A Partial Equilibrium Model of the Beef and Dairy Sector in Italy Under Imperfect Competition

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SUMMARY

In this paper we present a partial equilibrium model for the bovine sector (beef and dairy) in Italy, which can be used for simulation and forecasting. The structure of the model follows the vertical chain of the beef and dairy sector, allowing trade of both agricultural raw materials and final products. Since the processing and retailing stage is characterised by an imperfectly competitive structure, the model accounts for market power in modelling the price transmission mechanism. This provides further insights on the vertical transmission of shocks, both at the final level (i.e. the BSE crisis) and at the farm level (i.e. agricultural policy reform).

KEYWORDS: SIMULATION MODELS; POLICY ANALYSIS; IMPERFECT COMPETITION; BEEF; DAIRY.

1. Introduction

In this paper we present a partial equilibrium model for the bovine sector (beef and dairy) in Italy; the model can be used for forecasting and simulation purposes. The rationale for modelling the Italian sectors comes from the opportunity to make an analytical tool available to policy makers, mainly for simulating the impact of the Common Agricultural Policy (CAP) reform proposals at the national level and/or of specific interventions during market crises (i.e. BSE crisis). The objective is also to construct a model that could be easily integrated in more general models, such as the AGLINK model of the OECD (OECD, 1998) and the FAPRI model of the Centre for Agricultural and Rural Development (CARD: Devadoss *et al.*, 1993), both used for annual price forecasting (OECD, 2001; FAPRI, 2001).

2. The model

The structure of the model follows the vertical structure of the beef and dairy sector. Thus we have:

a) *the farm level*: the structure of farming activities and the behaviour of the producers are modelled in a profit maximising framework. Differences between beef and milk producer behaviour are mainly related to differences in their CMO (Common Market Organisation), in particular to the presence of a production quota for milk;
b) *the marketing, processing and retailing level*: in this stage the behaviour of agents involved in marketing, processing and retailing the products is considered. All these vertical relationships are modelled as a single stage; the interest is in modelling the impact on agricultural producers (upstream) and final consumers (downstream), assuming that all the vertical relations within this stage will only affect benefits distribution;
c) *the consumption level*: the final demand for beef and milk products is modelled at this stage, based on a utility maximising behaviour;
d) *the trade flows*: furthermore, at each stage, relevant trade flows for the products involved are modelled.

2.1. Domestic (agricultural) supply of beef and milk

The domestic supply of beef comes from both specialised beef farms and from milk farms. It depends essentially on farmers decisions on animal stocks, and on the technological yield growth trend, which is particularly important in the case of milk, given the presence of a production quota. Thus, the final supply will depends on animal stocks as well as on other market variables (beef price, input prices) and on some key policy variables (CAP beef premiums and, of course, the milk quota).

Cattle stocks for beef and milk are modelled first, and then beef supply is related to these stocks. The equation for beef stocks follows the classical Nerlovian structure (Nerlove, 1956), under the "adaptive" price expectation hypothesis (see Table 1 for a list of the variables in the model):

(1) $$stocksbf = f(stocksbf(-1), ppbf(-1), prembf, pfeed, pimpcatbf, trend)$$

The import price of live animals is a peculiar element of the Italian sector, since a significant part of beef animals for fattening is imported, mainly from France. The trend variable is a proxy for technological change.

The milk animal stock equation is:

(2) $$stocksmk = f\left(stockscow, stocksoa\,(-1), ppbf, trend\right)$$

where we distinguish between milk cows (*stockscow*) and other animals (*stocksoa*), since we assume that only the second component can respond in some way to the beef market variables, while the first (number of milk cows) is strictly linked to milk production. The structure of equation (2) is justified by the assumption that the milk quota is the most important variable that determines the number of milk cows, as a simple ratio between quota and milk yield per cow. In our model, the milk yield per cow follows an exogenous growth trend, thus driving automatically down the number of milk cows producing a given quota.

The beef supply equation is the following:

(3) $$qupbf = f\left(stocksbf\,(-1), stocksmk\,(-2), ppbf\,(-1)\right)$$

where the first two lags approximate the average length of the production cycle for beef and milk animals respectively.

Milk supply is considered predetermined, and of course equal to the national production quota, which implies that the producer price of milk should be "demand driven". However, taking into account that, under the CAP, there is a strong price support mechanism, through the intervention prices for butter and skimmed milk powder, and that, in Italy, the farm level price is established yearly through a national contract, signed by the representatives of milk producers and milk processors, we have introduced an equation for the milk producer price. This equation links the producer price to the price of the most representative dairy products, the price of imported liquid milk (the alternative source of raw material for an importing country like Italy) and the concentration ratio of the processing industry:[1]

(4) $$ppmk = f\left(pimpmk\_EU\,(-1), pcchpdo\,(-1), pclimk\,(-1), crmk\right)$$

The structure of equation (4) actually reproduce the structure of the price index agreed under the national contract, which is used to modify the milk reference price throughout the year, in order to take into account the market evolution.

2.2 Imports

Italy is a strong net importer of both live animals and beef. Among imported live animals, some of them are immediately slaughtered, while the rest is used for either fattening or breeding. The first component is clearly already included in the domestic supply of beef (*qupbf*), while the second enters beef production as an input, thus influencing farmers' choices in terms of the

[1] In a first attempt, we introduced also the intervention price for butter, but it was not statistically significant. This is because Italy, which is a net importer of milk and dairy products, does not use the intervention mechanisms; thus, the impact of the institutional prices is transmitted to the Italian market mainly through the variation in the milk import prices.

composition of their animal stocks; this is the reason why the import price enters the above beef animal stock equation.

Imports of beef are mainly made of carcasses, which needs some further processing before being sold to the final consumer. Thus, they are modelled as a (derived) input demand by the processing sector, which clearly depends on the ratio between import and domestic prices:

(5) $quimpbf = f(pimpbf\_EU / ppbf, pimpbf\_exUE / ppbf, trend)$

Equation (5) also discriminates among different import sources, in particular between EU and extra-EU beef imports, since the import price of the second includes a tariff component.

Imports of liquid milk used for further processing are modelled in a similar fashion:

(6) $quimpmk = f\left(pimpmk\_EU / ppmk, pc\_h, trend\right)$

where, again, processors choose this alternative source of raw material evaluating the ratio between the EU price and the domestic price, as well as the price of final dairy products. Note, however, that the imported liquid milk cannot be used to process all dairy products, since, as it is well known, both the EU and the national laws restrict the source of raw material for some PDO (Protected Denomination of Origin) cheeses, which are very important for Italian dairy production.

Since imports of final dairy products are substitutes of the national products, their import equations will be presented in the final consumption section.

2.3 Processing and retail

At this crucial stage of the vertical chain, there are important differences between the two sectors, basically because milk can be processed in many different dairy products.

Since beef processing is, for most part of the final products, a very simple technological process, we can assume a simple fixed proportion technology (see for example Bouamra and Requillart, 2000), with a linear technological coefficient (the ratio between dead weight and live weight of beef meat):

(7) $qutbf = \alpha^{bf} \cdot qupbf$

Moving to the dairy sector, given the strong final product differentiation, to make the model tractable we have considered five categories of dairy products (liquid milk, butter, PDO cheese, other cheese, other dairy products), for which we have some important technological constraints (butter in Italy is a joint product of cheese processing) and some constraints on the use of raw material (for PDO cheeses, the use of imported milk is forbidden). Thus, accounting for these constraints, a fixed proportion technology can be expressed by the following set of equations[2]:

(8) $qut\_limk = \alpha_{limk}^{mk} \cdot \left(qumk_{limk}^{dom} + quimpmk_{limk}^{imp}\right)$

(9) $qut\_otmk = \alpha_{otmk}^{mk} \cdot \left(qumk_{otmk}^{dom} + quimpmk_{otmk}^{imp}\right)$

(10) $qut\_otch = \alpha_{otch}^{mk} \cdot \left(qumk_{otch}^{dom} + quimpmk_{otch}^{imp}\right)$

(11) $qut\_chpdo = \alpha_{chpdo}^{la} \cdot qumk_{chpdo}^{dom}$

(12) $qut\_bu = \alpha_{bu}^{mk} \cdot \left(qumk_{otch}^{dom} + qumk_{chpdo}^{dom} + quimpmk_{otch}^{imp}\right)$

and

(13) $qumk = qumk_{limk}^{dom} + qumk_{otmk}^{dom} + qumk_{otch}^{dom} + qumk_{chpdo}^{dom}$

(14) $quimpmk = quimpmk_{limk}^{imp} + quimpmk_{otmk}^{imp} + quimplat_{otch}^{imp}$

where equations (13) and (14) guarantee the balance in the use of milk for processing.

Since the processing and retailing stage is characterised by an imperfectly competitive structure, the model accounts for market power: thus the price transmission mechanism is not perfectly competitive, and we believe that this will provide further insight on the vertical

[2] In other sectoral dairy models (see for example Bouamra and Requillart, 2000), the processing stage is modelled in a more complex set-up, considering two intermediate products obtained by raw milk (the fat and the non-fat components) and interpreting final dairy products as different mixes of these two products. This two-stage set-up is clearly very important for net exporters, where we have public intervention on butter and skimmed milk powder, but is a meaningless complication for a net importer like Italy, where there is no intervention.

transmission of shocks, both at the final level (i.e. the BSE crisis) and at the farm level (i.e. agricultural policy reform). Thus we refer to the oligopsonistic/oligopolistic paradigm, following the approach in Appelbaum (1982) and Azzam and Pagoulatos (1990).

For illustrative purposes, we first consider the beef sector. The theoretical model considers a sector with N^{cb} firms, producing a homogeneous product (beef), using M^{bf} processing inputs. Technology is represented by the following production function:

(15) $$q_j^{bf} = f^{j,bf}\left(x_{1j}^{bf}, x_{2j}^{bf}, \ldots, x_{M^{bf}j}^{bf}\right)$$

where q_j^{bf} is the output (processed beef) of firm j^{th}, while x_{ij}^{bf} is the quantity of the i^{th} input used by firm j^{th} in the production of beef; beef (raw agricultural input) is indicated with x_{1j}^{bf}. We assume that firm j^{th} has market power on final markets (sale of q_j^{bf}) and on agricultural input markets (purchase of x_{1j}^{bf}), but is a price-taker on other markets (processing inputs). Inverse demand on final markets is:

(16) $$ptbf = g^{bf}(qutbf)$$

where $qutbf = \sum_j q_j^{bf}$; inverse supply on agricultural beef market is:

(17) $$ppbf = h^{bf}(qupbf)$$

where $qupbf = \sum_j x_{1j}^{bf}$ is total purchase on agricultural markets. The firm problem is to choose quantity of inputs $\left(x_{1j}^{bf}, x_{2j}^{bf}, \ldots, x_{M^{cb}j}^{bf}\right)$ to maximise profit π_j^{bf} :

(18) $$\max \quad \pi_j^{bf} = ptbf \cdot q_j^{bf} - ppbf \cdot x_{1j}^{bf} - \sum_{i=2}^{M^{bf}} w_i^{bf} x_{ij}^{bf}$$

given technology and market conditions.

First-order conditions provide the following expression:

(19) $$ppbf\left(1 + \frac{\phi_j^{bf}}{\eta^{bf}}\right) = \left(1 - \frac{\theta_j^{bf}}{\varepsilon^{bf}}\right) f_{1j}^{j,bf}\, ptbf$$

The two conjectural elasticities θ_j^{bf} e ϕ_j^{bf} play an important role. As discussed in Appelbaum (1982) and Azzam and Pagoulatos (1990), when both values are zero we go back to perfect competition; instead, when the two values are one, we have the monopsonistic/monopolistic case. Value between zero and one reflect different levels of firm j^{th} market power. In fact, Appelbaum (1982) defines the degree of oligopoly power of firm j^{th} by reformulating the *Lerner* index:

(20) $$a_j^{bf} = \frac{ptbf - cma_j^{bf}}{ptbf} = \frac{ptbf\text{-}ptbf\left(1 - \frac{\theta_j^{bf}}{\varepsilon^{bf}}\right)}{ptbf} = \frac{\theta_j^{bf}}{\varepsilon^{bf}}$$

where cma_j^{bf} indicates marginal costs for firm j^{th}. In the same way, the degree of oligopsony power can be defined as:

(21) $$b_j^{bf} = \frac{cma_j^{bf} - ppbf}{ppbf} = \frac{\frac{ppbf}{f_{1j}^{bf}}\left(1 + \frac{\phi_j^{bf}}{\eta^{bf}}\right) - \frac{ppbf}{f_{1j}^{bf}}}{\frac{ppbf}{f_{1j}^{bf}}} = \frac{\phi_j^{bf}}{\eta^{bf}}$$

In order to translate this result to the market level, as pointed out by Muth and Wohlgenant (1999), we need to aggregate among firms. In this model we assume that the marginal productivity is identical across firms, i.e. $f_1^{j,bf} = f_1^{bf}, \forall j$, a reasonable assumption in beef processing: therefore, the conjectural elasticity at the market level is simply a weighted average of individual conjectural elasticities, with firms' market shares as weights (see also Azzam and Pagoulatos, 1990). Thus, we have the following expression at the market level:

(22) $$ppbf\left(1+\frac{\Phi^{bf}}{\eta^{bf}}\right)=\left(1+\frac{\Theta^{bf}}{\varepsilon^{bf}}\right)f_1^{bf}\cdot ptbf$$

where Θ^{bf} and Φ^{bf} indicate market conjectural elasticities.

In our model we consider the domestic market as the final market, given that export markets for beef are not relevant; thus the price *ptbf* is substituted by *pccb*. The value for f_1^{bf} is given by α^{bf}. Finally, estimates for Θ^{bf} and Φ^{bf} are given by:

(23) $$\Theta^{bf}=\sum_j \theta_j^{bf} S_j^{bf}$$

(24) $$\Phi^{bf}=\sum_j \phi_j^{bf} \hat{S}_j^{bf}$$

where S_j^{bf} and $\hat{S}_j^{bf}$ indicates the market share of firm j[th] on the final market and the agricultural input market, respectively. By assuming that firms follow a *Cournot* behavior ($\frac{\partial qtbf}{\partial q_j^{bf}}=1$) on both markets, then $\theta_j^{bf}=S_j^{bf}$ and $\phi_j^{bf}=\hat{S}_j^{bf}$; thus, conjectural elasticities at the sector level van be estimated using the *Herfindahl* index:

(25) $$\Theta^{bf}=\sum_j (S_j^{bf})^2$$

(26) $$\Phi^{bf}=\sum_j (\hat{S}_j^{bf})^2$$

Given that vertical relationships among processors and retailers are not modelled, we assume that the oligopsony power is exerted by slaughtering firms, while the oligopoly power is due to retailing firms. Price transmission is then given by:

(27) $$ppbf\left(1+\frac{\Phi^{bf}}{\eta^{bf}}\right)=\left(1+\frac{\Theta^{bf}}{\varepsilon^{bf}}\right)\alpha^{bf}\cdot pcbf$$

The same approach is applied to the milk processing and retailing sector, although milk processing involve the production of differentiated products. Consider a processing sector with N^{mk} firms, producing a range of products (multi-product firms): we have considered five final products (liquid milk, PDO cheese, other cheese, butter and other milk products). Technology is characterised by the presence of joint products (basically, butter is produced with cheese): thus we have defined four processes (liquid milk, PDO cheese and butter, other cheese and butter, other milk products) characterised by the following production functions:

(28) $$q_j^{k,mk}=f^{kj,mk}\left(x_{1j}^{k,mk},x_{2j}^{k,mk},\ldots,x_{Mj}^{k,mk}\right)$$

where $q_j^{k,mk}$ represents output of the k^{th} product (k = *limk* [liquid milk], *otda* [other dairy products], *otchbu* [other cheese and butter], *chpdobu* [PDO cheese and butter]) of firm j[th]; $x_{ij}^{k,mk}$ is the quantity of input i[th] used in the production of the k^{th} product, and raw milk is indicated with $x_{1j}^{k,mk}$. In the case of milk processing, given the contractual nature of raw milk price *ppmk*, we only consider market power on final markets. We have inverse demands for the five products *h*:

(29) $$pt\_h=g^{h,mk}\left(qut\_h\right)$$

where $qut\_h=\sum_j qt_j^{h,mk}$. The firm problem is to maximise profits and choosing how to allocate (domestic) milk to different destinations:

(30) $$\max \quad \pi_j^{mk} = \sum_h pt\_h \cdot qt_j^{h,mk} - ppmk \sum_k x_{1j}^{k,mk} - \sum_{i=2}^{M^{mk}} w_i^{mk} x_{ij}^{mk}$$

under the constraints:
$$q_j^{k,mk} = f^{kj,mk}\left(x_{1j}^{k,mk}, x_{2j}^{k,mk}, \ldots, x_{Mj}^{k,mk}\right)$$
$$qt_j^{limk,mk} = q_j^{limk,mk}$$
$$qt_j^{otda,mk} = q_j^{otda,mk}$$
$$qt_j^{chpdo,mk} = f\left(q_j^{chpdobu,mk}\right)$$
$$qt_j^{otch,mk} = f\left(q_j^{otchbu,mk}\right)$$
$$qt_j^{bu,mk} = f\left(q_j^{chpdobu,mk}, q_j^{otchbu,mk}\right)$$

Assuming a relatively simple technology, with fixed coefficients, identical across firms, [see equations (8)-(12)], and taking $pt\_h = pc\_h$, we obtain:

(31) $$ppmk = \left(1 - \frac{\theta_j^{limk,mk}}{\varepsilon^{limk,mk}}\right)\alpha^{limk,mk}\, pclimk$$

(32) $$ppmk = \left(1 - \frac{\theta_j^{otda,mk}}{\varepsilon^{otda,mk}}\right)\alpha^{odak,mk}\, pcotda$$

(33) $$ppmk = \left(1 - \frac{\theta_j^{chpdo,mk}}{\varepsilon^{chpdo,mk}}\right)\alpha^{chpdo,mk}\, pcchpdo + \left(1 - \frac{\theta_j^{bu,mk}}{\varepsilon^{bu,mk}}\right)\alpha^{chpdobu,mk}\, pcbu$$

(34) $$ppmk = \left(1 - \frac{\theta_j^{otch,mk}}{\varepsilon^{otch,mk}}\right)\alpha^{otch,mk}\, pcotch + \left(1 - \frac{\theta_j^{bu,mk}}{\varepsilon^{bu,mk}}\right)\alpha^{otchbu,mk}\, pcbu$$

providing the following equations at the market level:

(35) $$ppmk = \left(1 - \frac{\Theta^{limk,mk}}{\varepsilon^{limk,mk}}\right)\alpha^{limk,mk}\, pclimk$$

(36) $$ppmk = \left(1 - \frac{\Theta^{otda,mk}}{\varepsilon^{otda,mk}}\right)\alpha^{otmk,mk}\, pcotda$$

(37) $$ppmk = \left(1 - \frac{\Theta^{chpdo,mk}}{\varepsilon^{chpdo,mk}}\right)\alpha^{chpdo,mk}\, pcchpdo + \left(1 - \frac{\Theta^{bu,mk}}{\varepsilon^{bu,mk}}\right)\alpha^{chpdobu,mk}\, pcbu$$

(38) $$ppmk = \left(1 - \frac{\Theta^{otch,mk}}{\varepsilon^{otch,mk}}\right)\alpha^{otch,mk}\, pcotch + \left(1 - \frac{\Theta^{bu,mk}}{\varepsilon^{bu,mk}}\right)\alpha^{otchbu,mk}\, pcbu$$

Again, conjectural elasticities at the market level are approximated with *Herfindahl* indices:

(39) $$\Theta^{h,mk} = \sum_j (S_j^{h,mk})^2$$

where $S_j^{h,mk}$ is the firm j^{th} market share in the final market for product h^{th}.

2.4 Final demand at the retail level

Demand at the consumption level is modelled within the classical approach of consumer theory, under the assumption of weak separability in preference. Demand for beef is a conditional demand taking meat as a separable group:

(40) $$qucbf = f\left(pcbf, pcpk, pcpo, meatex, trend\right)$$

Given that import of processed milk products is important, we have modelled demand for milk products distinguishing between domestic and import consumption (an "*Armington*-type" model); we have the following (general) demand equation:

(41) $$quc\_s\_h,mk = f\begin{pmatrix} pclimk, pcotda, pcchpdo, pcotch, pcbu, \\ pimplimk, pimpotda, pimpchpdo, pimpotch, pimpbu, \\ dairyex, trend, other\ variables \end{pmatrix}$$

2.5 Export and stocks

In the beef sector, exports have a marginal role; thus we take exports as exogenous. With a similar reasoning, also stocks (private and public) are not modelled. Thus we have the following equilibrium identity:

(42) $$quimpbf + qupbf = qucbf + quexpbf$$

For the milk sector, at least at this stage, we have resort to the same approach, with the only exception of the export demand for PDO cheese, that represents a relevant share of export of milk products; we therefore have the following equation:

(43) $$quexpchpdo = f\left(pexpchpdo\_EU/pcchpdo, pexpchpdo\_exEU/pcchpdo, trend\right)$$

The closing identity (expressed in milk- equivalent) is:

(44) $$quimpmk + qupmk = qucmk + quexpda$$

3. Parameter estimates

Most of the parameters of the model were estimated using aggregate time-series data. However, the identification of some key parameters for the specific objectives of the present work required more detailed source of information.

One of the key points is the evaluation of the impact of per-head premiums for the beef sector. As it is well known, after the latest reforms, these premiums became the most relevant policy instrument of the CMO for beef. The problem is that, at the aggregate level, it is not possible to consider the variability characterising these per-head premiums and making them different for each farm (for example, as a result of the different breeding density).

For this reason, given the importance of premiums in simulating possible scenarios for the CAP, equations related to the herd size (both for beef and milk rearing) were estimated using a representative sample of Italian farms. This information was obtained from the FADN-INEA data-set for the period following the MacSharry CAP reform (1993-99), when the premium system assumed the present structure. The use of farm data allowed to differentiate premiums, obtaining enough variability to estimate the premium effect. The value of the premium parameter has been used later in the simulation phase.

Herd size equations have been formulated in the double-log form so that elasticities are constant over the time period (this has been a common strategy for most of the estimated equations). Per-head premiums have been approximated by the value of the premium for steers, that is the most relevant variable in determining income of Italian specialised beef farms. The estimation procedure considered the panel structure of the data using a fixed effect model (Judge *et al*., 1988, p. 468). Results are reported in table 2.

The other equations related to the meat sector consider the consumption, production, and import of meats. Parameters for meat consumption were taken from the elasticities computed by Mazzocchi (2001), a recent study that considers the impact of the BSE crisis on consumer's preferences (table 2). The equation for meat supply was estimated using a semi-log functional form (supplied quantities as a function of independent variables in the log form) (table 2). This choice was made in order to make the value of the supply elasticity dependent on the quantity supplied. Data on meat production were obtained from ISMEA for the period 1990-2000. The import equation, instead, was estimated in the double-log form using data from the National Institute of Statistics (ISTAT) for the period 1990-2000 (table 2).

For the dairy sector, the equation for the price of crude milk was estimated using data from different sources. The import price of crude milk was computed, implicitly, from ISTAT trade data, consumer prices were from the statistical office of the municipality of Milan, and the concentration ratio in the processing stage was obtained from NIELSEN data. Parameters are reported in table 2.

Elasticities for dairy consumption were obtained from an AIDS model estimated using data on aggregate Italian household consumption available from NIELSEN. Data are organised by semester, from 1990 to 2001, and report quantities and values of expenditure. The chosen aggregates were the same specified for the model: liquid milk, PDO cheese, butter, other cheese, other dairy products. Divisa price indices were computed for the cheese and other dairy products aggregates. The model was then estimated: elasticities computed at the sample mean, reported in table 3, were substituted in the double-log consumption equations of the simulation model.

Finally, parameters for dairy import end export equations were estimated using ISTAT annual data on trade for the period 1990-2000. Prices of the traded aggregates were computed from the reported traded quantities and values. Consumer prices were from the municipality of Milan. Each equation has been estimated using the formulation specified for the simulation model. Parameters are reported in table 4. For all of the trade equations a trend parameter was added and resulted significantly different from zero in most of the equations. Trend was the only significant parameter for the equation modelling the import of raw milk, indicating that the determinants of this trade flow go beyond a simple price response.

All of the trade equations include prices of the exchanged good and those of its close substitutes. For butter, we considered olive oil as a substitute. Data on total expenditure on fats were computed from ISMEA statistics.

Other parameters included in the model are for the price transmission identities. The alpha coefficients have been computed, for each aggregate, from the technological coefficients available from ISMEA and from Osservatorio Latte. Alphas for dairy aggregates have been computed as a weighted sum, based on the produced quantity, of coefficients of the included products. Values on concentration, represented by the *Herfindahl* index, were computed from data on market shares obtained from different sources. Market shares of meat packers were from Databank (2000) while retail shares were from Sckokai (2001). The differentiation by dairy product of retail concentration was based on the market channel shares for different dairy products available from Nielsen. Technological and concentration coefficient are reported in table 5.

4. Simulation results

We have used our model to simulate the impact of Agenda 2000 on the Italian beef and milk sector. We have considered the specific increase in Italian milk production quota, for the period 2000-2002; the increase in per head beef premiums; the reduction in the intervention price for beef (20% in a three-year period, moving towards a reference price for private storage); the reduction in the intervention prices for butter and skimmed milk powder for the period 2005-2007; the new milk premia per unit of quota are considered fully decoupled. The reduction in the intervention prices will affect intra-EU prices, and we assume a complete transmission on import prices, thus affecting the Italian market. In table 6 we report results from simulation for the endogenous variables of the model; all percentage variations must be referred to the base year 2000. Assumptions are made for the evolution of other exogenous variables of the model: for example, we assume that monetary variables, with a few exception, will follow the inflation rate, according to forecasts in FAPRI-Ireland (2001). Exogenous export are maintained at the current level (year 2000). An historical trend on milk yield is used.

For the beef sector, the reduction in the intervention price will impact producer prices: for the year 2003 we register a price reduction of 11,5%; however this reduction is largely below the 20%-cut in the intervention price. Thus, for an importing country, like Italy, we do not expect a full transmission of the reduction in intervention prices: this is in line with results from other simulation models (FAPRI-Ireland, 2001). Furthermore, after 2003 we see an increase in producer prices for beef: at the end of the simulation period (2008) the reduction is only 6.1% with respect to the base year (2000). Since we have modelled the processing-retailing stage as imperfectly competitive, price transmission between farm and retail level is not complete: the consumer price will decrease less than the producer price.

Beef consumption will benefit from a reduction in the consumer price: we see a consistent increase in beef consumption (+9.6% in 2008). However, the reduction in producer prices, although compensated by an increase in beef premiums, will affect negatively animal stocks (-4.4% at the end of the simulation period) and beef production (-2.0%); as a consequence we register a consistent increase in beef imports (+41.6%), mainly as a consequence of the (assumed) complete transmission of the 20%-cut in the intervention price on the EU price.

In the dairy sector, the increase in production quota for the period 2000/2002 will affect positively animal stocks; however, stocks in the dairy sector are mainly driven by quota and yield evolution, and therefore, starting in 2003, dairy stocks decrease (-1.7% at the end of the simulation period). It is somewhat surprising the evolution of the milk producer price during the period: they are maintained above the base year level even thought it decreases after 2005 as a consequence of Agenda 2000. This is related to the strong increase in consumer prices for cheese (PDO and other cheese) during the simulation period: this increase is transmitted, although not completely, to the price of raw liquid milk; on the other hand the consumer price for butter will fall, thus explaining the increase in consumption. At the consumption level, we have a significant increase in consumption of domestic and imported other dairy products (+23.5%) and cheese (+5.3% for domestic PDO cheese and +7.7% for other cheese); we also register a reduction in consumption of liquid milk (-8.2%), together with a substitution of domestically-produced milk with imported milk; consumption of butter shows a significant increase (+9.9%), with a complete substitution of imported butter with domestically-produced butter.

This general pattern is related to the shift in the allocation of raw material; we register an increase in the (domestic) production of cheese (+6.7% for PDO cheese and +9.4% for other cheese), and of course butter (+106.3%), and other dairy products (+4.5%), and a reduction in the production of liquid milk (-12.8%). The allocation of domestic raw material follow mainly the evolution of processed products; thus we have an increase in the quantity of (domestic) milk allocated to the production of cheese, and a reduction in that allocated to liquid milk and other dairy products, that can be produced with no constraints using imported raw material. This pattern reproduces a general trend that started in the '90s and continues in the simulation period.

Finally, the evolution of export markets for PDO cheese show a significant improvement: we have a constant positive trend during the period, with a +15.3% in the final year.

5. Concluding remarks

In this paper we have presented simulation results of the impact of Agenda 2000 CAP reform on the beef and milk sector in Italy, using a partial equilibrium model. This model can be used for other simulation purposes and forecasting exercise.

The model has 36 equations (behavioural and identities); the main CAP policy instruments have been introduced. Many parameters of the model have been obtained from direct estimation, and then calibrated. In particular, we have tried to model the response of beef producers to the beef premium scheme, the impact of the BSE crisis on beef demand, the allocation mechanism of raw milk to different processing products, the substitution between domestic and imported milk products, and the imperfectly competitive mechanism of price transmission between the farm and the retail level.

First results from the model are encouraging: some general indications are compatible with those obtained in other models, and the obtained trends are largely plausible. The model could be improved by introducing an explicit modelling of the crop sector, since the beef and milk production are still related to land availability and producers' decision are affected by market conditions and policy tools in the cereal sector.

TABLE 1 – LIST OF MAIN VARIABLES AND PARAMETERS IN THE MODEL

STOCKSBF = STOCKS OF BEEF BREEDINGS	Θ^{bf} = CONJECTURAL ELASTICITY AT THE SECTOR LEVEL IN THE FINAL MARKET FOR BEEF
PPBF = PRODUCER PRICE OF BEEF	Φ^{bf} = CONJECTURAL ELASTICITY AT THE SECTOR LEVEL IN THE INPUT MARKET FOR BEEF
PREMBF = BEEF PREMIUMS	QUT_h = PROCESSED QUANTITY OF PRODUCT h
PFEED = FEEDING PRICE	$QUMK_h^{dom}$ = QUANTITY OF DOMESTIC MILK PROCESSED FOR DESTINATION h
PIMPCATBF = IMPORT PRICE OF BREEDING CATTLE	$QUIMPMK_i^{imp}$ = QUANTITY OF IMPORTED MILK PROCESSED FOR DESTINATION h
TREND = TREND (TECHNOLOGICAL)	α_h^{mk} = TECHNICAL COEFFICIENT IN MILK PROCESSING FOR DESTINATION h
STOCKSMK = STOCKS OF MILK BREEDINGS	h = *LIMK* (LIQUID MILK), *CHPDO* (PDO CHEESE), *OTCH* (OTHER CHEESE), *BU* (BUTTER, *OTDA* (OTHER DAIRY PRODUCTS)
STOCKSCOW = STOCKS OF MILK COWS	$\varepsilon^{h,mk}$ = ABSOLUTE VALUE OF (FINAL) DEMAND PRICE ELASTICITY FOR MILK PRODUCT h
STOCKSOA = STOCKS OF OTHER MILK CATTLE	$\theta_j^{h,mk}$ = CONJECTURAL ELASTICITY OF FIRM j^{th} W.R.T. THE FINAL MARKET FOR MILK PRODUCT h
QUPBF = (AGRICULTURAL) PRODUCTION OF BEEF	Θ^{bf} = CONJECTURAL ELASTICITY AT THE SECTOR LEVEL IN THE FINAL MARKET FOR MILK PRODUCT h
QUMK = (DOMESTIC) MILK PRODUCTION QUOTA	*PTBF* = MARKET PRICE OF PROCESSED BEEF
PPMK = PRODUCER PRICE OF MILK	*PCBF* = (DOMESTIC) CONSUMER PRICE OF BEEF
$PIMPMK\_EU$ = IMPORT PRICE (INTRA-UE) OF MILK	PT_h = MARKET PRICE OF PROCESSED PRODUCT h
CRMK = CONCENTRATION RATIO IN MILK PROCESSING	PC_h = (DOMESTIC) CONSUMER PRICE OF PROCESSED PRODUCT h
QUIMPBF = IMPORT OF SLAUGHTERED BEEF	*QUCBF* = (DOMESTIC) CONSUMPTION OF BEEF
$PIMPCB\_EU$ = IMPORT PRICE (INTRA-UE) OF BEEF	*PCPK* = (DOMESTIC) CONSUMER PRICE OF PORK
$PIMPCB\_EXUE$ = IMPORT PRICE (EXTRA-UE) OF BEEF	*PCPO* = (DOMESTIC) CONSUMER PRICE OF POULTRY
QUIMPMK = IMPORT OF (RAW) LIQUID MILK	*MEATEX* = TOTAL EXPENDITURE IN MEAT
$PIMPMK\_EU$ = IMPORT PRICE (INTRA-UE) OF MILK	QUC_s_h = (DOMESTIC) CONSUMPTION OF (MILK) PRODUCT h FROM ORIGIN s
PCMKP = CONSUMER PRICE OF MILK PRODUCTS (INDEX)	PC_h = CONSUMER (DOMESTIC) PRICE OF PROCESSED PRODUCT h
QUTBF = PRODUCTION OF PROCESSED BEEF	$PIMP\_h$ = CONSUMER (IMPORT) PRICE OF PROCESSED PRODUCT h
α^{bf} = TECHNICAL COEFFICIENT IN BEEF PROCESSING	*PCFAT* = CONSUMER (DOMESTIC) PRICE OF OTHER FATS *PIMPFAT* = CONSUMER (IMPORT) PRICE OF OTHER FATS
$\varepsilon^{bf} \equiv \frac{\partial qtbf}{\partial ptbf}\frac{ptbf}{qtbf}$ = ABSOLUTE VALUE OF (FINAL) DEMAND PRICE ELASTICITY FOR BEEF	*DAIRYEX* = TOTAL EXPENDITURE IN DAIRY PRODUCTS
$\eta^{bf} \equiv \frac{\partial qpbf}{\partial ppbf}\frac{ppbf}{qpbf}$ = VALUE OF (AGRICULTURAL) SUPPLY PRICE ELASTICITY FOR BEEF	*CHEX* = TOTAL EXPENDITURE IN CHEESE *FATEX* = TOTAL EXPENDITURE IN FATS
$\theta_j^{bf} \equiv \frac{\partial qtbf}{\partial q_j^{bf}}\frac{q_j^{bf}}{qtbf}$ = CONJECTURAL ELASTICITY OF FIRM j^{th} W.R.T. THE FINAL MARKET;	s = DOM (DOMESTIC), IMP (IMPORTED)
$\phi_j^{bf} \equiv \frac{\partial qpbf}{\partial x_{1j}^{bf}}\frac{x_{1j}^{bf}}{qpbf}$ = CONJECTURAL ELASTICITY OF FIRM j^{th} W.R.T. THE AGRICULTURAL MARKET	*QUEXPBF* = EXPORT OF SLAUGHTERED BEEF *QUEXPDA* = EXPORT OF DAIRY PRODUCTS *QUEXPCHPDO* = EXPORT OF PDO CHEESE
$f_1^{j,bf}$ = MARGINAL PRODUCTIVITY OF THE AGRICULTURAL INPUT IN BEEF PROCESSING	$PEXPCHPDO\_EU$ = INTRA-UE EXPORT PRICE OF PDO CHEESE $PEXPCHPDO\_EXEU$ = EXTRA-UE EXPORT PRICE OF PDO CHEESE

TABLE 2 – VALUE OF THE ESTIMATED PARAMETER
(EQUATIONS IN DOUBLE-LOG FORM, UNLESS SPECIFIED)

	Dependent variables				
	STOCKSBF[1]	STOCKSMK[1]	QUCBF[2]	QUPBF[4]	PPMK
Explanatory variables					
INTERCEPT				-3154870	
STOCKSBF(-1)	0,188			436221	
PPBF		0,095			
PPBF(-1)	0,322			126312	
PREMBF	0,117				
TREND	-0,051		0[3]		
PFEED	-0,094				
PIMPCATBF	-0,066				
STOCKSOA(-1)		0.023			
STOCKSMK(-2)				436221	
PCBF			-0,324		
PCPK			-0,263		
PCPO			-0,140		
PIMPMK_EU(-1)					0.377
PCCHPDO(-1)					0.215
PCLIMK(-1)					0[3]
CRMK					0.122
MEATEX			1,859		

[1]Estimated using farm data from RICA-INEA.
[2]From Mazzocchi (2001).
[3]Value imposed equal to zero given it was not significantly different from it.
[4]Semi-log functional form.

TABLE 3 – PRICE AND EXPENDITURE ELASTICITIES FOR DAIRY CONSUMPTION COMPUTED AT THE MEAN
(AIDS MODEL ON NIELSEN DATA - 1990-2001)

	LIQUID MILK	PDO CHEESE	BUTTER	OTHER CHEESE	OTHER DAIRY PRODUCTS	TOTAL DAIRY EXPENDITURE
LIQUID MILK	-0.77	-0.32	0.22	-0.12	-0.05	1.03
PDO CHEESE	-0.13	-0.41	-0.02	-0.13	-0.25	0.93
BUTTER	0.64	-0.08	-0.69	-0.73	0.06	0.8
OTHER CHEESE	-0.09	-0.24	-0.18	-1.08	0.46	1.13
OTHER DAIRY PRODUCTS	-0.05	-0.68	0.02	0.98	-1.23	0.97

TABLE 4 – VALUE OF THE PARAMETER FOR IMPORT EQUATIONS (EQUATIONS IN DOUBLE-LOG FORM)

	Dependent variables						
	QUIMPLLIMK	QUIMPBU	QUIMPOTCH	QUIMPOTDA	QUIMPMK	QUIMPBF	QUEXPCHPDO
Explanatory variables							
PCLIMK/PCOTDA				0[1]			
PCOTDA/PCLIMK	0[1]						
PCCHPDO/PCOTCH			0[1]				
PCBU		6.759					
PCFAT		1.404					
PIMPLIMK/PCLIMK	-1.943						
PIMPLIMK/PCOTDA				1.812			
PIMPOTDA/PCOTDA				-3.381			
PIMPOTDA/PCLIMK	0[1]						
PIMPOTCH/PCOTCH			-0.344				
PIMPBU		-0.918					
PIMPFAT		-0.829					
PIMPMK/PPMK					0[1]		
PEXPCHPDO_UE/PCCHPDO							-0.470
PEXPCHPDO_EXUE/PCCHPDO							0[1]
DAIRYEX/PCLIMK	-1.574						
DAIRYEX/PCOTDA				2.594			
CHEX/PCOTCH			0[1]				
FATEX		-1.284					
PIMPBF_UE/PPBF						-2,366	
PIMPBF_EXUE/PPBF						0[1]	
TREND	0.293	0.153	0[1]	0.127	0.214	-0,089	0.239

[1]Value imposed equal to zero given it was not significantly different from it.

TABLE 5 – VALUE OF TECHNICAL AND MARKET CONCENTRATION COEFFICIENTS

Coefficients	***Values***
α^{bf}	0.5600
α_{LIMK}^{mk}	1.0000
α_{CHPDO}^{mk}	0.0843
α_{OTCH}^{mk}	0.1250
α_{BU}^{mk}	0.0462
α_{OTDA}^{mk}	0.4327
Θ^{bf}	0.0683
Φ^{bf}	0.0235
$\theta_j^{LIMK,mk}$	0.0700
$\theta_j^{CHPDO,mk}$	0.0600
$\theta_j^{OTCH,mk}$	0.0650
$\theta_j^{BU,mk}$	0.0800
$\theta_j^{OTDA,mk}$	0.0800

TABLE 6 – THE IMPACT OF AGENDA 2000 ON THE BEEF AND DAIRY SECTOR IN ITALY: SIMULATION RESULTS

	2000	2001	2002	2003	2004	2005	2006	2007	2008
STOCKSMK *(.000 heads)*	**4345**	4376	4352	4324	4318	4310	4298	4284	4269
Var 2000	-	*0.71%*	*0.17%*	*-0.49%*	*-0.62%*	*-0.80%*	*-1.08%*	*-1.39%*	*-1.75%*
PPMK *(euro/Kg)*	**0.34**	0.35	0.35	0.36	0.36	0.36	0.36	0.35	0.35
Var 2000	-	*2.90%*	*3.72%*	*5.05%*	*5.89%*	*6.69%*	*5.35%*	*4.15%*	*2.95%*
QUCDOMLIMK *(.000t)*	**3442**	3436	3370	3326	3279	3271	3238	3202	3088
Var 2000	-	*-0.18%*	*-2.09%*	*-3.37%*	*-4.72%*	*-4.97%*	*-5.93%*	*-6.96%*	*-10.28%*
QUCDOMOTDA (.000t)	**376**	382	391	397	403	410	419	428	438
Var 2000	-	*1.60%*	*4.04%*	*5.68%*	*7.33%*	*9.15%*	*11.62%*	*14.06%*	*16.53%*
QUCDOMCHPDO (.000t)	**305**	308	309	310	312	314	317	320	321
Var 2000	-	*0.89%*	*1.39%*	*1.77%*	*2.13%*	*3.03%*	*3.98%*	*4.95%*	*5.27%*
QUCDOMOTCH (.000t)	**777**	786	792	796	801	811	822	834	845
Var 2000	-	*1.19%*	*1.88%*	*2.48%*	*3.09%*	*4.31%*	*5.77%*	*7.33%*	*8.78%*
QUCDOMBU (.000t)	**120**	122	129	133	138	142	149	158	176
Var 2000	-	*1.51%*	*7.42%*	*11.09%*	*15.28%*	*18.24%*	*24.75%*	*31.99%*	*46.80%*
QUCIMPLIMK (.000t)	**347**	350	340	338	336	365	386	408	390
Var 2000	-	*0.66%*	*-2.21%*	*-2.56%*	*-3.30%*	*5.09%*	*11.05%*	*17.43%*	*12.29%*
QUCIMPOTDA (.000t)	**96**	97	100	102	104	115	127	141	145
Var 2000	-	*2.06%*	*4.80%*	*6.75%*	*8.69%*	*20.12%*	*33.36%*	*47.96%*	*51.40%*
QUCIMPOTCH (.000t)	**347**	346	347	347	347	352	359	365	366
Var 2000	-	*-0.30%*	*-0.15%*	*-0.11%*	*-0.04%*	*1.53%*	*3.27%*	*5.04%*	*5.42%*
QUCIMPBU (.000t)	**41**	39	21	15	10	9	5	3	1
Var 2000	-	*-6.19%*	*-49.98%*	*-64.03%*	*-75.33%*	*-79.19%*	*-87.81%*	*-93.05%*	*-97.91%*
QUIMPMK (.000t)	**1758**	1791	1822	1851	1879	1905	1930	1954	1976
Var 2000	-	*1.88%*	*3.64%*	*5.30%*	*6.86%*	*8.35%*	*9.76%*	*11.11%*	*12.41%*
PCLIMK (euro/Kg)	**1.03**	1.04	1.05	1.05	1.05	1.06	1.05	1.05	1.04
Var 2000	-	*1.06%*	*1.35%*	*1.83%*	*2.14%*	*2.43%*	*1.95%*	*1.51%*	*1.07%*
PCCHPDO (euro/Kg)	**11.91**	12.01	12.35	12.56	12.76	12.87	13.04	13.22	13.60
Var 2000	-	*0.91%*	*3.74%*	*5.45%*	*7.16%*	*8.07%*	*9.56%*	*11.04%*	*14.26%*
PCBU (euro/Kg)	**7.03**	7.08	6.56	6.31	6.02	5.90	5.47	5.06	4.29
Var 2000	-	*0.72%*	*-6.74%*	*-10.27%*	*-14.34%*	*-16.10%*	*-22.12%*	*-27.99%*	*-39.00%*
PCOTCH (euro/Kg)	**9.14**	9.21	9.41	9.54	9.66	9.73	9.84	9.95	10.18
Var 2000	-	*0.73%*	*2.99%*	*4.35%*	*5.71%*	*6.43%*	*7.62%*	*8.81%*	*11.38%*
PCOTDA (euro/Kg)	**3.59**	3.61	3.62	3.63	3.64	3.64	3.63	3.62	3.61
Var 2000	-	*0.68%*	*0.87%*	*1.19%*	*1.38%*	*1.57%*	*1.26%*	*0.97%*	*0.69%*
QUTMKLIMK (.000t)	**3100**	3092	3036	2993	2949	2911	2858	2800	2704
Var 2000	-	*-0.27%*	*-2.07%*	*-3.46%*	*-4.87%*	*-6.08%*	*-7.82%*	*-9.68%*	*-12.79%*
QUTMKBU (.000t)	**91**	95	120	130	140	145	156	167	187
Var 2000	-	*4.80%*	*32.51%*	*43.75%*	*54.41%*	*60.09%*	*72.61%*	*84.55%*	*106.34%*
QUTMKCHPDO (.000t)	**355**	359	361	364	366	369	373	377	379
Var 2000	-	*1.02%*	*1.79%*	*2.41%*	*3.01%*	*3.98%*	*5.04%*	*6.08%*	*6.69%*
QUTMKOTCH (.000t)	**527**	538	543	547	552	556	561	567	577
Var 2000	-	*1.95%*	*2.87%*	*3.73%*	*4.58%*	*5.35%*	*6.34%*	*7.49%*	*9.37%*
QUTMKOTDA (.000t)	**286**	290	297	301	305	301	298	293	299
Var 2000	-	*1.41%*	*3.71%*	*5.21%*	*6.73%*	*5.29%*	*4.12%*	*2.45%*	*4.54%*
QUMKDOMCHPDO (.000t)	**4215**	4258	4290	4316	4341	4382	4427	4471	4497
Var 2000	-	*1.02%*	*1.79%*	*2.41%*	*3.01%*	*3.98%*	*5.04%*	*6.08%*	*6.69%*
QUMKDOMOTCH (.000t)	**3209**	3272	3293	3312	3333	3350	3378	3412	3479
Var 2000	-	*1.97%*	*2.63%*	*3.23%*	*3.86%*	*4.40%*	*5.27%*	*6.34%*	*8.42%*
QUMKDOMOTDA (.000t)	**366**	369	379	384	390	376	364	349	359
Var 2000	-	*1.04%*	*3.76%*	*5.14%*	*6.62%*	*2.83%*	*-0.44%*	*-4.55%*	*-1.81%*
QUMKDOMLIMK (.000t)	**2648**	2631	2568	2517	2466	2422	2362	2298	2196
Var 2000	-	*-0.64%*	*-3.04%*	*-4.95%*	*-6.87%*	*-8.55%*	*-10.82%*	*-13.23%*	*-17.09%*
QUIMPMKOTCH (.000t)	**1011**	1030	1048	1065	1080	1095	1110	1123	1136
Var 2000	-	*1.88%*	*3.64%*	*5.30%*	*6.86%*	*8.35%*	*9.76%*	*11.11%*	*12.41%*
QUIMPMKOTDA (.000t)	**295**	301	306	311	316	320	324	328	332
Var 2000	-	*1.88%*	*3.64%*	*5.30%*	*6.86%*	*8.35%*	*9.76%*	*11.11%*	*12.41%*
QUIMPMKLIMK (.000t)	**452**	460	468	476	483	490	496	502	508
Var 2000	-	*1.88%*	*3.64%*	*5.30%*	*6.86%*	*8.35%*	*9.76%*	*11.11%*	*12.41%*
QUEXPCHPDO (.000t)	**50**	51	52	53	54	55	56	57	58
Var 2000	-	*1.78%*	*4.22%*	*6.31%*	*8.33%*	*9.78%*	*11.43%*	*12.99%*	*15.30%*
STOCKSBF (.000 heads)	**2866**	2921	2924	2880	2807	2783	2770	2755	2740
Var 2000	-	*1.91%*	*2.02%*	*0.47%*	*-2.07%*	*-2.88%*	*-3.35%*	*-3.87%*	*-4.39%*
QUPBF (.000t)	**1151921**	1149653	1155882	1151362	1139907	1133981	1132405	1130715	1128671
Var 2000	-	*-0.20%*	*0.34%*	*-0.05%*	*-1.04%*	*-1.56%*	*-1.69%*	*-1.84%*	*-2.02%*
QUCBF (.000t)	**1440051**	1472002	1508199	1543437	1547671	1553743	1561680	1569700	1577742
Var 2000	-	*2.22%*	*4.73%*	*7.18%*	*7.47%*	*7.90%*	*8.45%*	*9.00%*	*9.56%*
QUIMPBF (.000t)	**386517**	420737	450705	490463	506151	518150	527663	537372	547459
Var 2000	-	*8.85%*	*16.61%*	*26.89%*	*30.95%*	*34.06%*	*36.52%*	*39.03%*	*41.64%*
PPBF *(euro/Kg)*	**1.92**	1.85	1.78	1.70	1.72	1.75	1.77	1.78	1.80
Var 2000	-	*-3.44%*	*-7.23%*	*-11.53%*	*-10.20%*	*-8.90%*	*-7.99%*	*-7.08%*	*-6.15%*
PCBF (euro/Kg)	**7.90**	7.76	7.60	7.42	7.47	7.52	7.56	7.60	7.63
Var 2000	-	*-1.83%*	*-3.79%*	*-6.09%*	*-5.47%*	*-4.82%*	*-4.35%*	*-3.88%*	*-3.41%*

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