.

Thus concentration ratio considerably varies among countries as well as products. It seems that concentration is higher in France and UK as compared to Germany and Italy. We do not have statistics on the Netherlands or Denmark but it is very likely that concentration ratios are higher in these two countries as production is dominated by one or two large cooperatives.

Table 1. - Level of concentration of dairy processors (year 2002)

	Germany	Italy	France	UK
Liquid Milk				
CR-3		56.2	63.0	73.0
CR-6	49.8			
Butter				
CR-3	24.3	26.1	46.0	87.0
Powders				
CR-3	40.4	-	40.0	
CR-4				67.6
All cheeses				
CR-3			48.0	
CR-8				74.0
CR-10			76.0	
CR-16	49.3			
Hard cheese				
CR-3		22.6	60.0	

Source: contributions of EDIM project researchers

It also should be stressed that concentration in the cheese industry is significantly higher as soon as we consider separately the main cheese categories. This directly questions the definition of the relevant market. To illustrate this point, Table 2 provides information on the concentration ratio in the French cheese industry.

Table 2. - Concentration ratio in the French cheese industry (2000)

	CR-4	HHI
All cheeses	39.5%	570
Hard cheese	60.2%	1233
Semi-Hard cheese	39.1%	590
Soft cheese	61.9%	1374
Blue cheese	66.4%	1242
Fresh cheese	63.2%	1262
Processed cheese	89.9%	3748

Source: Chaaban, 2004.

To our knowledge, very few works analyzed the issue of imperfect competition for the EU dairy sector. The imperfect competition issue has received relatively low attention by European agricultural economists while this topic has received more attention for the US market. As McCorriston (2002) underlines, imperfect competition should not be neglected since evidence suggests that agricultural markets in Europe are oligopolistic and, in particular, there is a growing market power of retailers. Hence, if imperfect competition is important, it has implication also in the way government's agricultural policies are designed and evaluated.

Some works evaluate the degree of price transmission in the industry. Only few directly tests for market power. Milan (1999) studies the structure of 18 food industries in Spain for the period 1978-1992. The estimated Learner index shows the existence of market power for most of the industries, where the dairy industry rank ninth with a value of 0.072 significantly different from zero. Gohin and Guyomard (2000) focus on the retail level. According to their results, more than 20 percent of the wholesale-to-retail price margin for dairy products can be attributed to market power distortions. To get a more complete view, the reader should refer to Bouamra-Mechemache, Réquillart and Soregaroli (2004).

3. A spatial equilibrium model of the European dairy industry

3.1 Perfect competition assumption

We first present the spatial equilibrium model of the European dairy industry developed by Bouamra et al. (2002). It integrates the whole channel of the EU dairy industry from the supply of milk to the demand for final commodities through an intermediate step of processing milk into final commodities. It is an hedonic (milk characteristics), spatial equilibrium model which integrates an agricultural product (cow milk), 2 milk components (fat and protein), the different member states (14) and the rest of the world, and 14 final dairy products. The model integrates the EU dairy policy instruments that include milk production quota, intervention prices as floor prices for butter and SMP domestic markets, domestic subsidies for industrial uses of butter and SMP, a production subsidy for casein, export subsidies and import tariff rate quotas for each final dairy product as well as direct decoupled payments (June 2003 Luxemburg agreement). Moreover, GATT import and export commitments are explicitly modelled. We now formally present the model.

The inverse supply function for milk in region *i* is denoted $S_i(X_i)$ with X_i the quantity of milk collected. We denote c_x the constant marginal cost for collecting milk in each region. Because milk is a bulk product, we do not allow trade of raw milk between regions.

We denote $Y_{i,k}$ the production of the processed commodity *k* in region *i*. Production of commodity *k* involves two basic components (fat and protein) that are an integral part of raw milk and that are “rearranged” and allocated among processed commodities. We denote $\alpha_{i,s}$ the quantity of the s^{th} component per unit of raw milk produced in region *i* and $\gamma_{k,s}$ the quantity of the s^{th} component per unit of processed commodity *k*. Note that milk composition varies across regions while composition of final commodities does not. Final commodities are traded among regions and are assumed to be homogenous. Under a Leontief technology, the transformation of the raw milk into processed commodities must satisfy:

$$\sum_k Y_{i,k}\gamma_{k,s} \le X_i \alpha_{i,s} \qquad \forall i,s \tag{1}$$

Equation (1) ensures the balance in the allocation of component *s* in region *i*. Besides milk components, the production of commodity *k* also involves labour and capital inputs, which are provided at a constant marginal cost c_k. We assume that processing costs are identical among regions.

The inverse demand function for each final commodity k in region i is denoted $D_{i,k}(Z_{i,k})$ where $Z_{i,k}$ denotes the consumption of commodity k in region i. Similarly, the net import demand function from the rest of the world is denoted $D_{row,k}(Z_{row,k})$ where $Z_{row,k}$ denotes the consumption of commodity k in the rest of the world.

Trade across regions involves transportation cost. We assume a constant marginal cost for transportation of commodity k from region i to region j and denote it $t_{i,j,k}$. Intra-trade flows, denoted by $XD_{i,j,k}$, represent the quantity of commodity k that is transported from region i to region j. Note that $XD_{i,i,k}$ is the quantity of commodity k that is both produced and consumed in the same region i. Similarly extra-trade flows, denoted by $XE_{i,k,ex}$, represent the quantity of commodity k that is exported from region i to the rest of the world in the export regime ex. We distinguish subsidized exports (ex = "*sub*") from non subsidized exports (*ex* = "*nsub*"). The per-unit export subsidy for commodity k is denoted by $ES_{k,ex}$. Note that $ES_{k,"nsub"} = 0,\ \forall k$. The trade flow constraints across regions are:

$$\sum_j XD_{i,j,k} + \sum_{ex} XE_{i,k,ex} \le Y_{i,k} \qquad \forall i,k \tag{2}$$

$$Z_{i,k} \le \sum_j XD_{j,i,k} \qquad \forall i,k \tag{3}$$

$$Z_{row,k} \le \sum_{i,ex} XE_{i,k,ex} \qquad \forall k \tag{4}$$

In any region, these equations guarantee that exports plus domestic use cannot be larger than domestic production (equation 2), and that domestic consumption cannot exceed domestic production plus imports (equation (3) and equation (4)).

The model includes milk quota in each region i denoted by $\overline{X}_i$. We thus write the milk quota constraint as:

$$X_i \le \overline{X}_i \qquad \forall i\,. \tag{5}$$

We also introduce a constraint on the volume of subsidized exports denoted by $\overline{XE}_k$. We thus have:

$$\sum_i XE_{i,k,"sub"} \le \overline{XE}_k \qquad \forall k \tag{6}$$

As a basis for representing resource allocation, we consider the following optimization problem:

$$Max_{X_i, Y_{i,k}, Z_{i,k}, XD_{i,j,k}, XE_{i,k,ex}} QW(X_i, Y_{i,k}, Z_{i,k}, XD_{i,j,k}, XE_{i,k,ex}) =$$

$$\sum_{i,k}\int_0^{Z_{i,k}} D_{i,k}(u)du + \sum_k \int_0^{Z_{row,k}} D_{row,k}(u)du - \sum_i \int_0^{X_i} S_i(u)du - \sum_i X_i c_x - \sum_{i,k} c_k Y_{i,k} - \quad (7)$$

$$\sum_{i,j,k} t_{i,j,k} XD_{i,j,k} - \sum_{i,k,ex}(t_{i,\text{"row"},k} - ES_{k,ex}) XE_{i,k,ex}$$

Subject to (1)-(6), $X_i \geq 0, Y_{i,k} \geq 0, Z_{i,k} \geq 0, XD_{i,j,k} \geq 0, XE_{i,k,ex} \geq 0$.

Consider the Lagrangean associated with equation (7):

$$L = \sum_{i,k}\int_0^{Z_{i,k}} D_{i,k}(u)du + \sum_k \int_0^{Z_{row,k}} D_{row,k}(u)du - \sum_i \int_0^{X_i} S_i(u)du - \sum_i X_i c_x - \sum_{i,k} c_k Y_{i,k}$$
$$- \sum_{i,j,k} t_{i,j,k} XD_{i,j,k} - \sum_{i,k,ex}(t_{i,\text{"row"},k} - ES_{k,ex}) XE_{i,k,ex} - \sum_{i,s} \lambda^c_{i,s}(\sum_k Y_{i,k}\gamma_{k,s} - X_i \alpha_{i,s})$$
$$- \sum_{i,k} \lambda^Y_{i,k}(\sum_j XD_{i,j,k} + \sum_{ex} XE_{i,k,ex} - Y_{i,k}) - \sum_{i,k}\lambda^Z_{i,k}(Z_{i,k} - \sum_j XD_{j,i,k})$$
$$- \sum_k \lambda^{row}_k (Z_{row,k} - \sum_{i,ex} XE_{i,k,ex}) - \sum_i \lambda^q_i (X_i - \overline{X}_i) - \sum_k \lambda^w_i (\sum_i XE_{i,k,\text{"sub"}} - \overline{XE}_k)$$

where $\lambda^c_{i,s} \geq 0, \lambda^Y_{i,k} \geq 0, \lambda^Z_{i,k} \geq 0, \lambda^{row}_k \geq 0, \lambda^q_i \geq 0, \lambda^w_i \geq 0$, $\forall i,k,s$, are the Lagrange multipliers associated to constraints (1) to (6).

The Kuhn-Tucker conditions associated with the above maximization problem are:

$$\partial L / \partial X_i = -S_i(X_i) - c_x + \sum_s \lambda^c_{i,s}\alpha_{i,s} - \lambda^q_i \quad \begin{matrix} \leq 0, & X_i = 0 \\ = 0, & X_i > 0 \end{matrix} \quad \forall i \quad (8)$$

$$\partial L / \partial Y_{i,k} = -c_k - \sum_s \lambda^c_{i,s}\gamma_{k,s} + \lambda^Y_{i,k} \quad \begin{matrix} \leq 0, & Y_{i,k} = 0 \\ = 0, & Y_{i,k} > 0 \end{matrix} \quad \forall i,k \quad (9)$$

$$\partial L / \partial Z_{i,k} = D_{i,k}(Z_{i,k}) - \lambda^Z_{i,k} \quad \begin{matrix} \leq 0, & Z_{i,k} = 0 \\ = 0, & Z_{i,k} > 0 \end{matrix} \quad \forall i,k \quad (10)$$

$$\partial L / \partial Z_{row,k} = D_{row,k}(Z_{row,k}) - \lambda^{row}_k \quad \begin{matrix} \leq 0, & Z_{row,k} = 0 \\ = 0, & Z_{row,k} > 0 \end{matrix} \quad \forall k \quad (11)$$

$$\partial L / \partial XD_{i,j,k} = -t_{i,j,k} - \lambda^Y_{i,k} + \lambda^Z_{j,k} \quad \begin{matrix} \leq 0, & XD_{i,j,k} = 0 \\ = 0, & XD_{i,j,k} > 0 \end{matrix} \quad \forall i,j,k \quad (12)$$

$$\partial L / \partial XE_{i,k,\text{"sub"}} = -t_{i,\text{"row"},k} + ES_{k,\text{"sub"}} - \lambda^Y_{i,k} + \lambda^{row}_k - \lambda^w_i \quad \begin{matrix} \leq 0, & XE_{i,k,\text{"sub"}} = 0 \\ = 0, & XE_{i,k,\text{"sub"}} > 0 \end{matrix} \quad \forall i,k \quad (13a)$$

$$\partial L / \partial XE_{i,k,\text{"nsub"}} = -t_{i,row,k} - \lambda^Y_{i,k} + \lambda^{row}_k \quad \begin{matrix} \leq 0, & XE_{i,k,\text{"nsub"}} = 0 \\ = 0, & XE_{i,k,\text{"nsub"}} > 0 \end{matrix} \quad \forall i,k \quad (13b)$$

Interpreting λ^q_i as the unit quota rent in region *i*, equation (8) implies that when production is positive, the farm-gate price of milk, that is equal to the marginal cost plus the unit quota rent, is equal to the value of milk components minus the milk collecting cost. From equation (9), we interpret $\lambda^Y_{i,k}$ as the producer price for commodity *k* in region *i*. Similarly, from equations (10) and (11), $\lambda^{Z}_{i,k}$ and λ^{row}_{k} are market prices of commodity *k* in region *i* and in the rest of the world respectively.

Equation (12) states that if trade occurs from region *i* to region *j*, then the difference between the consumer price in region *j* and the producer price in region *i* is equal to the transportation cost between the two regions. Equation (13b) is equivalent to equation (12) in the context of international trade. Equation (13a) shows that export subsidy acts in the opposite direction of transportation costs. In addition, when the WTO constraint on subsidized exports is binding, an additional cost appears that corresponds to the shadow value associated to the constraint.

3.2 Imperfect competition assumption

We now assume that only few firms are active on some final commodity markets. These firms therefore exert some market power which we want to take into account. We assume a Cournot-Nash competition that is firms choose strategically their level of production. A firm can act on different markets in two ways. First, a firm can sell a given product in the different regions. Alternatively, a given firm can sell different products in a given region. As marginal costs are assumed to be constant in our setting (neither scale nor scope economies) and demands are independent, the maximisation program of a firm on a given market is then separable in all the choice variables (quantities sold on the different markets).

Formally, the maximisation program of a firm in region *i* which produces different commodities *k* is given by:

$$Max_{xd_{i,j,k},xe_{i,k}} \pi_i(xd_{i,j,k}, xe_{i,k}) =$$
$$\sum_{j,k} D_{j,k}(Z_{j,k})xd_{i,j,k} + \sum_{k} D_{row,k}(Z_{row,k})xe_{i,k} - \sum_{j,k} c_k(xd_{i,j,k} + xe_{i,k}) - \sum_{j,s} p_{i,s}\gamma_{k,s}(xd_{i,j,k} + xe_{i,k})$$
$$- \sum_{j,k} t_{i,j,k} xd_{i,j,k} - \sum_{k,ex} (t_{i,"row",k} - ES_{k,ex}) xe_{i,k,ex}$$

with $p_{i,s}$ the price of component *s* in region *I* and $xe_{i,k} = \sum_{ex} xe_{i,k,ex}$.

We thus consider that firms do not exert oligopsony power. Quantities produced by a firm are denoted in lower case letter while aggregate quantities are in upper case letter. Assuming that there are $n_{i,k}$ identical firms producing *k* on market in region *i*, we get $xd_{i,j,k} = XD_{i,j,k} / n_{i,k}$. First order conditions are given by:

$$\frac{\partial \pi_i(xd_{i,j,k}, xe_{i,k})}{\partial xd_{i,j,k}} = D_{j,k}(Z_{i,k}) + \frac{\partial D_{j,k}(Z_{i,k})}{\partial xd_{i,j,k}} xd_{i,j,k} - c_k - \sum_s p_{i,s}\gamma_{k,s} - t_{i,j,k} = 0 \qquad (14a)$$

$$\frac{\partial \pi_i(xd_{i,j,k}, xe_{i,k})}{\partial xe_{i,k,ex}} = D_{row,k}(Z_{row,k}) + \frac{\partial D_{row,k}(Z_{row,k})}{\partial xe_{i,k,ex}} xe_{i,k,ex} - c_k - \sum_s p_{i,s}\gamma_{k,s} - t_{i,"row",k} + ES_{k,ex} = 0 \tag{14b}$$

As it can be seen from above, firms consider each country as a separate market and its marginal revenue in a market is achieved independently of the other markets. If firms behave as "price takers" i.e. if they are in a perfectly competitive market, then $\frac{\partial D_{j,k}(Z_{j,k})}{\partial xd_{i,j,k}} = 0$. The marginal revenue of firm *i* in market *j* for commodity *k* is equal to the market price. However, if firms have some market power, then $\frac{\partial D_{j,k}(Z_{j,k})}{\partial xd_{i,j,k}} < 0$. Market prices will be higher than marginal revenue, which allows for some markup to the oligopolistic firms.

In order to introduce imperfect competition behaviour among firms or regions, the literature shows that the objective function has to be adjusted in such a way that the first order conditions of the model will now reflect the conditions of firms' profit maximization under strategic interaction.

Using conditions (14a and 14b), the model can be rewritten as the following maximizing program adjusted for imperfectly competitive market when n_i firms are acting in region *i*:

$$\begin{aligned}
&Max_{X_i, Y_{i,k}, Z_{i,k}, XD_{i,j,k}, XE_{i,k,ex}} QW(X_i, Y_{i,k}, Z_{i,k}, XD_{i,j,k}, XE_{i,k,ex}) = \\
&\sum_{i,k}\int_0^{Z_{i,k}} D_{i,k}(u)du + \sum_{i,j,k}\int_0^{XD_{i,j,k}} \frac{1}{n_{i,k}} \frac{\partial D_{j,k}(u_{j,k})}{\partial u_{i,j,k}} u_{i,j,k} du_{i,j,k} \\
&+ \sum_{i,k,ex}\int_0^{XE_{i,k,ex}} \frac{1}{n_{i,k}} \frac{\partial D_{row,k}(u_{k,ex})}{\partial u_{k,ex}} u_{i,k,ex} du_{i,k,ex} + \sum_k \int_0^{Z_{row,k}} D_{row,k}(u)du \\
&- \sum_i \int_0^{X_i} S_i(u)du - \sum_i X_i c_x - \sum_{i,k} c_k Y_{i,k} - \\
&\sum_{i,j,k} t_{i,j,k} XD_{i,j,k} - \sum_{i,k,ex}(t_{i,"row",k} - ES_{k,ex}) XE_{i,k,ex}
\end{aligned} \tag{15}$$

Subject to (1)-(6), $X_i \geq 0, Y_{i,k} \geq 0, Z_{i,k} \geq 0, XD_{i,j,k} \geq 0, XE_{i,k,ex} \geq 0$.

The difference between the objective functions in models (7) and (15) is the term :

$$\sum_{i,j,k}\int_0^{XD_{i,j,k}} \frac{1}{n_{i,k}} \frac{\partial D_{j,k}(u_{j,k})}{\partial u_{i,j,k}} u_{i,j,k} du_{i,j,k} + \sum_{i,k,ex}\int_0^{XE_{i,k,ex}} \frac{1}{n_{i,k}} \frac{\partial D_{row,k}(u_{k,ex})}{\partial u_{i,k,ex}} u_{i,k,ex} du_{i,k,ex}.$$

When the market is perfectly competitive, this term is equal to zero and the maximization program is consistent with model (7). If firms behave like Cournot-Nash competitors, then using (14a) and (14b) and the equality between marginal cost and marginal revenue, this term represents the total markup in the different markets. As shown by Kawaguchi, Suzuki and Kaiser (1997), other strategic interactions can be integrated in the model (in particular one can use the conjectural variations in order to model other strategies).

Solving for the Khun and Tucker conditions leads to the first order conditions (8) – (11) found in the perfect competition framework. However, conditions (12), (13a) and (13b) are modified to take into account the markups in the different markets:

$$\partial L / \partial XD_{i,j,k} = -t_{i,j,k} - \lambda_{i,k}^{Y} + \lambda_{j,k}^{Z} + \frac{1}{n_{i,k}} \frac{\partial D_{j,k}(XD_{j,k})}{\partial XD_{i,j,k}} \begin{cases} \leq 0, & XD_{i,j,k} = 0 \\ = 0, & XD_{i,j,k} > 0 \end{cases} \quad \forall i, j, k \tag{16}$$

$$\partial L / \partial XE_{i,k,"sub"} = -t_{i,"row",k} + ES_{k,"sub"} - \lambda_{i,k}^{Y} + \lambda_{k}^{row} - \lambda_{i}^{w} + \frac{1}{n_{i,k}} \frac{\partial D_{row,k}(XE_{i,k,"sub"})}{\partial XE_{i,k,"sub"}} \begin{cases} \leq 0, XE_{i,k,"sub"} = 0 \\ = 0, XE_{i,k,"sub"} > 0 \end{cases}, \ \forall i, k \tag{17a}$$

$$\partial L / \partial XE_{i,k,"nsub"} = -t_{i,row,k} - \lambda_{i,k}^{Y} + \lambda_{k}^{row} + \frac{1}{n_{i,k}} \frac{\partial D_{row,k}(XE_{i,k,"nsub"})}{\partial XE_{i,k,"nsub"}} \begin{cases} \leq 0, & XE_{i,k,"nsub"} = 0 \\ = 0, & XE_{i,k,"nsub"} > 0 \end{cases} \quad \forall i, k \tag{17b}$$

Equations (16), (17a) and (17b) differ from (12), (13a) and (13b) by the last term in the right hand side of the equations that reflects the margins on the considered trade activity. Note that the lower the number of firms acting in the domestic country is, the larger is the associated markup.

3.3 Application to the dairy sector

We develop a simplified version of the dairy spatial equilibrium model presented above, involving only two European Union regions, a northern European region (NORTH) that includes Austria, Denmark, Finland, Germany, Ireland, the Netherlands, Sweden and United Kingdom and a southern European region (SOUTH) that is composed of Belgium, Luxembourg, France, Greece, Italy, Portugal and Spain. In addition to these two aggregates of the EU countries, we consider a net demand for imports from the rest of the world.

The simplified model includes two commodity aggregates. First, we consider the aggregation of “industrial products” (IND). This aggregate is composed of butter, skim milk powder, whole milk powder, condensed milk and casein. The second commodity is the aggregation of “final consumption commodities” (FCT) which includes cheese, liquid milk, cream and fresh products.

The empirical model has been developed from observed data in year 2000 at the member state level and at the commodity level. To compute the aggregation over commodities, we have calculated weighted sum for production, consumption and export quantities using the weighting coefficient β_k

that represents the share of the value of components in commodity *k* in the total value of components included in all commodities:

$$\beta_k = \frac{\sum_s \gamma_{k,s} p_s}{\sum_k \sum_s \gamma_{k,s} p_s}$$

The observed price as well as the technical coefficients of an aggregate of commodities in a given region is computed as the weighted average of prices of the involved commodities by their respective production share in the total production.

We checked the validity of this simplified model on observed data in year 2000 in a perfect equilibrium framework. We then modified this validated simplified model to include imperfect competition assumptions using the methodology presented in the previous section.

The following figure represents the market equilibrium when the final commodity product is produced by a monopoly when quotas are binding. We consider two demands for milk, the derived demand for industrial products (D_{ind}) and the derived demand for final consumption product (D_{fct}). The aggregate demand for milk is thus (D_{fct} + D_{ind}). The equilibrium price in a perfect competition framework is thus P_{pc}. The monopoly equilibrium occurs when the total marginal revenue curve in milk or component equivalent which is equal to the sum of marginal revenue from industrial final consumption commodities and the derived demand for industrial products (D_{nd}+MR_{fct}), intersects the milk supply curve. When quotas are binding, the equilibrium price for industrial products given by p_{ind} is equal to the marginal cost of production at the equilibrium plus a positive quota rent. The price for final consumption commodities is obtained on the demand curve for *FCT* (D_{fct}). The actual price paid to milk producers is P_{ind} assuming that milk producers get the quota rent. Then the price for farmers is given by P_{ind} and processors of final commodity products get a rent equal to (P_{fct}- P_{ind}).

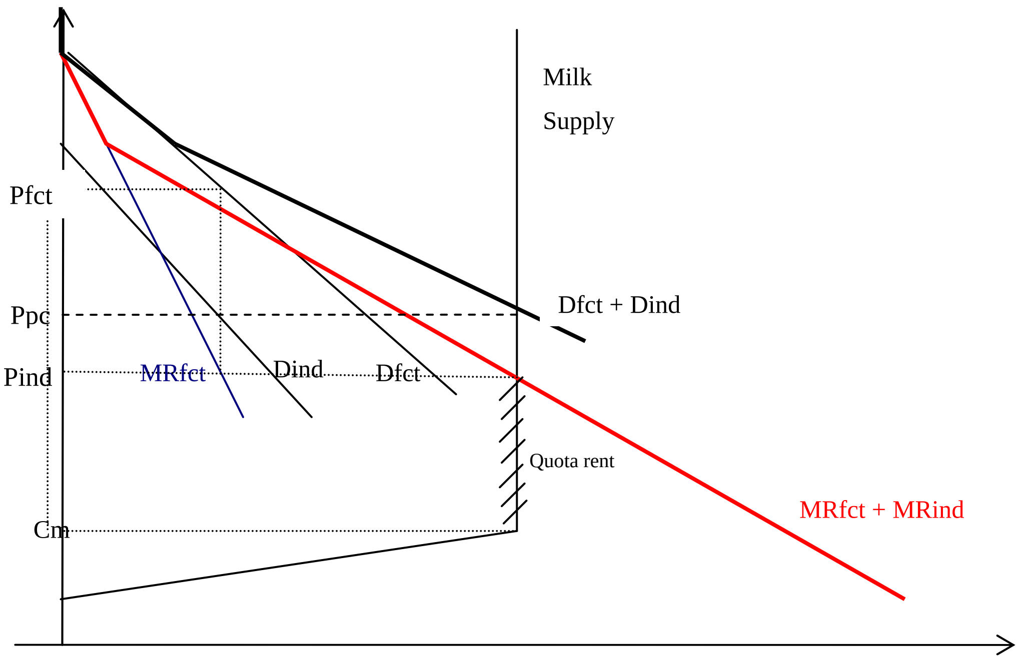

Figure 1: Market equilibrium in a monopoly framework

In the next section, we will compare the market equilibrium for different imperfect competition situations.

4. Simulation results

We compare the results from four scenarios which correspond to different assumptions on competition between firms. In scenario 1, perfect competition is assumed in the two regions and for the two products. This scenario is used as a reference scenario. In scenario 2, we assume that FCT is produced by a monopoly in each region. In scenario 3, we assume that, in each region, FCT is produced by 10 firms that compete à la Cournot. Finally in scenario 4, we assume that, in each region, FCT and IND are produced by 10 firms which compete à la Cournot. Table 3 presents the main results.

When only one firm produces FCT in each region, the milk quota is no longer binding and the equilibrium productions for final products change. Total production of FCT decreases while total production of IND increases. In both regions, firms reduce their production of FCT in order to take advantage of their monopoly power. This has a negative effect on the milk price which induces an increase in the production of IND. The reduction in milk cost generates a decrease in the production cost and thus in the price of IND. Then the consumption increases in each region. However, the increase in IND production is only true at the aggregate level but not at the regional level. Finally, as the marginal cost of production for IND decreases, the EU exports of IND to the rest of the world increase compared to the perfect competition scenario.

The demand for FCT is highly inelastic and contrary to IND, FCT price dramatically increases. Another consequence is the increase in intra-trade. Note that there is some bilateral ‘dumping’ as each firm sells its product in the other EU region at a price lower than the price set in its own region. Even if the price of FCT is now dramatically higher than the world market price, the EU exports for FCT do not decrease as compared to the perfect competition case. This is because firms discriminate prices among countries. On the one hand, firms will reduce their exports on world market in order to take advantage of some market power (however, world markets are much more elastic than domestic ones, which limits the exercise of market power). On the other hand, milk price is lower and competitiveness of FCT has thus increased. This has a positive impact on the level of exports.

Moreover, the presence of market power generates a dramatic change in milk component prices. Both products, IND and FCT, require the utilisation of the two milk components but in different proportions. FCT contains proportionally more protein and IND contains more fat. As a result, the demand for protein decreases more than the demand for fat as the production of FCT significantly falls. This induces an increase in the price of fat and a decrease in the price of protein. These changes in fat and protein prices lead to a decrease in farm milk price (as a result of the decrease in the global demand for milk) and to a decrease in the procurement cost of raw material for the two industries.

Finally, the monopoly in FCT production entails a big change in welfare distribution. This is a consequence of the assumption on the elasticity of demand for FCT which allows huge mark-up on this market. However, as a consequence of market power, the farmer surplus is reduced, the consumer surplus is reduced, the processor surplus is increased, the taxpayer cost is increased following to the increase in exports and global welfare is reduced.

When the market power is lower (scenario 3), results are similar to the one of the second scenario. The market equilibrium is characterized by a reduction in milk price, a change in component prices, an increase in FCT price, larger EU exports and changes in the distribution of surplus as well as in global welfare. However, a closer looks reveals qualitative differences. Now, the decrease in FCT production is lower than in the monopoly case and the quotas on milk production are binding. Moreover, implicit quotas on components (fat and protein) also remain binding. This explains why the productions of IND and FCT remain constant in both regions (as compared to the reference scenario). In other terms, due to the quotas on milk production, the reference scenario implements a solution where the productions of IND and FCT are already restricted as compared to their level without quotas. The exercise of market power, which basically is to restrict production, thus uses a similar mechanism that is to limit production. In this case, the market equilibrium with market power is such that firms find profitable to use the totality of the milk quota and thus they do not restrict more the production of FCT. If the existence of some market power on FCT production does not change the quantity produced, it changes the implicit price of fat and protein. Due to the constraints on fat and protein, there exists a zone for which the exercise of market power has an impact on component prices, on quantities sold in each market and on trade but not on the total quantities that are produced. We get this result because we consider two components and only two products in this model. This constrains the solution as it would be the case if we had considered only one product using one raw material.

When we consider that both sectors are subject to imperfect competition (scenario 4), we find similar results but which now apply to the two sectors.

Table 3. - Dairy market equilibrium for different assumptions on imperfect competition

	Scenario 1: Perfect competition			**Scenario 2: Monopoly for FCT**			**Scenario 3: n_{FCT}=10, n_{IND}=∞**			**Scenario 4: n_{FCT}=10, n_{IND}=10**		
	North	South	EU	North	South	EU	North	South	EU	North	South	EU
Price (€/unit)												
MILK	0.273	0.278		0.159	0.189		0.220	0.224		0.21	0.219	
FAT	2.60	1.82		4.19	2.83		4.49	3.83		3.53	3.24	
PTN	5.34	6.95		0.00	2.92		1.42	2.79		2.34	3.35	
IND	30.14	30.14		25.45	25.70		30.14	30.14		32.02	31.93	
FCT	46.06	48.86		84.19	84.19		48.28	48.28		48.28	48.28	
milk cost (€/kg)												
IND	24.60	24.59		19.88	20.13		24.57	24.58		22.12	23.07	
FCT	25.00	27.80		12.71	17.94		18.17	20.56		18.21	20.57	
Quota rent	0.091	0.063		0.000	0.000		0.037	0.008		0.028	0.003	
Production												
MILK	69718	45247		60920	39631		69718	45247		69718	45247	
IND	263	153		315	134		263	153		263	153	
FCT	545	342		343	299		545	342		545	342	
Consumption												
IND	177	141		188	149		177	141		172	138	
FCT	464	396		329	287		456	398		456	398	
Trade in IND												
from North	177	0		188	15		177	0		103	76	
from South	0	141		0	134		0	141		70	62	
to Row	86	12		112	0		86	12		85	22	
Trade in FCT												
from North	464	54		179	147		320	192		320	192	
from South	0	342		150	140		136	205		136	205	
to Row	27	0		17	10		33	0		33	0	
Surplus (M€)												
Farmer	12667	7711	20378	4855	3742	8597	8965	5240	14205	8312	5008	13320
Processor	0	0	0	16502	12732	29234	4155	1890	6045	5016	2308	7324
Consumer	36982	30633	67615	22730	19224	41954	35962	30863	66825	35634	30614	66248
Taxpayer			1742			1912			1853			1952
Welfare			86251			77874			85222			84940

In table 4, we briefly analyse the impact of removing export subsidies for the different competition assumptions. Results show that removing export subsidies increases welfare whatever the structure of the industry. The welfare gains rise with the exercise of market power.

However, in term of welfare, the exercise of market power in this sector of production characterized by rather low demand elasticities could cost as much as the price distortion induced by export subsidies. Indeed in our simulation, the presence of export subsidies leads to a net cost of around €1 billion, which roughly corresponds to the cost in welfare from the market power exercised by an industry composed by 10 firms producing each commodity in each country.

It does not mean that removing export subsidies is not a good policy, but that imperfect competition may also potentially be an important source of welfare losses.

Table 4. - Dairy market equilibrium with no export subsidy for different assumptions on imperfect competition (M€)

	Scenario 1: Perfect competition	**Scenario 2: Monopoly for FCT**	**Scenario 3: n_{FCT}=10, n_{IND}=∞**	**Scenario 4: n_{FCT}=10, n_{IND}=10**
Surplus				
EU farmers	14255	7550	11202	10771
EU processors	0	29001	6105	7488
EU consumers	73070	42720	69192	68064
EU Welfare	87325	79271	86499	86323
Welfare loss due to imperfect competition	0	8054	826	1002
Increase in welfare (due to export subsidy removal)	1075	1397	1277	1383

Concluding remarks

The above analysis has shown how the introduction of market power in the spatial dairy industry model changes the market equilibrium characteristics. The main qualitative results of our simulation exercise showed that the existence of market power on some markets:

- significantly modifies the implicit price of milk components;
- could lead to an increase in EU exports as firms price discriminate among countries; with market power, domestic price is not the adequate indicator of competitiveness;
- modify dramatically the distribution of surplus among agents;
- is potentially an important source of welfare losses. Losses from market power exercise could be as high as welfare losses generated by distorting policies such as export subsidies policy.

To conclude, this analysis suggests that agricultural economists should devote much more attention to imperfect competition in the agricultural and food sector.

This simplified model of the dairy industry should now be extended to analyse a more general model that allows for allocation of milk components into several processed commodities to analyse precisely how market power modifies the allocation of commodities.

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