Multi-stage Market Power in the Italian Fresh Meat Industry

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Abstract

In line with the New Empirical Industrial Organisation literature, a three-stage modelling of the fresh meat industry in Italy is developed to evaluate the extent of the oligopsonistic behaviour of downstream operators on upstream ones. Moreover, retailers are allowed to exercise oligopolistic market power over consumers purchasing three types of meats assumed substitutable in consumption. Employing a flexible technique for estimating such a model on a uniquely compiled database, evidence that market power is mainly exercised at the retail is unveiled. In fact, roughly 75 – 85% of the price margin at the retail level can be associated with the occurrence of oligopolistic market power. Empirical findings do not support the existence of oligopsonistic power of retailers over processors and of the latter over farmers.

Keywords: market power, fresh meat, multistage marketing chain, Italy

JEL Codes: C330, L130, Q110

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Introduction

The modern organisation of the marketing chain of an agricultural commodity can be thought of being formed of, at least, three stages: the farm-level production, the processing and the retailing stage. These stages identify the interactions between producers, processors, retailers and consumers.The value added produced by the marketing chain with respect to the output of the farming activity (i.e., the agricultural commodity) might be represented by the possibility, for the consumer, to conveniently purchase the desired quality, quantity and preparation of a given food product, at the best possible price, in his/her shopping at the preferred point of sale.Nonetheless, this total value added needs to be redistributed among all the players in the marketing chain to ensure that their costs are remunerated, the economic viability of their business is maintained and there is room for developing their operations (Richards et al., 2011). In presence of market power at any stage of the chain, some operators might extract some of the producer's surplus pertaining to its supplier(s), through a oligopsonistic behaviour, or to its customer(s), through an oligopolistic one.

Since the competitive organisation of a market, comprising both producers and consumers, is known to maximise social welfare while being efficient in the distribution of surplus across market players, an empirical assessment of the departure from this organisation provides the necessary evidence for market-based or regulatory interventions to prevent costs savings from economies of scale to turn into the exercise of market power. Therefore, this paper – focusing on the Italian fresh meat[1] industry - aims to estimate the extent of oligopsonistic market power enforced in the sequential relationships occurring between the retail, processing and production (farm-gate) stages of the Italian marketing chain of this fresh produce (Sexton and Zhang, 2001). Moreover, the analysis explores the possibility that consumers experience a reduced surplus due to the oligopoly power that retailers impose on them. The remainder of the paper is organised as follows. The next section reviews the existing literature on the quantification of market power in the food marketing chains. In the third section, the details of the proposed three-stages three-products model are presented. Section 4 describes the dataset used in empirical estimation while the fifth one reports how the theoretical model is

[1] Throughout the paper, the term meat should be interpreted, if not stated otherwise, as comprising beef, chicken and pork.

translated into the empirical one. The section presenting the estimated results follows while the last section concludes.

Literature review

The empirical studies dealing with the analysis of the extent of market power and/or pricing strategies can be classified and reviewed according to the combination of two leading dimensions of their theoretical underlying model: the number of stages of the marketing chain that are put under scrutiny and the number of products that are considered substitutable in consumption. Moreover, a trade-off between the model's explanatory power and its technical sophistication seems to emerge and might be worth dissecting.

Focusing on the issue of the number of stages of the marketing chain and the number of substitutable goods in consumption considered, a trade-off seems to emerge. Although violating the assumption of agricultural goods being jointly demanded, O'Donnell et al. (2007) evaluate the existence of market power at the processing stage of the Australian marketing chains for 13 different grains and oilseeds products. Processors are assumed to purchase raw agricultural products from producers (or producers' marketing boards) and to sell their own output to further processors or to final consumers. It appears that flour and cereal food, beer and malt as well as other food manufacturers exert oligopsonistic power - towards producers - when procuring wheat, barley, oats and triticale for their respective operations. According to the value of the calculated Lerner index, barley producers - and some of their marketing boards - seem to express some degree of monopoly selling to processors. Nonetheless, every other marketing chain appears to behave competitively. In particular, consumers record the smallest level of buying market power in every of the marketing chain considered (O'Donnell et al., 2007).

Applied work on a one-product one-stage marketing chain have focused on the relationship between large and powerful manufacturers and retailers (Berto Villas-Boas 2007; Bonnet and Dubois, 2010).[2] These contributions, using a flexible and inherently two-way game theoretic

[2] The actual type (i.e., direction) and intensity of market power between these two actors of the food marketing chain is a function of the type of game considered (Kadiyali et al., 2000), of the payoffs associated with the negotiated solution and with the outside option, of the negotiating power (i.e., the possibility of appropriating a larger share of the total channel surplus (Misra and Mohanty, 2008)) and position (i.e., a measure of what is to be lost by leaving the negotiation to take up the outside option (Draganska et al., 2009)).

approach, estimate a number of non-nested competing models giving rise to a specific stream of literature. Among the one-stage multiple-products New Empirical Industrial Organisation (NEIO) models, Schroeter and Azzam (1990), working on the US beef and pork meat marketing chain, provide empirical evidence on the existence of a non-competitive form of interaction between integrated firms and their final customers.[3] The two meats are assumed to be substitutable in demand and jointly offered on the final market. Therefore, Schroeter and Azzam (1990) might be regarded as one of the first studies to employ a model of a single-stage non-competitive market interaction for more than one product demanded by consumers.[4] They establish that around half of the farm-to-retail price spread for both types of meat might be due to some form of market power. Gohin and Guyomard (2000) estimate an empirical model of the pricing rules implemented at the distribution stage of the French marketing chain for dairy, meat and other food products, with the latter being supposed demand related final goods (i.e., substitutable among themselves). Focusing on three products, Gohin and Guyomard (2000) choose to restrict their attention to the sole retailing stage modelling the economic behaviour of consumers, retailers and wholesalers. In particular, retailers are assumed to express some oligopoly power towards consumers (i.e., downstream) as well as some oligopsony power towards wholesalers (i.e., upstream). The estimation of an inverse demand system for the final goods, single supply functions for the wholesale goods and the price transmission equations, arising from the retailer's profit maximising behaviour, leads to rejecting the hypothesis of competitive organisation of the French food retailing stage. Similarly, Hyde and Perloff (1998) estimate the extent of market power in the retail market for beef, lamb and pork meat both assumed as being and not being substitutable in consumption. It appears that the market for every type of meat is organised according to a perfectly competitive structure.

Among the one-product multiple-marketing stages NEIO models, Fulton and Tang (1999) consider the whole marketing chain for Canadian chicken modelling explicitly the behaviour of producers, processors and retailers. Fulton and Tang (1999) estimate a violation of the hypothesis of perfect competition in the marketing chain although it is unclear whether market power concentrates either at the processing and/or retail stage. In fact, the restriction

[3] In Schroeter and Azzam (1990) the marketing chain is not explicitly divided up in stages. In fact, there is no mentioning of a farming stage except for the latter being the source of the agricultural input which is then processed and sold on the market.

[4] Schroeter and Azzam (1990) cite Gelfand and Spiller (1987) as the only previous contribution which considered the strategic interaction between firms producing two demand related products.

of farm supply, implemented by marketing boards, seems to play a somewhat minor role in pricing chicken above its marginal cost.

The choice of the marketing stage to focus on and the number of products assumed to be jointly produced/consumed is related – in a bi-directional way – to the theoretical model of choice. Gohin and Guyomard (2000) build on the theoretical work of Schroeter and Azzam (1990) while Hyde and Perloff (1998) extend the structural approach (e.g., Bresnahan (1982)) employing simultaneously a demand system (modelled using a Linear Approximation of the Almost Ideal Demand System (LA/AIDS)) and a market power parameter as well as a marginal cost function for each of the three types of meat they consider. O'Donnell et al. (2007) develop the NEIO model in Griffith (2000), which specifies marketing margins which are linear in the prices of non-agricultural inputs and in the quantities of the agricultural ones, modelling the behaviour of both consumers and producers in their upstream and downstream relationship with processors, assuming a variable proportions technology. Therefore, the model allows for the identification of the existence of "... some market power in the sale of outputs *and/or* the purchase of inputs." (O'Donnell et al., 2007:355).

Lastly, contributions in the NEIO literature differ with respect to the empirical specification of the relevant theoretical functions as well as the quantitative technique employed to obtain the value of the parameters of interest given the available data. Gohin and Guyomard (2000) specify the retailer's total cost function according to the Gorman polar form[5], the wholesaler's input supply function according to a log-linear form and the final demand system according to its inverse formulation as defined by Huang (1988). Although O'Donnell et al. (2007) make the same modelling choice, they note that this should introduce the quite demanding assumption of constant marginal costs and revenues across firms. Gohin and Guyomard (2000) estimate the model's relevant equations separately, using appropriate Instrumental Variables (IV) techniques, since a simultaneous and Full Information Maximum Likelihood (FIML) procedure did not converge. A similar approach is adopted by Schroeter and Azzam (1990), although they calibrate the values of some key supply parameters on those existing in authoritative literature. Hyde and Perloff (1998) analyse the existence of market power in three demand-related marketing chains for meat in Australia captured in quarterly observations on meat consumption, retail, wholesale prices and labour costs. The

[5] "The Gorman polar form is often chosen to facilitate the aggregation of individual level functions into industry level ones (O'Donnell et al., 2007:356).

simultaneous estimation of the LA/AIDS, the system's relevant constraints and the retailers' optimality conditions relies on non-linear 3SLS. The starting values of the nonlinear procedure are the sole demand system's estimated parameters while a fourth order autocorrelation correction respects the frequency of the available data (Cashin, 1991) and a first order correction is applied to the optimality conditions (Hyde and Perloff, 1998). Fulton and Tang (1999) estimate the model's relevant equations using a Seemingly Unrelated Regression (SUR) technique. A similar approach has been followed by O'Donnell et al. (2007) , while they also impose the signs of the own-price elasticities of output demand being nonpositive and of own-elasticities of input supply being nonnegative using a Bayesian prior.

To the best of our knowledge, a three-stages three-products modelling of a marketing chain has not been carried out yet within the NEIO literature. Likewise, using a Generalised Methods of Moments (GMM) estimation technique to handle in a flexible manner several of the issues which, using other techniques, are usually taken care of placing significant restrictions on the data generating process is fairly new (Sckokai et al., 2009). The next section details the setup of such a model.

The Theoretical Model

Following Sexton and Zhang (2001), and their formalisation of the model with successive oligopsony power, farmers produce an agricultural product which is sold to processors exerting oligopsony power on the previous stage of the chain. In turn, the output of the processing stage is transferred to retailers which face the consumers' demand. At this stage, retailers are assumed to exert both oligopsony power towards processors and oligopoly power towards consumers in each of the markets for the three different meats. The representative retailer (whose variables will be denoted by the superscript *r*) faces an inverse demand function, by consumers, for the i^{th} type of meat which, to be representative of real-life transactions, is characterised by substitution in consumption according to:

$$\begin{aligned} P_b^r &= P_b^r\left(Q_b^r, Q_c^r, Q_p^r; \mathbf{X}\right) \\ P_c^r &= P_c^r\left(Q_b^r, Q_c^r, Q_p^r; \mathbf{X}\right) \\ P_p^r &= P_p^r\left(Q_b^r, Q_c^r, Q_p^r; \mathbf{X}\right) \end{aligned} \tag{1}$$

where the subscripts *b*, *c* and *p* denote the beef, chicken and pork meat respectively, P_i^j and Q_i^j are the industry level price and quantity of the i^{th} meat at the j^{th} stage of the marketing chain, and $\boldsymbol{X}$ is a vector of exogenous demand shifters.

At the production stage, farmers (whose variables will be denoted by the superscript *f*) are assumed to be price taker in their output market and to be specialised in the production of only one type of meat at a time. This hypothesis seems to be reasonable due to the specific investments required to meet the established breeding standards in terms of food quality and safety as well as given the structural differences in bovine, poultry and swine feedlots and the managerial implications they have. Hence, at the farm stage (denoted by the superscript *f*), the supply of agricultural commodities can be modelled according to the following inverse supply functions:

$$\begin{aligned} P_b^f &= P_b^f\left(Q_b^f;\mathbf{Y}\right) \\ P_c^f &= P_c^f\left(Q_c^f;\mathbf{Y}\right) \\ P_p^f &= P_p^f\left(Q_p^f;\mathbf{Y}\right) \end{aligned} \tag{2}$$

where $\mathbf{Y}$ is a vector of exogenous supply shifters and the remaining terms are as previously defined. Further assumptions, quite common in the literature (e.g., Sexton and Zhang (2001)), concern retailers and processors adopting fixed-proportions and constant returns to scale technology to transform their respective inputs into outputs. Moreover, retailers' technology is separable across the products marketed to the final consumer. Finally, each stage's output is measured using units which ensure that $Q^f = Q^w = Q^r = Q$ with superscripts *w* denoting the processing stage of the marketing chain.[6] This last requirement is satisfied selecting the quantity of each meat demanded at the retail level as the reference quantity in the model.

At the processing stage, processors are supposed to handle all the three types of meat considered here. This assumption might not necessarily hold at the processor's plant level

[6] The assumption of constant output throughout all the stages of the food marketing chain requires to carefully choose the marketing chain of interest. The latter should be characterised by a short time span intervening between the raw agricultural product leaving the farm gate and the retail product being purchased by the consumer as well as by a marginal loss of output in weight terms. We believe the marketing chain for fresh meat respects these assumptions.

where the different characteristics of the production lines[7], of the slaughtering process and of the sanitation requirements[8] might imply the specialisation of the premises. Nonetheless, it might hold at the "processing group" level. The latter might be intended as the business entity (i.e., holding, group) which has consolidated its competitive position acquiring a number of specialised diverse operators and generating a large processor able to exploit its significant scale to influence the market's dynamics, especially in its relation with large multi-output retailers. Although the previous argument might imply a direct and robust link between higher industry concentration and the existence of a sizeable market power, Saghaian (2007) reports that Azzam and Anderson (1996) do not find any relationship between increased concentration and market power when analysing the literature on firms' behaviour in the US meatpacking industry. In fact, increased concentration might be the outcome of economies of size allowing firms to lower their operational costs and building the extra profits (without exploiting any uncompetitive and/or illegal behaviour) necessary to acquire one of their competitors. On the other hand, exploiting existing market power would yield higher profits (potentially employed to consolidate a processor's market share) through a higher than "normal" price.[9]

In presence of market power towards the representative farmer and being unable to affect the price it receives from the retailer, the representative wholesaler chooses its output level by maximising its profits π^w defined as:

$$\max_{q_b^w, q_c^w, q_p^w} \quad \pi^w = P_b^w q_b^w + P_c^w q_c^w + P_p^w q_p^w - P_b^f\left(Q_b;\mathbf{Y}\right) q_b^w - P_c^f\left(Q_c;\mathbf{Y}\right) q_c^w + \\ - P_p^f\left(Q_p;\mathbf{Y}\right) q_p^w - C^w\left(q_b^w, q_c^w, q_p^w;\mathbf{V}^w\right) \qquad (3)$$

where $C^w\left(q_b^w, q_c^w, q_p^w;\mathbf{V}^w\right)$ represents the costs of running the processing operation, other than the ones associated with procuring the agricultural commodity at the farm stage. In turn, they depend upon the quantity of each meat handled by the operator q_b^w, q_c^w, q_p^w and by a

7 For instance, the processing line at a pig processing plant is much lower than the one at a beef processing plant. Therefore, using the former to process beef meat would imply that carcasses hit the ground undermining their microbiological safety.

8 It would be possible to process pork meat using a beef processing line provided the necessary sanitation procedures have been carried out. This would translate into dedicating a full day of operation of a multi-purpose plant to the processing of a specific type of meat.

9 The assumption of processors being large and multi-output is established in the literature. For instance, Schroeter and Azzam (1990) report evidence of US meat processors operating both hog and cattle plants.

vector of wholesaler's exogenous cost shifters $\mathbf{V}^w$. Lower case variables denote firm level decision variables. Note that the output of the single wholesaling firm q_i^w for the i^{th} type of meat contributes to the overall market output Q_i. The representative wholesaler produces the optimal quantities of processed beef, chicken and pork meat setting the relevant first order conditions (FOCs) from (3) to zero. Rearranging to express the value of P_i^w as a function of the exogenous variables and structural parameters, we obtain:

$$
\begin{aligned}
P_b^w &= P_b^f\left(Q_b;\mathbf{Y}\right)+\frac{\partial P_b^f\left(Q_b;\mathbf{Y}\right)}{\partial Q_b}Q_b\theta_b^f + c_b^w\left(q_b^w,q_c^w,q_p^w;\mathbf{V}^w\right)\\
P_c^w &= P_c^f\left(Q_c;\mathbf{Y}\right)+\frac{\partial P_c^f\left(Q_c;\mathbf{Y}\right)}{\partial Q_c}Q_c\theta_c^f + c_c^w\left(q_b^w,q_c^w,q_p^w;\mathbf{V}^w\right)\\
P_p^w &= P_p^f\left(Q_p;\mathbf{Y}\right)+\frac{\partial P_p^f\left(Q_p;\mathbf{Y}\right)}{\partial Q_p}Q_p\theta_p^f + c_p^w\left(q_b^w,q_c^w,q_p^w;\mathbf{V}^w\right)
\end{aligned}
\tag{4}
$$

where $c_i^w\left(q_b^w,q_c^w,q_p^w;\mathbf{V}^w\right)$ is the marginal value of other processing costs for the i^{th} type of meat and $\theta_i^f=\frac{\partial Q_i}{\partial q_i^w}\frac{q_i^w}{Q_i}\quad i=b,c,p$ might be interpreted as the conjectural elasticity of the representative wholesaler towards the representative farmer.

In presence of market power towards consumers, the representative retailer affects the price the final consumer pays on the retail market. Similarly, the representative retailer is supposed to exert oligopsonistic power toward the wholesaler which, in turn, is thought to affect the representative farmer's production choice. The representative retailer's profits $\left(\pi^r\right)$ maximisation problem can be written as:

$$\max_{q_b^r, q_c^r, q_p^r} \pi^r = P_b^r\left(Q_b\left(q_b^r,q_c^r,q_p^r\right),Q_c\left(q_b^r,q_c^r,q_p^r\right),Q_p\left(q_b^r,q_c^r,q_p^r\right);\mathbf{X}\right)q_b^r +$$
$$+P_c^r\left(Q_b\left(q_b^r,q_c^r,q_p^r\right),Q_c\left(q_b^r,q_c^r,q_p^r\right),Q_p\left(q_b^r,q_c^r,q_p^r\right);\mathbf{X}\right)q_c^r +$$
$$+P_p^r\left(Q_b\left(q_b^r,q_c^r,q_p^r\right),Q_c\left(q_b^r,q_c^r,q_p^r\right),Q_p\left(q_b^r,q_c^r,q_p^r\right);\mathbf{X}\right)q_p^r +$$
$$-\left(P_b^f\left(Q_b;\mathbf{Y}\right)+\frac{\partial P_b^f\left(Q_b;\mathbf{Y}\right)}{\partial Q_b}Q_b\theta_b^f + c_b^w\left(q_b^w,q_c^w,q_p^w;\mathbf{V}^w\right)\right)q_b^r + \quad (5)$$
$$-\left(P_c^f\left(Q_c;\mathbf{Y}\right)+\frac{\partial P_c^f\left(Q_c;\mathbf{Y}\right)}{\partial Q_c}Q_c\theta_c^f + c_c^w\left(q_b^w,q_c^w,q_p^w;\mathbf{V}^w\right)\right)q_c^r +$$
$$-\left(P_p^f\left(Q_p;\mathbf{Y}\right)+\frac{\partial P_p^f\left(Q_p;\mathbf{Y}\right)}{\partial Q_p}Q_p\theta_p^f + c_p^w\left(q_b^w,q_c^w,q_p^w;\mathbf{V}^w\right)\right)q_p^r +$$
$$-C^r\left(q_b^r,q_c^r,q_p^r;\mathbf{V}^r\right)$$

where $C^r\left(q_b^r,q_c^r,q_p^r;\mathbf{V}^r\right)$ represents the costs of running the retailing operation, other than the ones associated with procuring the intermediate goods produced at the wholesaling stage. In turn, they depend upon the quantity of each meat handled by the operator q_b^r, q_c^r, q_p^r and by a vector of retailer's exogenous cost shifters $\mathbf{V}^r$. Once again, lower case variables denote firm level decision variables and the output of the single retailer q_i^r for the i^{th} type of meat contributes to the overall market output Q_i. The market quantity of the i^{th} type of meat offered at the wholesaling stage of the marketing chain Q_i depends on the representative wholesaler's decision of producing a certain quantity of each type of meat in a technological setting characterised by significant joint production (Schroeter and Azzam, 1990).

The representative retailer chooses the optimal quantities of beef, chicken and pork meat to be retailed by setting the relevant FOCs from (5) to zero. Define $\zeta_{i,j}^r = \frac{\partial P_i^r\left(Q_b,Q_c,Q_p;\mathbf{X}\right)}{\partial Q_j}\frac{Q_j}{P_i^r\left(Q_b,Q_c,Q_p;\mathbf{X}\right)}$ for i,j=b,c,p the representative retailer's own/cross price flexibility of consumer demand, $\phi_{i,j}^r = \frac{\partial Q_i}{\partial q_j^r}\frac{q_j^r}{Q_i}$ for i,j=b,c,p the own/cross conjectural elasticity of the representative retailer in its interaction with the representative consumer (i.e., the measure of the expected degree of oligopoly power), $\xi_i^f = \frac{\partial P_i^f\left(Q_i;\mathbf{Y}\right)}{\partial Q_i}\frac{Q_i}{P_i^f\left(Q_i;\mathbf{Y}\right)}$ for i,j=b,c,p the own-price flexibility of supply of the representative farmer and $\theta_{i,j}^{w} = \frac{\partial Q_i}{\partial q_j^r}\frac{q_j^r}{Q_i}$ for i,j=b,c,p the own/cross conjectural elasticity of the representative retailer in its interaction with the representative processor (i.e., the measure of the expected degree of oligopsony power). In turn, using these definitions and considering that $c_i^r\left(q_b^r, q_c^r, q_p^r; \mathbf{V}^r\right)$ is the marginal value of other retailing costs for the i^{th} type of meat, the FOCs from (5) read as follows:

$$
\begin{aligned}
&\left(1+\zeta^{r}_{b,b}\phi^{r}_{b,b}+\zeta^{r}_{b,c}\phi^{r}_{c,b}+\zeta^{r}_{b,p}\phi^{r}_{p,b}\right)P^{r}_{b}\left(Q_{b},Q_{c},Q_{p};\mathbf{X}\right)+\left(\zeta^{r}_{c,b}\phi^{r}_{b,b}+\zeta^{r}_{c,c}\phi^{r}_{c,b}+\zeta^{r}_{c,p}\phi^{r}_{p,b}\right)P^{r}_{c}\left(Q_{b},Q_{c},Q_{p};\mathbf{X}\right)\frac{q^{r}_{c}}{q^{r}_{b}}+\left(\zeta^{r}_{p,b}\phi^{r}_{b,b}+\zeta^{r}_{p,c}\phi^{r}_{c,b}+\zeta^{r}_{p,p}\phi^{r}_{p,b}\right)\frac{q^{r}_{p}}{q^{r}_{b}}P^{r}_{p}\left(Q_{b},Q_{c},Q_{p};\mathbf{X}\right)+\\
&-\left(\left(1+\theta^{f}_{b}\right)\xi^{f}_{b}P^{f}_{b}\left(Q_{b};\mathbf{Y}\right)+\frac{\partial^{2}P^{f}_{b}\left(Q_{b};\mathbf{Y}\right)}{\partial Q_{b}^{2}}Q_{b}^{2}\theta^{f}_{b}\right)\theta^{w}_{b,b}-\left(\left(1+\theta^{f}_{c}\right)\xi^{f}_{c}P^{f}_{c}\left(Q_{c};\mathbf{Y}\right)+\frac{\partial^{2}P^{f}_{c}\left(Q_{c};\mathbf{Y}\right)}{\partial Q_{c}^{2}}Q_{c}^{2}\theta^{f}_{c}\right)\theta^{w}_{c,b}\frac{q^{r}_{c}}{q^{r}_{b}}-\left(\left(1+\theta^{f}_{p}\right)\xi^{f}_{p}P^{f}_{p}\left(Q_{p};\mathbf{Y}\right)+\frac{\partial^{2}P^{f}_{p}\left(Q_{p};\mathbf{Y}\right)}{\partial Q_{p}^{2}}Q_{p}^{2}\theta^{f}_{p}\right)\theta^{w}_{p,b}\frac{q^{r}_{p}}{q^{r}_{b}}+\\
&-\left(1+\xi^{f}_{b}\theta^{f}_{b}\right)P^{f}_{b}\left(Q_{b};\mathbf{Y}\right)-c^{w}_{b}\left(q^{w}_{b},q^{w}_{c},q^{w}_{p};\mathbf{V}^{w}\right)-c^{r}_{b}\left(q^{r}_{b},q^{r}_{c},q^{r}_{p};\mathbf{V}^{r}\right)=0\\
&\left(\zeta^{r}_{b,b}\phi^{r}_{b,c}+\zeta^{r}_{b,c}\phi^{r}_{c,c}+\zeta^{r}_{b,p}\phi^{r}_{p,c}\right)\frac{q^{r}_{b}}{q^{r}_{c}}P^{r}_{b}\left(Q_{b},Q_{c},Q_{p};\mathbf{X}\right)+\left(1+\zeta^{r}_{c,b}\phi^{r}_{b,c}+\zeta^{r}_{c,c}\phi^{r}_{c,c}+\zeta^{r}_{c,p}\phi^{r}_{p,c}\right)P^{r}_{c}\left(Q_{b},Q_{c},Q_{p};\mathbf{X}\right)+\left(\zeta^{r}_{p,b}\phi^{r}_{b,c}+\zeta^{r}_{p,c}\phi^{r}_{c,c}+\zeta^{r}_{p,p}\phi^{r}_{p,c}\right)\frac{q^{r}_{p}}{q^{r}_{c}}P^{r}_{p}\left(Q_{b},Q_{c},Q_{p};\mathbf{X}\right)+\\
&-\left(\left(1+\theta^{f}_{b}\right)\xi^{f}_{b}P^{f}_{b}\left(Q_{b};\mathbf{Y}\right)+\frac{\partial^{2}P^{f}_{b}\left(Q_{b};\mathbf{Y}\right)}{\partial Q_{b}^{2}}Q_{b}^{2}\theta^{f}_{b}\right)\theta^{w}_{b,c}\frac{q^{r}_{b}}{q^{r}_{c}}-\left(\left(1+\theta^{f}_{c}\right)\xi^{f}_{c}P^{f}_{c}\left(Q_{c};\mathbf{Y}\right)+\frac{\partial^{2}P^{f}_{c}\left(Q_{c};\mathbf{Y}\right)}{\partial Q_{c}^{2}}Q_{c}^{2}\theta^{f}_{c}\right)\theta^{w}_{c,c}-\left(\left(1+\theta^{f}_{p}\right)\xi^{f}_{p}P^{f}_{p}\left(Q_{p};\mathbf{Y}\right)+\frac{\partial^{2}P^{f}_{p}\left(Q_{p};\mathbf{Y}\right)}{\partial Q_{p}^{2}}Q_{p}^{2}\theta^{f}_{p}\right)\theta^{w}_{p,c}\frac{q^{r}_{p}}{q^{r}_{c}}+\\
&-\left(1+\xi^{f}_{c}\theta^{f}_{c}\right)P^{f}_{c}\left(Q_{c};\mathbf{Y}\right)-c^{w}_{c}\left(q^{w}_{b},q^{w}_{c},q^{w}_{p};\mathbf{V}^{w}\right)-c^{r}_{c}\left(q^{r}_{b},q^{r}_{c},q^{r}_{p};\mathbf{V}^{r}\right)=0\\
&\left(\zeta^{r}_{b,b}\phi^{r}_{b,p}+\zeta^{r}_{b,c}\phi^{r}_{c,p}+\zeta^{r}_{b,p}\phi^{r}_{p,p}\right)\frac{q^{r}_{b}}{q^{r}_{p}}P^{r}_{b}\left(Q_{b},Q_{c},Q_{p};\mathbf{X}\right)+\left(\zeta^{r}_{c,b}\phi^{r}_{b,p}+\zeta^{r}_{c,c}\phi^{r}_{c,p}+\zeta^{r}_{c,p}\phi^{r}_{p,p}\right)\frac{q^{r}_{c}}{q^{r}_{p}}P^{r}_{c}\left(Q_{b},Q_{c},Q_{p};\mathbf{X}\right)+\left(1+\zeta^{r}_{p,b}\phi^{r}_{b,p}+\zeta^{r}_{p,c}\phi^{r}_{c,p}+\zeta^{r}_{p,p}\phi^{r}_{p,p}\right)P^{r}_{p}\left(Q_{b},Q_{c},Q_{p};\mathbf{X}\right)+\\
&-\left(\left(1+\theta^{f}_{b}\right)\xi^{f}_{b}P^{f}_{b}\left(Q_{b};\mathbf{Y}\right)+\frac{\partial^{2}P^{f}_{b}\left(Q_{b};\mathbf{Y}\right)}{\partial Q_{b}^{2}}Q_{b}^{2}\theta^{f}_{b}\right)\theta^{w}_{b,p}\frac{q^{r}_{b}}{q^{r}_{p}}-\left(\left(1+\theta^{f}_{c}\right)\xi^{f}_{c}P^{f}_{c}\left(Q_{c};\mathbf{Y}\right)+\frac{\partial^{2}P^{f}_{c}\left(Q_{c};\mathbf{Y}\right)}{\partial Q_{c}^{2}}Q_{c}^{2}\theta^{f}_{c}\right)\theta^{w}_{c,p}\frac{q^{r}_{c}}{q^{r}_{p}}-\left(\left(1+\theta^{f}_{p}\right)\xi^{f}_{p}P^{f}_{p}\left(Q_{p};\mathbf{Y}\right)+\frac{\partial^{2}P^{f}_{p}\left(Q_{p};\mathbf{Y}\right)}{\partial Q_{p}^{2}}Q_{p}^{2}\theta^{f}_{p}\right)\theta^{w}_{p,p}+\\
&-\left(1+\xi^{f}_{p}\theta^{f}_{p}\right)P^{f}_{p}\left(Q_{p};\mathbf{Y}\right)-c^{w}_{p}\left(q^{w}_{b},q^{w}_{c},q^{w}_{p};\mathbf{V}^{w}\right)-c^{r}_{p}\left(q^{r}_{b},q^{r}_{c},q^{r}_{p};\mathbf{V}^{r}\right)=0 \qquad (6)
\end{aligned}
$$

Our theoretical model, to be estimated on industry level data, is formed by the equations in (1), (2), (4) and (6).

The Data

To estimate the model empirically, a dedicated dataset of monthly observations over the period January 2002 – December 2010 is compiled. This period should be sufficient to analyse, although in a static way, the evolution of the margins for the three types of meat as well as the changes in demand and supply behaviours.

Table 1 provides the definition, source, mean and standard deviation of each variable employed in estimation.

Table 1 about here

Note that the somewhat limited number of ingredients, of the livestock's daily ration, reported in Table 1 is the outcome of a careful correlation analysis carried out to limit the extent of large correlations – due to common national and international trends affecting these commodities as well as being listed on the same commodity exchange – between the feedstuffs employed in the empirical estimates.

While data for farm level's inputs and outputs, as well as the output of the processing stage, are drawn from the relevant listings at selected Italian Chambers of Commerce, retail level data[10] originate from the Ismea-ACNielsen survey of the purchasing behaviour of 9,000 households in Italy. The survey methodology is centred around the home scanning of barcodes and the submission of data, codified using a reference list, which accommodate the consumption of fresh, loose and other foodstuff produced in the household. The two stage stratified[11] nationally representative survey provides consumption data on a 28 days base from February 2000 to December 2010.

[10] Since the Ismea-ACNielsen panel provides information on the value and volume of purchases, retail prices – obtained as value over volume – should be intended as unit values. Hovhannisyan and Gould (2011) warn that using unit values might generate a measurement error bias due to the composition of commodity aggregates being possibly regarded as endogenous given the consumer chooses among products of different quality and because of the composition of specific commodity purchases within a broader aggregate. While we are aware of this additional complication in our analysis, we believe it is somewhat tackled through our estimation technique of choice (i.e., GMM) one the one hand and could be matter for future research on the other.

[11] Households are first selected according to a broad geo-economic classification based on the interaction between residence and the type of trading in that area. The panel is further balanced relying on eight additional

Figure 1 to 3 depict the absolute magnitude and the evolution of the margins across the three stages of the three meats' marketing chains.

Figure 1-3 about here

Inspecting the three panels, it is somewhat striking to note that the retail prices of the three types of meat have increased noticeably while the respective farm and processing level time series appear largely flat with marked fluctuations around the average value. Besides the seasonal preference for some type of meat, the significant price drops occurring over the period are likely to have been connected with the outbreaks of animal diseases and/or the occurrence of significant threats to food safety. Moreover, except for beef meat – where a decent margin arises also between the processing and the farm level – every meat features retail to processing margins which largely exceed the ones at the previous stages of the marketing chain.

The Empirical Model

Estimating the theoretical model presented in equations (1), (2), (4) and (6) requires to specify the preferred analytical forms of equations (1), (2) and of the marginal costs' functions $c_i^w(q_b^w, q_c^w, q_p^w)$ and $c_i^r(q_b^r, q_c^r, q_p^r)$. Moreover, since only industry, rather than firm, level data are available, we need to aggregate this system of equations over the number of existing firms.

We follow Deaton and Muellbauer (1980) and define the AIDS retailers' demand function (1) as:

$$W_i = \mathrm{A}_i + \sum_j \Gamma_{ij} \ln P_j^r + \mathrm{B}_i \ln \frac{X}{P} + \mathbf{\Delta}_i \mathbf{N} \qquad i = b, c, p \tag{7}$$

where $W_i = \frac{P_i^r Q_i}{X}$ represents the share of expenditure devoted to the overall retail purchase of the i^{th} type of meat, Q_i is the quantity of the i^{th} type of meat demanded at the retail level and P_i^r is its related retail market price. Moreover, P is a general price index, X is the total expenditure for the three meats and the vector $\mathbf{N}$ contains additional exogenous demand

socio-economic variables (e.g., *inter alia* the number of household members, per capita income in the area and the socio-economic status of the household, household lifestage).

shifters including a logarithmic time trend and a set of eleven monthly dummies to account for seasonality in consumption. $\mathrm{A}_i, \Gamma_{ij}, \mathrm{B}_i, \mathbf{\Delta}_i$ are the parameters to be estimated. To facilitate identification, we approximate $\ln P$ with the Stone price index such that $\ln P = \sum_i W_i \ln P_i$ (Stone, 1967). Nonetheless, to avoid that the A_i parameters are identified only up to a scalar multiple (i.e., to avoid that the unit of measurement affects the estimates), we scale retail prices and total expenditure at their sample mean (Moschini, 1995). This modelling choice, allows for substitution patterns in demand while it relies on multistage budgeting and weak separability between the types of meats considered. Moreover, it requires the following parametric restrictions to ensure that the three demand functions in (7) add up to total expenditure (i.e., $\sum W_i = 1$), are homogeneous of degree zero in prices and total expenditure as well as satisfy the Slutsky symmetry (Deaton and Muellbauer, 1980):

$$\sum \mathrm{A}_i = 1 \qquad \sum_i \Gamma_{ij} = 0 \qquad \sum_j \Gamma_{ij} = 0 \qquad \sum \mathrm{B}_i = 0 \qquad \Gamma_{ij} = \Gamma_{ji} \tag{8}$$

At the farm stage we suppose that the representative producer cannot easily, and in the short run, substitute between the types of meat produced such that the three industry level supply equations in (2) are defined as follows:

$$Q_i = \Lambda_i + \mathrm{K}_i P_i^f + \sum_k \mathrm{P}_{ik} Z_k + \mathbf{I}_{ik} \mathbf{S_{ik}} \quad i = b, c, p \tag{9}$$

where P_i^f is the industry-level price paid by processors to farmers for the i^{th} type of meat, Q_i is the meat equivalent quantity put on the market by producers and Z_k is a set of exogenous shifters above and beyond the effect of the intercept Λ_i. In particular, Z_k includes the price of the feedstuffs composing the daily ration of the animal producing the i^{th} type of meat and the price of fuel. To achieve price homogeneity in equation (9), we scale the farm level price of the i^{th} type of meat and the prices of the other inputs at the value of MWGFAR. Lastly, the vector $\mathbf{S_{ik}}$ collects the mutually exclusive dummies accounting for the fluctuations in farm level supply due to the typical duration of the breeding cycle of each livestock. In particular, for beef production half a year dummies are deployed, for chicken breeding a set of mutually exclusive dummies for a two months period is constructed while we model hog breeding including quarterly dummies. The estimation procedure returns values for $\Lambda_i, \mathrm{K}_i, \mathrm{P}_{ik}, \mathbf{I_{ik}}$.

Processors (or the processing groups forming the industry) have meat-specific processing techniques which require specifying three different functions for the marginal costs of processing:

$$c_i^w = \Omega_i + \mathbf{\Psi}_{\mathbf{ik}}\mathbf{D}_{\mathbf{k}} + \Upsilon_i Q_i^w \quad i = b, c, p \tag{10}$$

where Ω_i is a meat-specific intercept, $\mathbf{D}_{\mathbf{k}}$ is a vector of explanatory variables including POWER and MWGPRO while Q_i^w is the amount of meat handled by the processing industry. This part of equation (10) ensures that the linear specification of the processors' marginal costs is increasing in the quantity of the processed meat. The estimation procedure provides the value of Ω_i, $\mathbf{\Psi}_{\mathbf{ik}}$ and Υ_i.

Retailers provide all three types of meat to consumers such that their marginal cost functions can be defined as follows:

$$c_i^r = \mathrm{T} + \mathrm{N}G + \mathrm{H}\sum_i Q_i^r \quad i = b, c, p \tag{11}$$

where T is an intercept, G is MWGRET while $\sum_i Q_i^r$ corresponds to the total amount of the three meats the retailers handle. The latter ensures that the retailers' marginal other costs, although linear, are increasing in the quantity brought on the market reflecting a simple retailing technology which entails completing the same tasks for every meat on display. The estimation procedure provides the value of $\mathrm{T}, \mathrm{N}, \mathrm{H}$.

The industry level price transmission equations are defined as:

$$\begin{aligned} P_b^w &= P_b^f\left(Q_b;\mathbf{Y}\right)\left(1+\Xi_b^f\Theta_b^f\right) + c_b^w\left(Q_b, Q_c, Q_p; \mathbf{V}^w\right) \\ P_c^w &= P_c^f\left(Q_c;\mathbf{Y}\right)\left(1+\Xi_c^f\Theta_c^f\right) + c_c^w\left(Q_b, Q_c, Q_p; \mathbf{V}^w\right) \\ P_p^w &= P_p^f\left(Q_p;\mathbf{Y}\right)\left(1+\Xi_p^f\Theta_p^f\right) + c_p^w\left(Q_b, Q_c, Q_p; \mathbf{V}^w\right) \end{aligned} \tag{12}$$

where Θ_i^f should be interpreted as a measure of the departure from a marginal pricing rule implemented, at the industry level, by processors in their relationship with farmers (Sckokai et al., 2009). This interpretation, proposed by Bresnahan (1982) and Hyde and Perloff (1998), arises from the marginal cost function of every processor depending upon the firm level quantity of meat brought on to the market. Therefore, different levels of marginal costs originate from differences in the operating scale of processing firms while preserving every possibility of non-linear aggregation of output levels across the firms in the sector (Sckokai et al., 2009).[12]

Exploiting the linear form of the three farm-level supply functions in (9), $\frac{\partial^2 P_i^f\left(Q_i;\mathbf{Y}\right)}{\partial Q_i^2}=0$ such that the processor to retailer price transmission equations in (6) can be further simplified and restated, at the industry level, as:

$$
\begin{aligned}
&\left(1+Z^r_{b,b}\Phi^r_{b,b}+Z^r_{b,c}\Phi^r_{c,b}+Z^r_{b,p}\Phi^r_{p,b}\right)P^r_b\left(Q_b,Q_c,Q_p;\mathbf{X}\right)+\left(Z^r_{c,b}\Phi^r_{b,b}+Z^r_{c,c}\Phi^r_{c,b}+Z^r_{c,p}\Phi^r_{p,b}\right)P^r_c\left(Q_b,Q_c,Q_p;\mathbf{X}\right)\frac{Q_c}{Q_b}+\\
&+\left(Z^r_{p,b}\Phi^r_{b,b}+Z^r_{p,c}\Phi^r_{c,b}+Z^r_{p,p}\Phi^r_{p,b}\right)\frac{Q_p}{Q_b}P^r_p\left(Q_b,Q_c,Q_p;\mathbf{X}\right)-\left(1+\Theta^f_b\right)\Xi^f_b P^f_b\left(Q_b;\mathbf{Y}\right)\Theta^w_{b,b}+\\
&-\left(1+\Theta^f_c\right)\Xi^f_c P^f_c\left(Q_c;\mathbf{Y}\right)\Theta^w_{c,b}\frac{Q_c}{Q_b}-\left(1+\theta^f_p\right)\Xi^f_p P^f_p\left(Q_p;\mathbf{Y}\right)\Theta^w_{p,b}\frac{Q_p}{Q_b}-\left(1+\Xi^f_b\theta^f_b\right)P^f_b\left(Q_b;\mathbf{Y}\right)+\\
&-c^w_b\left(Q_b,Q_c,Q_p;\mathbf{V}^w\right)-c^r_b\left(Q_b,Q_c,Q_p;\mathbf{V}^r\right)=0\\
&\left(Z^r_{b,b}\Phi^r_{b,c}+Z^r_{b,c}\Phi^r_{c,c}+Z^r_{b,p}\Phi^r_{p,c}\right)\frac{Q_b}{Q_c}P^r_b\left(Q_b,Q_c,Q_p;\mathbf{X}\right)+\left(1+Z^r_{c,b}\Phi^r_{b,c}+Z^r_{c,c}\Phi^r_{c,c}+Z^r_{c,p}\Phi^r_{p,c}\right)P^r_c\left(Q_b,Q_c,Q_p;\mathbf{X}\right)+\\
&+\left(Z^r_{p,b}\Phi^r_{b,c}+Z^r_{p,c}\Phi^r_{c,c}+Z^r_{p,p}\Phi^r_{p,c}\right)\frac{Q_p}{Q_c}P^r_p\left(Q_b,Q_c,Q_p;\mathbf{X}\right)-\left(1+\Theta^f_b\right)\Xi^f_b P^f_b\left(Q_b;\mathbf{Y}\right)\Theta^w_{b,c}\frac{Q_b}{Q_c}+\\
&-\left(1+\Theta^f_c\right)\Xi^f_c P^f_c\left(Q_c;\mathbf{Y}\right)\Theta^w_{c,c}-\left(1+\Theta^f_p\right)\Xi^f_p P^f_p\left(Q_p;\mathbf{Y}\right)\Theta^w_{p,c}\frac{Q_p}{Q_c}-\left(1+\Xi^f_c\Theta^f_c\right)P^f_c\left(Q_c;\mathbf{Y}\right)+\\
&-c^w_c\left(Q_b,Q_c,Q_p;\mathbf{V}^w\right)-c^r_c\left(Q_b,Q_c,Q_p;\mathbf{V}^r\right)=0\\
&\left(Z^r_{b,b}\Phi^r_{b,p}+Z^r_{b,c}\Phi^r_{c,p}+Z^r_{b,p}\Phi^r_{p,p}\right)\frac{Q_b}{Q_p}P^r_b\left(Q_b,Q_c,Q_p;\mathbf{X}\right)+\left(Z^r_{c,b}\Phi^r_{b,p}+Z^r_{c,c}\Phi^r_{c,p}+Z^r_{c,p}\Phi^r_{p,p}\right)\frac{Q_c}{Q_p}P^r_c\left(Q_b,Q_c,Q_p;\mathbf{X}\right)+\\
&+\left(1+Z^r_{p,b}\Phi^r_{b,p}+Z^r_{p,c}\Phi^r_{c,p}+Z^r_{p,p}\Phi^r_{p,p}\right)P^r_p\left(Q_b,Q_c,Q_p;\mathbf{X}\right)-\left(1+\Theta^f_b\right)\Xi^f_b P^f_b\left(Q_b;\mathbf{Y}\right)\Theta^w_{b,p}\frac{Q_b}{Q_p}+\\
&-\left(1+\Theta^f_c\right)\Xi^f_c P^f_c\left(Q_c;\mathbf{Y}\right)\Theta^w_{c,p}\frac{Q_c}{Q_p}-\left(1+\Theta^f_p\right)\Xi^f_p P^f_p\left(Q_p;\mathbf{Y}\right)\Theta^w_{p,p}-\left(1+\Xi^f_p\Theta^f_p\right)P^f_p\left(Q_p;\mathbf{Y}\right)+\\
&-c^w_p\left(Q_b,Q_c,Q_p;\mathbf{V}^w\right)-c^r_p\left(Q_b,Q_c,Q_p;\mathbf{V}^r\right)=0
\end{aligned}
\qquad (13)
$$

where $Z^r_{i,j}$ are the own/cross price flexibility of consumer demand at the retail industry level, $\Phi^r_{i,j}$ are the industry average value of the own/cross conjectural elasticities retailers express in their relationship with consumers, Ξ^f_i is the farming stage elasticity of supply at the

[12] The linear aggregation of output, over firms (i.e., $Q=\sum_n q_n$), is a restrictive assumption which implies that firm-level cost functions are quasi-homothetic. In turn, this leads to technical differences across firms affecting the sole level of fixed costs while marginal costs are constant and identical across firms. All the previous demanding assumptions are unnecessary when a more general form of non-linear aggregation of output (i.e., $Q=f\left(q_1,q_2,\ldots,q_n\right)$) is supposed (Chambers, 1997).

industry level and $\Theta_{i,j}^{w}$ is the industry average value of the own/cross conjectural elasticities processors exert towards farmers.

Allowing the variables in the three demand equations in (7), in the three supply equations in (9) and the two sets of three price transmission ones in (12) and in (13) to be measured with error, a system of 12 equations in 12 endogenous variables $\left(P_i^f, P_i^w, P_i^r, Q_i \text{ with i=b,c,p}\right)$ arises and can be estimated using simultaneous procedures due to its parameters being identified.

Following some of the established literature, we estimate the aforementioned system of equations relying on the GMM econometric technique (Sckokai et al., 2009). This procedure, contrary to, for instance, Maximum Likelihood (ML), avoids placing demanding assumptions on the underlying data generating process, while it returns standard errors which are robust to the occurrence of heteroscedasticity, of – possibly - an unknown form, and autocorrelation (HAC) (Greene, 2011). On the other hand, it implements an IV estimator which requires the identification of a set of suitable instruments, composed of both external and internal ones, to account for the endogenity of price and quantities. The method is based on a set of M moment conditions used to estimate the K parameters of the model, with M≥K (Greene, 2011). We adopt a standard set of instrumental variables' moment conditions with the instruments being orthogonal to the residuals in each equation. Therefore, since we employ the same set of L instruments for each equation, the number of moment conditions amounts to M=gL.

To avoid the system of demand equations in (7) being singular, one of the share equation needs to be dropped such that we estimate eleven equations (i.e., two equations from (7) and each of the three equations in (9), (12) and (13)). Estimates are invariant to which equation is actually dropped and estimation is performed, using the GMM routine in TSP 5.1, excluding the AIDS equation for the demand of chicken meat.

The estimating model ((7)-(13)) is highly non-linear in nature, leading to significant difficulties in achieving convergence. Thus, the initial conditions of the GMM procedure are constructed from the sample data in three steps. Firstly, we estimate the sole demand equations; secondly and similarly, we estimate the sole supply equations; lastly, holding the sets of parameters from the previous estimation stages constant, we retrieve the values of the parameters in the six price transmission equations. In estimating each component of the larger system (7)-(13), we employ 3SLS.

Results

Table 2 reports the estimates of the model's coefficients of interest. Results have been obtained using a list of IVs comprising both external and internal instruments. In particular, we have considered all the exogenous variables in the model (i.e., a constant, total expenditure – in both real and nominal terms – the time trend, the monthly dummies for demand, the hourly wage indexes (MWGFAR, MWGPRO, MWGRET), the price of feedstuff for the livestock's daily rations (FEED1 to FEED5) and the energy related costs (FUEL, POWER)) and the prices of alternative sources of the same nutrients provided by meat (i.e., fresh and aged gorgonzola, mozzarella, fresh and aged taleggio, Grana Padano cheese aged between 60 and 90 days and Parmigiano Reggiano cheese aged 12 months) as external instruments. Together with the model's exogenous variables, the wholesale price of fresh taleggio gives rise to a suitable set of external IVs. Internal instruments comprise the price of all meats at each stage of the marketing chain and the quantity, demanded at the retail level, of beef and pork meat lagged one period (Gohin and Guyomard, 2000).

The J-test for over-identifying restrictions assesses whether the structure of the model is correct. In presence of M moment conditions and K parameters to be estimated, the Sargan statistics for the M-K over-identifying restrictions is χ^2 distributed with M-K degrees of freedom (Greene, 2011). Under the null hypothesis, the over-identifying restrictions hold meaning that the model can be deemed correctly specified. The value of the test is 260.59 with a P-value of 0.986 with 313 degrees of freedom.

Table 2 about here

Since the model is non-linear in the endogenous variables, it has been estimated in its implicit form such that no goodness-of-fit measures can be calculated. Nonetheless, the model's performance can be inferred inspecting the significance of the estimated parameters. It appears that every estimated equation, except the marginal costs' function for processing chicken meat, features statistically significant parameters. In total, 43 out of the 70 estimated parameters (more than 60% of them) are significant such that the model can be taken to perform satisfactorily. The most interesting finding from Table 2 might be the independence of the processors' and retailers' marginal costs from the quantity produced such that they may be deemed constant.

Table 3 presents the Marshallian elasticity of demand and supply at the sample mean values of prices, quantities and expenditures. The three demand equations are well behaved since both own-price and expenditure elasticities have the expected sign. Only the own-price elasticity for chicken meat is positive but, being insignificant, can be considered as being zero in magnitude. All meats have inelastic demands with the one for beef meat being more than three times as big as the one for pork. The three meat differ markedly also according to the value of their expenditure elasticity, with the demand for beef and pork meat being four and three times, respectively, as sensitive to the amount spent by the consumer as compared to the demand for chicken. Since conditional elasticities are considered, beef meat cannot be deemed a luxury good *per se* but it is evident that its levels of demand are certainly more sensitive than any other type of meat to changes in expenditure. Both pork and chicken meat feature demand functions which are inelastic to total expenditure suggesting they can be considered as necessity goods (with chicken meat being more of a necessity than pork meat). This evidence can corroborate the suspicion that the first, and most affordable, source of meat proteins is indeed poultry.

Analysing cross-price elasticities, they are all negative in sign and statistically significant at the 1% level. This suggests that an increase in the price of every meat considered in the system determines a decline in the quantity consumed of the remaining types of meat. In turn, beef, chicken and pork meat appear more complement, than substitute, in gross consumption.

The farmers' elasticity of supply is positive and statistically significant, at the 1% level, for beef while at 5% level for pork meat. The farmers' elasticity of supply for chicken meat is negative and statistically insignificant, such that it can be considered to be zero. In fact, its estimated absolute value is also very small.

Table 3 about here

Table 4 collects the market power parameter of interest as defined by the conjectural elasticity parameters appearing in (12) and (13). Statistically significant conjectural elasticities occur only at the retail level, suggesting that retailers are able to extract consumer surplus through a departure from pricing at marginal costs. Own quantity conjectural elasticities are statistically significant for all types of meat, although only the one for beef meat reaches the 1% level. Moreover, it is the one expressing the highest effect - across the nine relevant parameters - with a value of 0.2912. The second largest, and statistically significant at conventional levels, is the conjectural elasticity of the retailers' demand for pork meat to a change in one of the retailers' demand for beef suggesting competition for shelf space between these two food items at the retail level. The latter is, in turn, roughly four times as large as the conjectural elasticity of the retailers' demand for beef to a change in the one for pork (i.e., the symmetric cross-product conjectural elasticity).

Since conjectural elasticities of retail demand are significant, Schroeter and Azzam (1990) provide useful guidance in calculating a Lerner type index, to facilitate the understanding of the extent of the oligopoly total price distortion[13], as:

$$D_i = \frac{p_i^r - p_i^w - \dfrac{\partial C_i^w}{\partial Q_i}}{p_i^r - p_i^w} \qquad i = b, c, p \tag{19}$$

The index measures, for every type of meat, the incidence of the market power distortion on the observed price margin. Results reflect the evidence provided by the conjectural elasticities since the price distortion calculated for beef is the highest. It appears that roughly 83% of the observed price margin for beef meat can be explained by a significant departure from marginal costs pricing. The second highest level of price distortion (77%), due to the expression of market power, accrues to retailers marketing pork meat. Lastly, some 73% of the chicken price margin at the retail level can be attributed to market power. Comparing this evidence with similar measures of estimated market power in meat(s) marketing chains, the present work seems to unveil a markedly larger manifestation of market power compared to previous studies. Where market power existed, although in a one-stage multi-product modelling of meat marketing chains (Schroeter and Azzam, 1990; Gohin and Guyomard, 2000), it almost never exceeded half of the price margin.

[13] Note that, in a similar manner, the Lerner type index for the price distortion due to oligopsony power could be calculated substituting the necessary information into (19). Nonetheless, since none of the conjectural elasticities of processors towards farmer is significant, the associated Lerner type indeces are insignificant too. Therefore, we have decided to not report them.

Table 4 about here

Regarding the two other remaining stages of the meat marketing chain, the estimated conjectural elasticities – which should capture the extent of the largely claimed oligopsonistic power of downstream operator on upstream ones – do not highlight any incidence of departure from the operators' competitive behaviour (except for the 5% significance of the retailers' conjectural elasticity of demand for beef to the choice of pork when purchasing from processors). This evidence can only suggest the absence of oligopsony power of retailers towards processors, since this framework does not allow us to evaluate any other form of market power, except the one explicitly modelled (see Berto Villas-Boas (2007)). Likewise, it appears that the farmers do not suffer from any form of oligopsonistic power of processors. The insignificance of the market power parameters for the farming and processing stages of the marketing chain might be the result of these data being unable to correctly represent the value of prices and quantities involved in the transaction of both the agricultural commodities and the processed meats at the two upstream stages. In fact, we are unable to account for, *inter alia*, the pre-committed quantities, delivered at set prices, under annual agreements between processors and farmers. Similarly, the present analysis does not detect any evidence of retailers requiring a quantity discount on the reference price for processed meats listed by the Commodity Commissions at the Chambers of Commerce considered in this study.

Although these finding are somewhat contrary to the anecdotal evidence of downstream operators retaining much of the price premium, added to the value of the agricultural commodity by the marketing chain, they can be granted some validity. In fact, besides the model validity being upheld by the Sargan test for overidentifying restrictions, these results appear consistent with the requirement, expressed by Cakir and Balagtas (2012), that "For prices to be defined, the conduct parameter must be less than the absolute value of the relevant price elasticity of demand…" (Cakir and Balagtas, 2012:650).

Conclusions

This paper contributes to the NEIO literature on the analysis of the extent of market power in agricultural marketing chains, proposing a three-stages three-products modelling of the Italian fresh meat industry. The model features both retailers' oligopolistic behaviour towards consumers and successive oligopsonistic behaviour of downstream operators towards upstream ones. The empirical estimation of the model's conjectural elasticities on a uniquely compiled dataset, provides the sole evidence of retailers being able to extract a sizeable share of consumer surplus. This is reflected in industry-level Lerner type indexes which attribute more than half of the retail price gap to the occurrence of market power.

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Tables and Figures

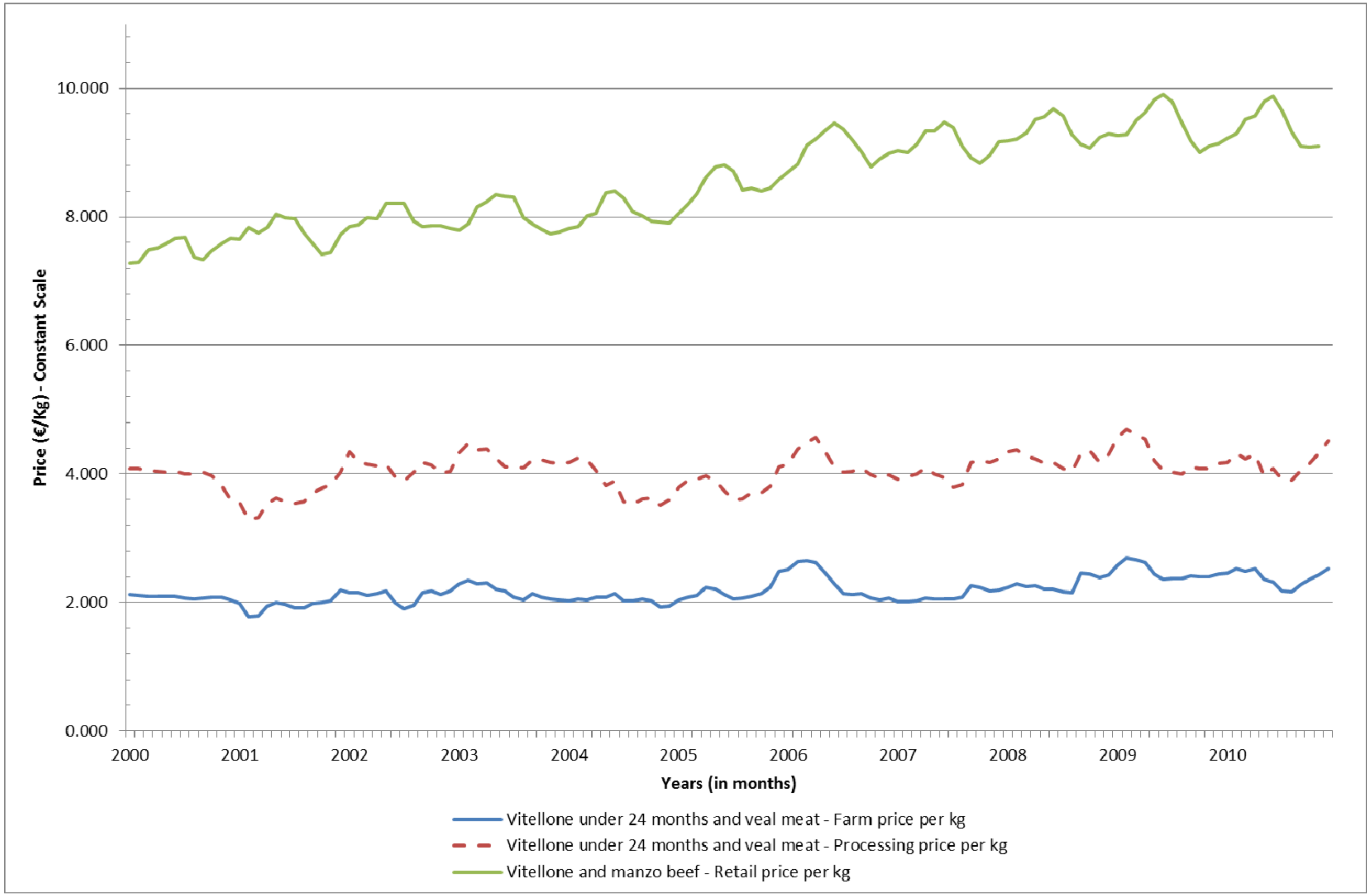
Table 1 Sample's summary statistics for the relevant variables

Variable	Definition	Mean	S. D.
p_b^f	Per kilo price of a vitellone under 24 months of age devoted to meat production of the first quality and veal (weighted average with alive quantities as weights)†	2.2254	0.1884
p_c^f	Per kilo price of chickens bred on the ground of a heavy size and turkeys (weighted average with alive quantities as weights)§	1.2962	0.1323
p_p^f	Per kilo price of a lean pig for fresh meat production in the 90-115 kilos weight range¥	1.0130	0.1583
p_b^w	Per kilo price of a half carcass without kidney from a male vitellone under 24 months of age which matches the U quality on the E.U.R.O.P.A. international quality classification grid and veal of extra quality (weighted average with alive quantities as weights)†	4.0933	0.2451
p_c^w	Per kilo price of a traditional chicken of a heavy size and eviscerated turkeys (weighted average with alive quantities as weights)†	2.1467	0.2368
p_p^w	Per kilo price of a half carcass of pork cut according to the MEC specification¥	1.6957	0.2412
p_b^r	Per kilo price (value over quantity) of veal, manzo and vitellone meat#	9.2109	0.6215
p_c^r	Per kilo price (value over quantity) of turkey and chicken meat#	6.0640	0.1728
p_p^r	Per kilo price (value over quantity) of pork meat (excludes processed cuts)#	5.0365	0.4193
Q_b	Quantity (kilos) of veal, manzo and vitellone meat#	3.29E+07	4.34E+06
Q_c	Quantity (kilos) of turkey and chicken meat#	1.68E+07	3.08E+06
Q_p	Quantity (kilos) of pork meat (excludes processed cuts)#	1.94E+07	2.59E+06
FEED1	Monthly average price, per tonne, of soy-flour¥	268.0304	59.2178
FEED2	Monthly average price, per tonne, of the first cut of alfalfa¥	116.5955	27.4286
FEED3	Monthly average price, per tonne, of soy-oil¥	0.9231	0.2217
FEED4	Monthly average price, per tonne, of wheat-flour¥	147.3386	34.0740
FEED5	Monthly average price, per tonne, of corn-flour¥	194.3961	36.0632
FUEL	Monthly average price of the agricultural subsidised fuel for deliveries up to 5000 litres and with 0.001% or 10 ppm in sulphur¥	0.7191	0.1538
MWGFAR	Index, base 2000, for the contractual hourly wages of blue and white collar workers for the ATECO 2007 classification "breeding animals in the primary sector"$	101.4624	6.5938
MWGPRO	Index, base 2000, of the contractual hourly wages of blue and white collar workers for the ATECO 2007 classification "preparing and conserving meat and meat-based products" $	102.0002	8.3234
POWER	Index, base 2000, of the cost of electricity, gas, steam and air$	144.4421	26.6950
MWGRET	Index, base 2000, of the contractual hourly wages of blue and white collar workers for the ATECO 2007 classification "retail trading in non-specialised shops"$	100.7456	7.2571
FRESHTAL	Per kilo price of fresh taleggio†	3.8367	0.2036

Source: own calculations based on 108 monthly observations

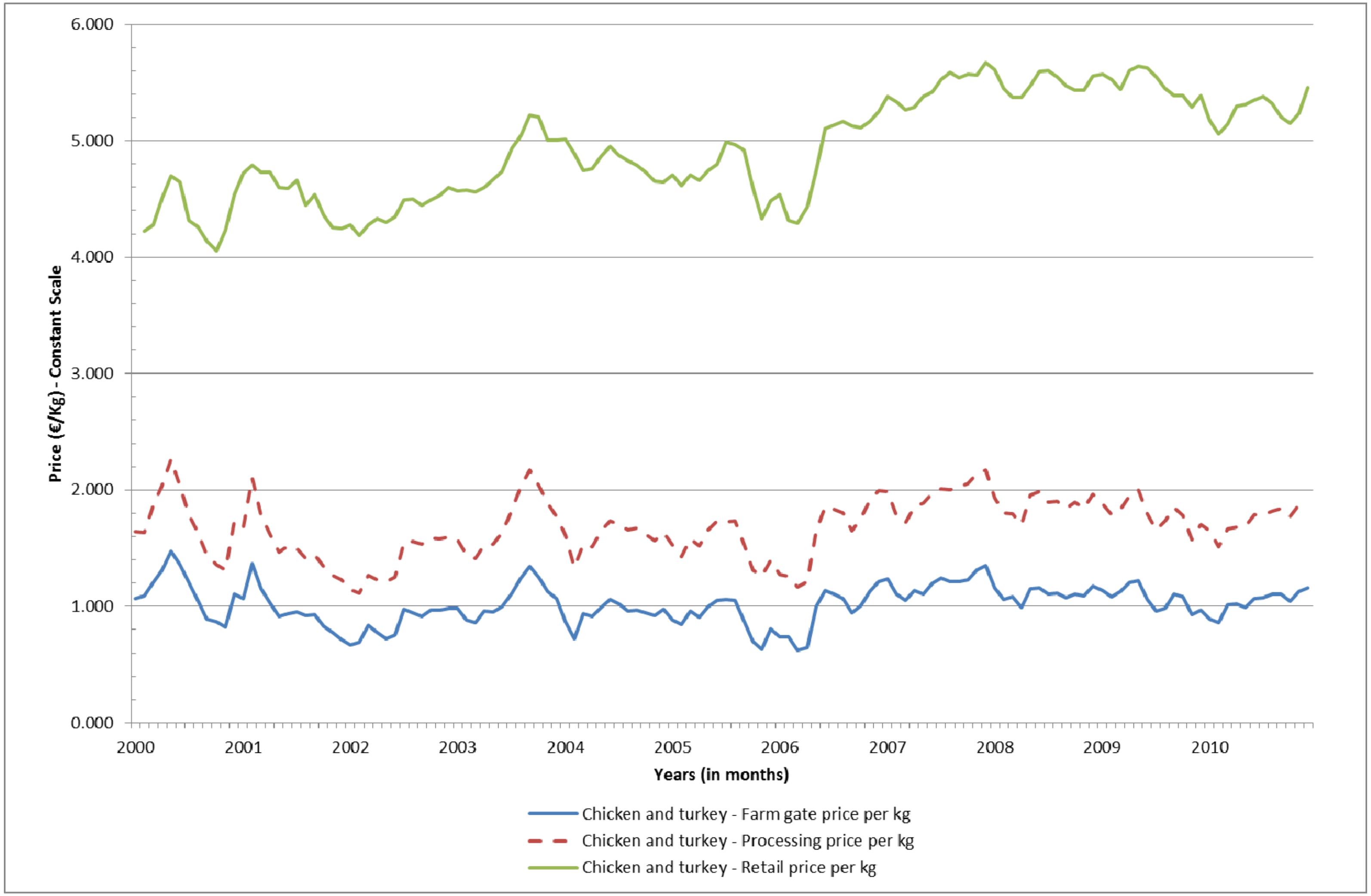
Notes to Table 1: † value sourced from the Commodity Exchange Listing at the Milan Chamber of Commerce; § value sourced from the Commodity Exchange Listing at the Forlì Avian and Rabbit Exchange; ¥ value sourced from the Commodity Exchange Listing at the Modena Chamber of Commerce; # value sourced from the Ismea-ACNielsen panel of household purchases; $ value sourced from the Italian Institute for Statistics

Figure 1 The formation and evolution of the margin in the fresh beef meat marketing chain



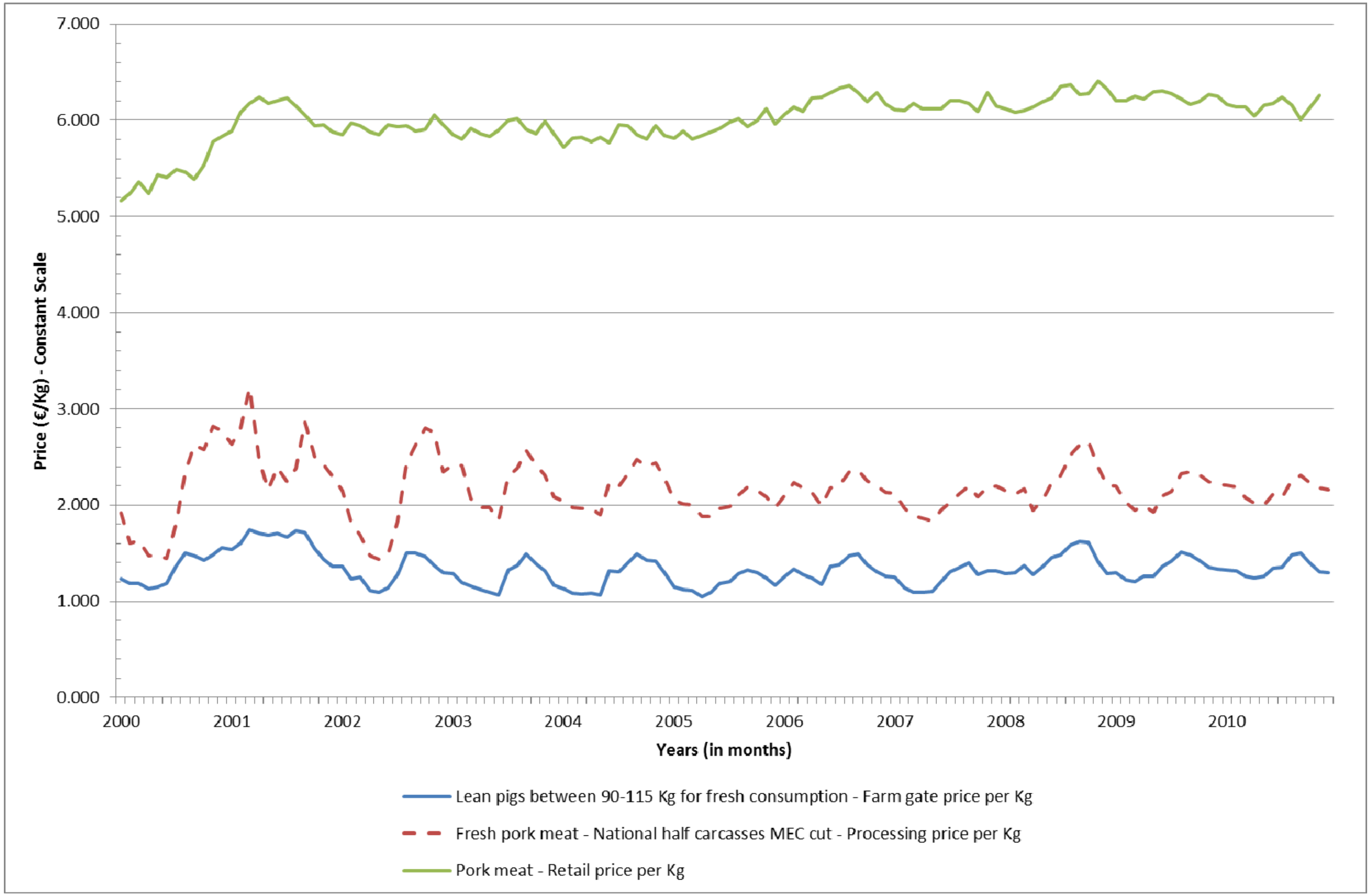
Source: own elaboration on data from the Milan Commodity Exchange (farm gate and processing price) and ISMEA-ACNIELSEN panel (retail price)

Figure 2 The formation and evolution of the margin in the fresh poultry meat marketing chain



Source: own elaboration on data from the Forlì and Milan Commodity Exchanges (farm gate and processing price, respectively) and ISMEA-ACNIELSEN panel (retail price)

Figure 3 The formation and evolution of the margin in the fresh pork meat marketing chain



Source: own elaboration on data from the Modena Commodity Exchange (farm gate and processing price) and ISMEA-ACNIELSEN panel (retail price)

Table 2 Estimates of the model's parameters

Parameter	Estimate	Parameter	Estimate	Parameter	Estimate	Parameter	Estimate
Two independent share equations of demand							
A_b	0.5917*** (0.0108)	$\Delta_{b,4}$	0.0000 (0.0044)	A_p	0.2002*** (0.0056)	$\Delta_{p,5}$	-0.0257*** (0.0033)
$\Gamma_{b,b}$	0.2688*** (0.0120)	$\Delta_{b,5}$	0.0046 (0.0046)	$\Gamma_{p,p}$	0.1650*** (0.0017)	$\Delta_{p,6}$	-0.0329*** (0.0052)
$\Gamma_{b,p}$	-0.1143*** (0.0039)	$\Delta_{b,6}$	0.0275*** (0.0069)	B_p	-0.0117 (0.0170)	$\Delta_{p,7}$	-0.0303*** (0.0067)
B_b	0.1440*** (0.0216)	$\Delta_{b,7}$	0.0413*** (0.0087)	$\Delta_{trend,p}$	0.0081*** (0.0021)	$\Delta_{p,8}$	-0.0225*** (0.0060)
$\Delta_{trend,b}$	0.0040 (0.0051)	$\Delta_{b,8}$	0.0340*** (0.0079)	$\Delta_{p,1}$	0.0002 (0.0019)	$\Delta_{p,9}$	-0.0259*** (0.0030)
$\Delta_{b,1}$	-0.0176*** (0.0030)	$\Delta_{b,9}$	0.0130*** (0.0040)	$\Delta_{p,2}$	0.0019 (0.0026)	$\Delta_{p,10}$	-0.0106*** (0.0019)
$\Delta_{b,2}$	-0.0165*** (0.0036)	$\Delta_{b,10}$	-0.0048 (0.0029)	$\Delta_{p,3}$	-0.0085*** (0.0025)	$\Delta_{p,11}$	0.0008 (0.0015)
$\Delta_{b,3}$	-0.0140*** (0.0037)	$\Delta_{b,11}$	-0.0114*** (0.0019)	$\Delta_{p,4}$	-0.0131*** (0.0033)		

Farmers' marginal costs

Parameter	Estimate	Parameter	Estimate	Parameter	Estimate	Parameter	Estimate
Λ_b	24,606,200*** (3,959,540)	Λ_c	23,393,500*** (1,444,130)	I_{bim2}	757,615 (415,492)	Λ_p	17,734,000*** (1,107,350)
K_b	530,607,000*** (133,887,000)	K_c	-123,085,000 (101,906,000)	I_{bim3}	-34,134 (419,163)	K_p	181,517,000** (77,068,000)
$P_{b,feed1}$	-2,276,020*** (450,132)	$P_{c,feed1}$	383,224 (287,066)	I_{bim4}	-2,563,410*** (413,160)	$P_{p,feed5}$	-401,473 (247,560)
$P_{b,feed2}$	2,025,590*** (726,244)	$P_{c,feed3}$	110,841,000** (53,342,700)	I_{bim5}	945,018*** (320,700)	$P_{p,fuel}$	-73,164,500 (89,285,800)
$P_{b,fuel}$	21,451,100 (246,713,000)	$P_{c,feed4}$	122,217 (435,853)			I_{term1}	-70,339 (250,122)
I_{sem1}	193,181 (469,846)	$P_{c,fuel}$	-702,750,000*** (125,008,000)			I_{term2}	-3,148,030*** (303,935)
		I_{bim1}	650,784 (352,346)			I_{term3}	-4,708,100*** (226,704)

Parameter	Estimate	Parameter	Estimate	Parameter	Estimate
Processors' marginal costs					
Ω_b	1.2745** (0.6057)	Ω_c	0.5815 (0.3093)	Ω_p	1.1354*** (0.3845)
$\Psi_{b,power}$	0.0041*** (0.0014)	$\Psi_{c,power}$	0.0010 (0.0007)	$\Psi_{p,power}$	0.0013** (0.0006)
$\Psi_{b,mwgpro}$	-0.0006 (0.0058)	$\Psi_{c,mwgpro}$	-0.0005 (0.0031)	$\Psi_{p,mwgpro}$	-0.0087** (0.0038)
$\Upsilon_{q_b^w}$	0.0000 (0.0000)	$\Upsilon_{q_c^w}$	0.0000 (0.0000)	$\Upsilon_{q_p^w}$	0.0000 (0.0000)
Retailers' marginal costs					
Τ	3.0951*** (0.7847)	Ν	0.0036 (0.0067)	Η	0.0000*** (0.0000)

Source: own estimation using TSP 5.1 on 108 monthly observations

Note to Table 2: *** significant at 1%, ** significant at 5%; standard errors in parentheses; 12 autocorrelation lags specified for Bartlett kernel estimation of HAC consistent VCV matrix; instrument list: exogenous variables, fresh taleggio and price and quantities lagged one period

Table 3 Estimates of the model's elasticities of demand and supply

	Beef	Chicken	Pork
Price elasticity of demand at the retail level			
Beef	-0.6980***	-0.3031***	-0.2380***
	(0.0216)	(0.0235)	(0.0072)
Chicken	-0.3830***	0.1836	-0.1228***
	(0.1032)	(0.1013)	(0.0316)
Pork	-0.5306***	-0.2396***	-0.1718***
	(0.0497)	(0.0349)	(0.0170)
Expenditure elasticity of demand at the retail level			
	1.2390***	0.3222***	0.9421***
	(0.0358)	(0.1031)	(0.0841)
Price elasticity of supply at the farm level			
	0.3536***	-0.0633	0.1378**
	(0.0892)	(0.0524)	(0.0585)

Source: own estimation using TSP 5.1 on 108 monthly observations
Note to Table 3: *** significant at 1%, ** significant at 5%; standard errors in parentheses; 12 autocorrelation lags specified for Bartlett kernel estimation of HAC consistent VCV matrix; instrument list: exogenous variables, fresh taleggio and price and quantities lagged one period

Table 4 Estimates of the model's market power parameters

	Beef	Chicken	Pork
Processors' oligopsonistic power towards farmers			
	-0.0172	-0.0330	-0.0178
	(0.1302)	(0.0351)	(0.0558)
Retailers' olipsonistic power towards processors			
	Beef	**Chicken**	**Pork**
Beef	0.2091	0.0296	0.0647**
	(0.1292)	(0.0310)	(0.0295)
Chicken	0.0370	-0.0955	-0.0137
	(0.0436)	(0.0878)	(0.0141)
Pork	0.0015	0.0222	0.1556
	(0.0450)	(0.0229)	(0.0943)
Retailers' oligopolistic power towards consumers			
	Beef	**Chicken**	**Pork**
Beef	0.2912***	0.0203	0.0256**
	(0.0522)	(0.0177)	(0.0129)
Chicken	0.0361	0.0080**	0.0023
	(0.0443)	(0.0040)	(0.0040)
Pork	0.0975***	0.0070	0.0085**
	(0.0185)	(0.0058)	(0.0043)
Lerner type index†			
	0.8255***	0.7327***	0.7721***
	(0.1548)	(0.2371)	(0.2022)

Source: own estimation using TSP 5.1 on 108 monthly observations
Note to Table 4: *** significant at 1%, ** significant at 5%; standard errors in parentheses; 12 autocorrelation lags specified for Bartlett kernel estimation of HAC consistent VCV matrix; instrument list: exogenous variables, fresh taleggio and price and quantities lagged one period; † index calculated according to equation (19)