Producer Organizations and Members Performance in Hog Production

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Very preliminary and incomplete

Abstract: In this paper, we study how the boundary of hog producer organizations affects the economic performance of their members. From a French database providing economic and technical information on 886 hog farms, we estimate a system of equations including demand for input and output supply in order to evaluate marginal costs and margins at farm level. We show that belonging to a cooperative that develops financial links upstream and downstream allows farmers to reach, on average, lower marginal costs higher margins. In addition, even if the marketing cooperatives or bargaining associations allow their members to enjoy higher hog price than the average price, the farmers belonging to this type of producer organizations do not exhibit enough cost economies to reach large margins.

*Keywords***:** hog farms; producer organization; margin; marginal cost; vertical coordination

JEL Classification: Q13, D24, L22

Introduction

The increasing competition among agricultural regions reinforces the need for farmers to look for cost economies. Vertical coordination may be one way to increase efficiency in food supply chain by better exploiting those cost economies. In some countries, farmers increasingly use contracts. In the U.S., the production value under agricultural contracts has increased from 28 percent in 1991 to 39 percent in 2008. This trend raises the question of their impact on farm performance. Melhim and Shumway (2013) show that the wheat and corn farms that use marketing contracts improve their efficiency. Morrison-Paul *et al.* (2004) also find that contracts increase efficiency. However, they also note that the isolated effect of contracts is small. In hog production, Key (2013) finds a positive effect of production contracts on farm size for small-scale operations. In other countries, agricultural contracts are not so widespread and vertical coordination takes various forms. Agricultural cooperatives may be a coordination scheme that can affect the cost structure of their members. Because farms are usually too small to integrate alone upstream or dowstream, they gather to create either producer organizations which can be bargaining association (horizontal concentration) or supply and/or marketing cooperatives (vertical organization) (Sexton and Lavoie, 2001). This coordination scheme is widespread in France and in the European Union even if their market share varies a lot from one country to another. Cooperatives represent approximately 40 percent in the EU and 55 percent in France (Bijman *et al.*, 2012). Agricultural cooperatives can help farmers to improve their productivity and also reduce their transaction costs. They help them to reduce risks or when they integrate downstream activities, they may add value to their members' raw product through innovation and product quality.

In our paper, we study how the vertical relations of producer organizations (POs) affect farmers' economic performance. To our knowledge, no study has been done on this question. We examine how the financial links between POs and upstream and downstream

firms influence the cost structure and the margins of hog farms. In the French hog sector, POs play a key role to organize hog sales as 90 percent of French hog production are sold through these POs. However, they develop various strategies as far as vertical relationships are concerned. Some POs are bargaining associations. These bargaining associations do not own assets and their members keep the ownership of their raw product. They collectively bargain with processors and/or input suppliers. Other POs belong to a marketing cooperative that owns meatpacking plants whereas others integrate upstream (feed mills and/or genetic services) and downstream activities.

The paper is organized as follows. In the next Section, we present the empirical model while data are described in Section 3. The results are reported and analyzed in Section 4. The last Section concludes.

A cost function-based model

To evaluate the short-run marginal costs and margins at farm level, we estimate a system of equations including demand for input and output supply. As in the standard approach, we use a cost function-based approach in order to identify the parameters of the production technology. For empirical estimation, we have to choose an appropriate production function. In the current literature, the quadratic and the translog functions are the most frequently used functional forms. Many studies on scale economies have chosen the translog function developed by Christensen *et al.* (1973) because this functional form facilitates the computation of elasticities under homogeneity and regularity constraints, but this functional form does not allow an analytical solution for the output level (see Alvarez and Aria, 2003 and Moschini, 1988 for estimation of scale economies in agriculture). Others have chosen the normalized quadratic function such as Fernandez-Cornejo *et al.* (1992). This function requires the choice of one input as the numéraire, which thus is treated differently from other inputs.

Consequently, both functions have shortcomings as tools for short-run analysis (see Morrison 1988 for a more complete discussion). We use the same strategy developed in Morrison Paul (2001b) and applied in Duvaleix-Tréguer and Gaigné (2015) on hog farm data. We consider that the farm's minimum cost of producing the output *Y* is characterized by a general form given by $G(\mathrm{w}, Y, \mathrm{x}, \mathrm{d})$ where **w** is a vector of *I* variable inputs prices (feed, labor and piglets with $i = f, l, p$ respectively), **x** is a vector of *K* quasi-fixed inputs (sows and capital with $k = s, c$ respectively), and **d** is a vector of control variables. The choice of these control variables is discussed when we present the equations we estimate. We consider that labor is a variable input because we know the number of hours of labor at the different stages of the production sequence.

The cost function *G* is approximated by a combined generalized Leontief-Quadratic form (Morrison Paul 2001b), given by

$$\begin{aligned} \mathrm{G}\left(\mathrm{w}, \mathrm{Y}, \mathrm{x}, \mathrm{d}\right) = & \sum_i \sum_j \alpha_{ij} w_i^{0.5} w_j^{0.5} + \sum_i \beta_i w_i Y + \sum_i \gamma_i w_i Y^2 \\ & + \sum_i \sum_k \delta_{ik} w_i x_k + \sum_i \sum_k \eta_{ik} w_i x_k Y + \sum_i \sum_k \sum_l \rho_{ikl} w_i x_k x_l + \sum_i \sum_r \mu_{ir} w_i d_r \end{aligned} \quad (1)$$

where α_{ij}, β_i, γ_i, δ_{ik}, η_{ik}, ρ_{ikl}, and μ_{ir} are the coefficients to be estimated (with $\alpha_{ij} = \alpha_{ji}, \delta_{ik} = \delta_{ki}, \text{and } \rho_{ikl} = \rho_{ilk}$) and d_{ir} represents the control variables (that we specify below). This flexible form is able to capture many aspects of cost economies through input substitutability, the utilization rate of quasi-fixed input, and scale economies. It is worth noting that such a flexible functional form captures the cross-effects among all arguments of the cost function while allowing for linear homogeneity in price $\left(G(\lambda w, .) = \lambda G(w, .)\right)$. In addition, there are no a priori restrictions on the shapes of curves representing technology. Because $\partial^2 G / \partial w_i^2 < 0$, or equivalently, $\alpha_{ij} > 0$ (global concavity), and $\partial^2 G / \partial x_k^2 > 0$, or equivalently, $\rho_{ikk} > 0$ (convexity), are not ensured, we assess *ex post* if $\alpha_{ij} > 0$ and $\rho_{ikk} > 0$.

We also characterize optimization decisions for the inputs and the output. We can obtain the farm's conditional input demand functions where the levels of output, quasi-fixed inputs, and input prices are taken as given. By using Shepard's lemma, at the given level of output, the demand for each of the three variable inputs $v_i (= \partial G / \partial w_i)$ is expressed as

$$v_i = \alpha_{ii} + \alpha_{ij} w_i^{-0.5} \sum_{j \neq i} w_j^{0.5} + \beta_i Y + \gamma_i Y^2 + \sum_k \delta_{ik} x_k + \sum_k \eta_{ik} x_k Y + \sum_k \sum_l \rho_{ikl} x_k x_l + \sum_r \mu_{ir} d_{ir} \quad (2)$$

We use control variables in each input demand. As feed input represents over 60 percent of the hog production cost, hog producers develop several strategies. Some of them produce their own feed input, others choose to purchase it. Therefore, we introduce three dummy variables to control for *Home-Grown Feed*: with only home-grown feed, with only purchased feed, and with both home-grown and purchased feed. Moreover, as we do not have information on the composition of feed, we use the *Feed Conversion Ratio* to capture feed quality effect. This ratio measures the total feed consumption over the gain in weight during the fattening duration. A low feed conversion ratio implies that pigs from a farm consume less feed than pigs from another farm to reach the same weight. Therefore, the feed used to obtain a lower feed conversion ratio contains either higher nutritional contents or attributes that facilitate feed intake. In the labor input demand function, we primarily control for *Hired Labor* by introducing a dummy variable. In the piglet input demand function, we control for the *Specialization* of hog farms. Four types of hog farms, classified according to their specialization stage, are identified in the survey. We are more specifically interested in farrow-to-finish farms as this production system is dominant in France.

Finally, we assess how producer organizations (POs) influence marginal costs and margins in hog farms. Although French hog producers sell their production through POs, these organizations offer a wide diversity of coordination schemes in their upstream and downstream partnerships (Roguet and Rieu, 2011). The vertical relationships the POs develop may influence the farmers' decision to be a member of one or another PO. Then according to

the PO, its strategy may also influence how hog farmers make managerial decisions on their farm. Each PO develops its own strategy as far as vertical integration (backward and forward) and member services (feed, genetic, processing activities, etc.) are regarded. Some POs favor low feed prices because they own feed mills. Other POs choose to create value on their downstream market through product differentiation. Finally some POs prefer giving advices; for example, they might help farmers to better manage feed intake in order to obtain better technical results. To take into account those POs' characteristics, we identify three types. In the first type of POs, hog farmers are members of *Marketing Cooperatives* which only integrate processing activities. The second type of POs are *Supply* (*and* also, for some of them, *Marketing*) *Cooperatives*. Those cooperatives choose to integrate backward (feed mills or genetic selection). The last type of POs includes *Bargaining Associations* as some French hog producers prefer to maintain managerial autonomy in their production choices. We also create a dummy variable to control for the *Cooperative Specialization*. When POs integrate backward or forward, they can be either multipurpose cooperatives or specialized in the hog supply chain.

We also include the short-run supply function given by the maximization of the profit equation $\pi = pY - \mathrm{G}(\mathrm{w}, \mathrm{Y}, \mathrm{x}, \mathrm{d})$ where *p* is the unit price of hogs. The equilibrium output is implicitly given by $p = \partial G / \partial Y$ or, equivalently,

$$p = \sum_i \beta_i w_i + 2\sum_i \gamma_i w_i Y + \sum_i w_i \left(\sum_k \eta_{ik} x_k \right) + \sum_i \sum_r \mu_{ir} w_i d_{ir} \quad (3)$$

In the supply equation, we control for the *Specialization* of hog farms, and the *Meat Quality* at the farm level through the lean meat percentage. We create a dummy for hog farmers who obtain a lean meat percentage greater than 61, which is when they obtain the highest premium.

Hence, we estimate a system of four equations that includes three input demands (feed, labor and piglet demands) and the supply function employing the Zellner's method. Using parameters α_{ij}, β_i, γ_i, δ_{ik}, η_{ik}, ρ_{ikl}, and μ_{ir} and σ_{f1} and σ_{f2}, we can evaluate the marginal costs, the margins, the cost-output relationship, and the margin-output relationship. Let *MC* be the short-run marginal cost for a given feed price with $MC = \partial G/\partial Y = \sum_i w_i(\beta_i + 2\gamma_i Y + \sum_k \eta_{ik} x_k)$ whereas the short-run margin is expressed as $p - MC$. We also use the short-run cost elasticity to a change in output $\varepsilon_{CY}(= \mathrm{d\,lnC/dlnY})$ along the long-run cost curve where $\varepsilon_{CY} < 1$ indicates that average costs decrease with output.

Data

We use a database provided by the French Pork Institute (IFIP) that gives economic and technical information on 886 hog farms in 2011 and 2012. As we know the PO to which each hog farm belongs, we collect information to establish the downstream and upstream financial links of the hog POs in our sample. We know whether financial relations exist between each PO and a feed mill and/or genetic selection firm on the upstream side and between each PO and a meatpacking firm on the downstream side for the two years 2011 and 2012. In our sample, 369 hog farms belong to Marketing Cooperatives, 357 farmers are members of Supply (and Marketing) Cooperatives and the last 161 farms are members of Bargaining Associations (Table 1).

Table 1 about here

Both surveys include a broad range of data on outputs, inputs, and management and technical and social variables at the farrowing and finishing stages. We only select hog farms that operate the finishing stage of hog production and exclude all farms specialized in the farrowing stage. In addition, only farms with complete and reliable information for the selected outputs and inputs at the finishing stage are included in our database. For each farm,

the technical survey provides the output quantity and hog price, the average feed price and quantity used at each stage, and the feed cost when farmers make home-grown feed. We also obtain information about the number of sows, the piglet price when purchased by feeder-to-finish farms, and piglet production costs for farrow-to-finish farms. In addition, we know whether the farm produces home-grown feed and the cost and quantity of home-grown feed. The production costs are determined by the French Pork Institute (IFIP), all the economic actors in the hog industry commonly adopt these cost figures.[1] In the complementary bookkeeping survey, we also know the labor cost (family and hired labor) and the number of hours associated with hog production for each stage and whether the farm has hired labor. As a result, we are able to determine the unit labor cost (in € per hour). Table 2 provides some descriptive statistics on input prices (feed, labor, and piglets) and output. The average price of hogs is approximately 135 € per head, or 1.54 € per kilogram. The average feed price is 263 €/ton. The average profit is negative, it is approximately -17.3€/head on average with a high standard deviation (62.6 €/head). On average, hog farms produce 2,869 hogs per year.

Table 2 about here

However, the hog farms in our sample are heterogeneous in size, and the input and output prices differ among farms depending on the type of POs they are members of. The hog farms who are members of Specialized Supply and Marketing Cooperatives are larger on average (3,532 hogs per year). The smallest farms are members of Specialized Marketing Cooperatives (2,564 hogs per year). Feed use is a crucial issue in hog farms as feed input represents approximately 68 percent of the total production cost of hog farms in our sample. Feed price also differ among farms. It is lower for the farmers who are members of a Multipurpose Cooperative than for the farmers who are members of a Specialized

[1] The formulae used to determine the different production costs are available on the IFIP website (http://www.ifip.asso.fr/resultats-economiques-elevages-extranet-partenaires.html).

Cooperative. Note also the farmers belonging to Bargaining Associations enjoy the highest output prices, on average.

Table 3 about here

The farms, members of a Multipurpose Supply (and Marketing) Cooperative exhibit the lowest average costs (145.5 €/head). Whereas, the highest average costs are reached by the members of Marketing Cooperatives (approximately 156 €/head). In our sample, on average, the hog farms get negative average profit (from respectively -9, -10 €/head for the members of Bargaining Associations and those of Multipurpose Supply Cooperatives to -28.1 for the members of Specialized Supply (and Marketing) Cooperatives.

Estimation and Results

We estimate the system of four equations (three input demand equations (2) and the output supply equation (3) by using the three-stage least squares estimation method (as in Morrison Paul, 2001b).[2] The results for the estimated coefficients are reported in Appendix A.

If we pool the data and estimate a single equations system, we implicitly assume that farms use a common technology. Such an empirical strategy could potentially biases estimates of marginal costs and margins. Indeed, farm's production technology may depend on the nature of PO (Bargaining Association, Marketing Cooperative, and Supply Cooperative) to which the farm belongs. The nature of vertical and horizontal organization of the POs may impact the technology choice of its members. As a result, we estimate the equation system for each type of farm to take into account that farms do not necessarily share the same production

[2] As mentioned in Morrison Paul (2001a and2001b), GMM methods provide results "virtually identical" to those obtained by implementing three-stage least squares estimation methods.

technology. In our case, the degrees of freedom remain high enough for each sub-sample. We report in Appendix A the estimated marginal and margins when we pool the data.

Before we explore the effect of the coordination schemes of hog POs on farms' performance, we first assess whether our results are consistent. It appears that the generalized R^2 shows an excellent fit for the equation system (0.98). Note also that we have checked the regularity conditions at every data point and not at the sample mean. Remember that we must have $\partial^2 G / \partial w_i^2 = \partial \nu_i / \partial w_i = -0.5 w_i^{-1.5} \Sigma_{j \neq i} (\hat{\alpha}_{ij} w_j^{0.5}) < 0$ and $\partial \nu_i / \partial Y = \hat{\beta}_i + 2\hat{\gamma}_i Y + \Sigma_k \hat{\eta}_{ik} x_k > 0$. By inspection, we have $\partial \nu_i / \partial w_i < 0$ and $\partial \nu_i / \partial Y > 0$ for each observation. Therefore, increasing the hog production or decreasing input price entails an increase in input demands, as expected. Therefore, the demand functions satisfy the conditions required by the theory.

In addition, it appears that hog farms technologies exhibit scale economies. At the mean of the data estimated for each subsample, the cost elasticity ε_{cy} is lower than 1, suggesting the presence of cost economies associated with the output size. The average short-run cost elasticity is approximately 0.77, 0.83, and 1.02 for farms belonging to Supply (& Marketing) Cooperatives, Marketing Cooperatives, and Bargaining Associations respectively. Some statistical tests indicate that this cost elasticity is significantly below one for a wide range of observations for the farmers who are the members of an agricultural cooperative. Therefore, technology used in hog farms belonging to a Supply and/or Marketing Cooperatives production is characterized by increasing returns to scale. We confirm the findings in Azzam and Skinner (2007) and Rasmussen (2010) from a different approach as well as in Duvaleix-Tréguer (2015). We can also analyze the nature of scale economies. In each sub-sample, it appears that the farmers use relatively less feed for each additional hog unit while they use relatively more piglets with the output size. However, hog farmers do not use relatively less

labor when output size increases. However, the technology used by the members of Bargaining Associations seems to be characterized by constant returns. Unlike the other types of farms, they do not use relatively less feed when hog production rises.

Table 4 about here

We now focus on the impact of the boundary of POs on the economic performance of its members. As shown in Table 4, belonging to a cooperative that develops financial links upstream and downstream allows farmers to reach, on average, lower marginal costs (111 €/head). In addition, those farms, members of a Supply (& Marketing) Cooperative, generate, on average, the higher level of profit margin (21.8 €/head) even if their output price (132,9 €/head) is below the mean output price. These farms are larger than the other farms in our sample, approximately 3200 hogs per year on average. They exhibit enough cost economies to cope with the hog market price.

The marginal cost of the farmers who belong to a Marketing Cooperative reaches on average 125.3 €/head. However, they are able to reach a positive profit margin on average (11.4 €/head). Their output price (136.7 €/head) is higher than the average output price. The Marketing Cooperatives, by owning processing plants, allow its members to receive a higher output price through two channels. First, the processing plant's technology may exhibit scale economies and pass them on to farmers through higher output price. Second, the cooperative may create value added. It also appears that these farmers are smaller farms. They produce around 2600 per year on average. Even if those farms exhibit higher marginal costs, they obtain a positive margin.

The farmers who are members of Bargaining Associations get the highest marginal cost (146 €/head) and thus they get a negative margin on average (-9.8 €/head). Those farms are smaller on average (2,709 hog per year). They do not seem able to exhibit scale economies as they operate close to their minimum average costs. Those farmers use the Bargaining

Association to sell hogs and increase contract reliability with meatpackers. Indeed, bargaining associations can facilitate price discovery on the food markets when uncertainty prevails and increase contract reliability (Hueth and Marcoul 2003, 2006). Even if the agricultural cooperative creates value added to increase the output price, they do not exhibit enough cost economies to reach large margins.

Table 5 about here

In Table 5, it appears the estimated short-run marginal cost decreases with hog production. More precisely, the short-run marginal cost declines strongly for low values of hog production and slightly for high values of output. These estimates suggest a flattening of the average cost curve for high levels of production (an L-shaped cost curve). On average, the estimated value of $\partial MC/\partial Y$ is negative and significantly different from zero. Most farms face average costs that are decreasing.

The farmers who are members of a Multipurpose Marketing Cooperative, that is to say that the cooperative chooses to integrate downstream activities on its hog supply chain and also develop other agricultural outlets, get an output price that is significantly lower than other hog farms. And as a consequence, those farmers reach a lower margin than the farmers who are members of other types of cooperatives. This result raises several questions about the multipurpose cooperative's strategy. Is the cooperative efficient enough on the hog market? What are the market shares of hog products? To go further, we would need to collect more information about the cooperative's characteristics.

Conclusion

These preliminary results provide insightful paths to investigate the effects of the types of cooperatives on farms' performance. The positive effect of joining Supply (& Marketing) Cooperative on cost efficiency captures two potential mechanisms. First, the most efficiency

or larger farms prefer to join this type of cooperative (sorting effect). Second, by integrating backward (and forward), the cooperative is able to pass its scale economies on to farmers.

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Table 1.

Number of farms	**Multipurpose cooperatives**	**Specialized cooperatives**	**Independent producer organizations**	
Marketing cooperatives	59	310		369
Supply (& market.) coops	173	183		357
Bargaining Associations			161	161
	232	493	161	886

Source: IFIP and authors

Table 2. Summary statistics – all farms (886 obs.)

	Mean	**Std. Dev.**	**Q_1**	**Median**	**Q_3**
Feed price (€/ton)	263.0	33.3	248.4	268.0	280.2
Labour price (€/hours)	17.7	4.7	15.5	17.6	18.6
Piglet price (€/head)	20.7	13.0	11.9	14.2	33.4
Output price (€/head)	135.3	25.4	123.5	133.3	143.4
Output (head)	2,869	2718	1341	2250	3382
Variable cost[(a)] (€)	343,724	333,310	174,559	264,733	406,270
Total cost (€)	412,685	382,838	208,194	327,079	498,336
Average cost (€/head)	152.6	62.2	131.7	141.9	156.7
Total profit (€)	-31,574	99,360	-49,704	-16,995	8,921
Average profit (€)	-17.3	62.6	-25.9	-8.9	4.3

(a) variable cost corresponds to the sum of variable input costs (G)
Source: IFIP – GTE-TB databases

Table 3. Summary statistics

	Mean	**Std. Dev.**	**Q_1**	**Median**	**Q_3**
			Supply (& Marketing) Cooperatives		
Output (head)	3215.8	2438.3	1594.6	2566.2	4119.2
Feed price (€/ton)	267.3	24.6	254.0	271.7	282.0
Hog price (€/head)	132.9	21.7	123.5	132.5	142.3
Average cost (€/head)	152.5	84.2	131.8	141.7	155.1
Average profit (€/head)	-19.6	84.8	-25.4	-9.0	1.9
			Multipurpose Supply (& Marketing) cooperatives (173 obs)		
Output (head)	2882	1680	1642	2424	3466
Feed price (€/ton)	258.4	28.9	239.0	259.0	276.0
Hog price (€/head)	134.9	27.1	123.3	133.0	143.1
Average cost (€/head)	145.5	24.9	130.6	141.1	153.9
Average profit (€/head)	-10.6	26.5	-21.6	-7.5	4.1
			Specialized Supply (& Marketing) Cooperatives (183 obs)		
Output (head)	3532	2953	1497	2664	4731
Feed price (€/ton)	275.7	15.4	268.0	277.0	285.6
Hog price (€/head)	131.0	14.6	123.6	132.0	141.2
Average cost (€/head)	159.1	114.6	132.1	142.0	155.9
Average profit (€/head)	-28.1	114.9	-27.7	-10.9	0.5
			Marketing Cooperatives		
Output (head)	2603.7	3239.5	1116	1851	3060
Feed price (€/ton)	258.9	35.2	244.0	266.0	279.0
Hog price (€/head)	136.7	25.1	123.2	133.5	144.1
Average cost (€/head)	155.6	44.3	133.8	143.2	161.0
Average profit (€/head)	-18.8	45.6	-28.4	-10.8	4.0
			Multipurpose Marketing Cooperatives (59 obs)		
Output (head)	2812	2500	1054	1893	4065
Feed price (€/ton)	251.9	32.3	219.8	263.0	278.0

Hog price (€/head)	129.1	14.8	119.6	130.6	138.5
Average cost (€/head)	156.9	68.6	126.2	139.9	160.8
Average profit (€/head)	-27.7	69.0	-32.1	-16.6	0.3
	Specialized Marketing Cooperatives (310 obs)				
Output (head)	2564	3364	1143	1846	2894
Feed price (€/ton)	260.2	35.7	247.0	266.3	279.0
Hog price (€/head)	138.1	26.3	123.9	134.9	145.7
Average cost (€/head)	155.3	39.5	134.3	143.8	163.3
Average profit (€/head)	-17.2	39.6	-27.5	-9.8	4.9
	Bargaining Associations (161 obs)				
Output (head)	2709	1753	1585	2464	3222
Feed price (€/ton)	262.9	43.3	236.4	265.6	280.7
Hog price (€/head)	137.2	32.7	124.3	133.9	142.5
Average cost (€/head)	146.1	30.1	129.0	138.7	152.1
Average profit (€/head)	-9.0	29.4	-18.8	-4.4	7.4

Source: IFIP – GTE-TB databases

Table 4. Short-run cost elasticities, marginal costs and margins– all farms (886 obs.)

	Mean	**Std. Dev.**	**Q_1**	**Median**	**Q_3**
	Supply (& Marketing) Cooperatives				
ε_{CY}	0.77	0.22	0.67	0.77	0.88
Marginal cost (MC)	111.1	22.9	94.5	112.5	128.2
Margin	21.8	31.9	-0.28	19.9	39.3
	Multipurpose Supply (& Marketing) Cooperatives (173 obs.)				
ε_{CY}	0.77	0.16	0.67	0.76	0.86
Marginal cost (MC)	111.1	25.4	94.5	111.0	125.1
Margin	23.8	29.5	1.82	23.0	41.3
	Specialized Supply (& Marketing) Cooperatives (183 obs.)				
ε_{CY}	0.76	0.27	0.66	0.78	0.90
Marginal cost (MC)	111.0	32.4	94.6	114.0	130.6
Margin	20.0	34.0	-1.18	16.7	38.7
	Marketing Cooperatives				
ε_{CY}	0.83	0.22	0.73	0.84	0.94
Marginal cost (MC)	125.3	31.1	112.8	127.4	143.3
Margin	11.4	32.8	-9.0	7.5	27.4
	Multipurpose Marketing Cooperatives (59 obs.)				
ε_{CY}	0.79	0.19	0.70	0.78	0.92
Marginal cost (MC)	117.5	27.3	96.0	124.0	135.2
Margin	11.7	28.7	-5.1	9.8	29.0
	Specialized Marketing Cooperatives (310 obs.)				
ε_{CY}	0.84	0.22	0.75	0.85	0.95
Marginal cost (MC)	126.8	31.6	114.0	127.9	144.7
Margin	11.4	33.6	-9.4	6.7	27.4
	Bargaining Associations				
ε_{CY}	1.02	0.21	0.89	1.02	1.14
Marginal cost (MC)	146.9	31.2	128.3	144.6	162.5
Margin	-9.8	30.6	-25.7	-7.7	8.6

Table 5. Marginal cost and Margins

	Marginal Cost	Margins	Output price
ref: *Bargaining Associations*			
Multi. Supply (& Market.) Coop	-23.14***	24.09***	-4.02
Spe. Supply (& Market.) Coop	-26.51***	24.47***	-2.04
Multi. Marketing Coop	-23.31***	10.45***	-12.86***
Spe. Marketing Coop	-28.11***	21.13***	-2.00
Y	-0.0090***	0.0073***	-0.0017***
YY	4.67e-08***	-1.2e-08	3.47e-08**
Feed Conversion Ratio	1.18	20.38***	21.56***
Only home-grown feed	-0.94	2.35	1.40
Only purchased feed	4.13***	-7.33***	-3.20
Hired labor	-1.34	1.39	0.06
EN	35.7***	-35.07***	0.65
PE	22.8***	-25.11***	-2.30
ME	-2.09	-5.88**	-7.97***
Meat quality	0.28	-1.18	-0.91
Year 2012	6.99***	6.09***	13.08***
R^2	0.81	0.65	0.13
# of obs.	886	886	886

Note: The references are: for the feed farm strategy, both home-grown and purchased feed; for farm specialization, the farrow-to-finish farms that sold less than 20% of their piglets. EN refers to the finish farms where the quantity of piglets purchased at 8kg are less than 20%. PE refers to the finish farms where the quantity of piglets purchased at 8kg are more than 20%. ME refers to the farrow-to-finish farms that sold more than 20% and less than 50% of their piglets. This classification is realized by IFIP.

Appendix A.

Parameter estimates for the hog farms which belong to Marketing Cooperatives (369 obs)

	Estimate	t-statistics		Estimate	t-statistics
$\alpha_{F,F}$	-63.6***	(-2.68)	$\alpha_{P,P}$	-397.5***	(-3.57)
$\alpha_{F,L}$	100.3***	(3.73)	$\alpha_{P,F}$	26.3*	(1.88)
$\alpha_{F,P}$	26.3*	(1.88)	$\alpha_{P,L}$	-66.2	(-0.62)
β_{F}	0.05***	(37.34)	β_{P}	0.81***	(21.73)
γ_{F}	-1.22e-06***	(-6.30)	γ_{P}	2.63e-05***	(6.63)
$\delta_{F,K}$	0.05*	(1.88)	$\delta_{P,K}$	1.03***	(4.38)
$\delta_{F,S}$	0.12***	(2.65)	$\delta_{P,S}$	5.45***	(5.30)
$\eta_{F,K}$	4.72e-06*	(1.90)	$\eta_{P,K}$	-1.88e-04***	(-3.66)
$\eta_{F,S}$	1.12e-06	(0.12)	$\eta_{P,S}$	-0.002***	(-14.24)
$\rho_{F,K,K}$	-5.3e-05**	(-2.32)	$\rho_{P,K,K}$	-1.21e-05	(-0.66)
$\rho_{F,S,S}$	4.34e-04**	(1.98)	$\rho_{P,S,S}$	0.04***	(11.89)
$\rho_{F,K,S}$	1.86e-04**	(2.28)	$\rho_{P,K,S}$	-2.81e-04	(-0.34)
$\alpha_{L,L}$	-532.6	(-1.49)			
$\alpha_{L,F}$	100.3***	(3.73)			
$\alpha_{L,P}$	-66.2	(-0.62)			
β_{L}	0.27***	(3.64)			
γ_{L}	3.43e-07	(0.04)			
$\delta_{L,K}$	-1.80***	(-2.63)			
$\delta_{L,S}$	7.92***	(4.82)			
$\eta_{L,K}$	-1.07e-05	(-0.83)			
$\eta_{L,S}$	3.44e-04	(0.82)			
$\rho_{L,K,K}$	0.001*	(1.80)			
$\rho_{L,S,S}$	-0.009	(-1.06)			
$\rho_{L,K,S}$	0.011***	(4.74)			

Note: The specification includes control variables: the type of hog farms (4 categories), the home-grown feed production (3 categories), hired labour, meat quality (2 categories). We do not report the coefficient values for dummy variables, they are available upon request.
The significance thresholds are respectively 1%(***), 5%(**) and 10%(*).

Parameter estimates for the hog farms which belong to Supply (& Market.) Cooperatives (356 obs)

	Estimate	t-statistics		Estimate	t-statistics
$\alpha_{F,F}$	-176.2***	(-5.82)	$\alpha_{P,P}$	-317.6**	(-1.93)
$\alpha_{F,L}$	200.4***	(5.60)	$\alpha_{P,F}$	16.0	(1.10)
$\alpha_{F,P}$	16.0	(1.10)	$\alpha_{P,L}$	-136.4	(-1.08)
β_F	0.04***	(29.84)	β_P	0.59***	(11.25)
γ_F	-1.65e-06***	(-4.41)	γ_P	1.09e-04***	(8.89)
$\delta_{F,K}$	0.11***	(4.11)	$\delta_{P,K}$	-0.06	(-0.26)
$\delta_{F,S}$	0.18***	(3.48)	$\delta_{P,S}$	13.76***	(11.19)
$\eta_{F,K}$	-9.62e-07	(-0.42)	$\eta_{P,K}$	9.33e-05	(1.36)
$\eta_{F,S}$	6.93e-06	(0.47)	$\eta_{P,S}$	-0.004***	(-8.60)
$\rho_{F,K,K}$	-9.2e-05***	(-3.71)	$\rho_{P,K,K}$	4.72e-04**	(2.13)
$\rho_{F,S,S}$	-2.23e-04	(-1.05)	$\rho_{P,S,S}$	0.04***	(6.51)
$\rho_{F,K,S}$	1.59e-04	(1.63)	$\rho_{P,K,S}$	-0.0019	(-1.16)
$\alpha_{L,L}$	-2214.2***	(-4.67)			
$\alpha_{L,F}$	200.4***	(5.60)			
$\alpha_{L,P}$	-136.4	(-1.08)			
β_L	0.52***	(4.94)			
γ_L	-2.12e-07	(-0.01)			
$\delta_{L,K}$	-2.46***	(-3.94)			
$\delta_{L,S}$	9.10***	(4.60)			
$\eta_{L,K}$	4.56e-05	(0.25)			
$\eta_{L,S}$	-1.30e-03	(-1.06)			
$\rho_{L,K,K}$	-4.03e-04	(-0.65)			
$\rho_{L,S,S}$	0.01	(1.00)			
$\rho_{L,K,S}$	6.76e-03	(1.53)			

Note: The specification includes control variables: the type of hog farms (4 categories), the home-grown feed production (3 categories), hired labour, meat quality (2 categories). We do not report the coefficient values for dummy variables, they are available upon request.
The significance thresholds are respectively 1%(***), 5%(**) and 10%(*).

Parameter estimates for the hog farms which belong to Bargaining Associations (161 obs)

	Estimate	t-statistics		Estimate	t-statistics
$\alpha_{F,F}$	-172.5***	(-3.45)	$\alpha_{P,P}$	-573.3***	(-3.21)
$\alpha_{F,L}$	89.1***	(3.34)	$\alpha_{P,F}$	36.1**	(2.14)
$\alpha_{F,P}$	36.1**	(2.14)	$\alpha_{P,L}$	-129.8	(-1.09)
β_{F}	0.05***	(22.37)	β_{P}	0.98***	(15.33)
γ_{F}	2.77e-07	(0.48)	γ_{P}	2.08e-05**	(1.84)
$\delta_{F,K}$	0.17**	(2.18)	$\delta_{P,K}$	0.04	(0.08)
$\delta_{F,S}$	0.42***	(4.55)	$\delta_{P,S}$	4.68***	(2.97)
$\eta_{F,K}$	-2.37e-06	(-0.38)	$\eta_{P,K}$	-1e-04***	(-0.74)
$\eta_{F,S}$	-3.11e-05	(-1.47)	$\eta_{P,S}$	-0.003***	(-7.63)
$\rho_{F,K,K}$	1.67e-04	(1.23)	$\rho_{P,K,K}$	-2.14e-04	(-0.29)
$\rho_{F,S,S}$	-1.43e-04	(-0.37)	$\rho_{P,S,S}$	0.04***	(8.79)
$\rho_{F,K,S}$	-9.77e-04***	(-3.53)	$\rho_{P,K,S}$	0.003*	(1.70)
$\alpha_{L,L}$	-804.4**	(-2.33)			
$\alpha_{L,F}$	89.1***	(3.34)			
$\alpha_{L,P}$	-129.8	(-1.09)			
β_{L}	0.52***	(3.55)			
γ_{L}	-3.48e-05	(-1.20)			
$\delta_{L,K}$	1.76	(1.32)			
$\delta_{L,S}$	6.80***	(2.78)			
$\eta_{L,K}$	-4.73e-04	(-1.16)			
$\eta_{L,S}$	-1.17e-03	(-1.25)			
$\rho_{L,K,K}$	3.86e-04***	(-0.02)			
$\rho_{L,S,S}$	0.032**	(2.52)			
$\rho_{L,K,S}$	-0.006	(-1.06)			

Note: The specification includes control variables: the type of hog farms (4 categories), the home-grown feed production (3 categories), hired labour, meat quality (2 categories). We do not report the coefficient values for dummy variables, they are available upon request.
The significance thresholds are respectively 1%(***), 5%(**) and 10%(*).