Short-term marginal costs in French agriculture

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Abstract

The paper investigates short-term marginal costs in French agriculture for field cropping, beef cattle, and dairy farms during the period 1995-2006. The multi-input multi-output Symmetric Generalised MacFadden cost function is used, with three variable inputs (crop-specific, animal-specific, energy costs), four outputs and three quasi-fixed inputs. Results indicate that marginal costs are on average lower for crop farms than for livestock samples. However, for crop farms, Common Agricultural Policy crop direct payments are related to high production costs, while livestock direct payments have no relation to production costs for dairy farms.

Keywords

short-term marginal costs; Symmetric Generalised MacFadden cost function; French farms; CAP subsidies

1. Introduction

The paper investigates short-term marginal costs in French agriculture. The objective is threefold. Firstly, short-term marginal costs are compared between the major productions (field cropping, beef cattle, dairy). Secondly, the evolution of the costs during the 12-year period of 1995-2006 is analysed, in particular whether there are breaks related to the Common Agricultural Policy (CAP) (Agenda 2000, 2003 Luxemburg reform) or to shocks (e.g. mad cow) disease. Thirdly, the relation between the costs and various variables, in particular CAP subsidies, is investigated. The analyses are based on the Symmetric Generalised MacFadden cost function as used by Baudry et al. (2008), Wieck and Heckelei (2007), and Pierani and Rizzi (2003), all for dairy farms.

Research on costs of production in agriculture has long been a large centre of interest. Production costs analysis is often associated to competitiveness assessment, a topic that has gained more and more interest due to international negotiations on trade (Latruffe, 2010). Moreover, as underlined by Cesaro et al. (2008), the calculations of farm production costs are commonly used by policy-makers to decide about farm support, in particular supported price. Although in the European Union since the 90es price support has been progressively replaced by decoupled payments, production costs are still informative to policy-makers, in particular when related to the level of subsidies received by farms.

The remaining of the paper is organised as follows. The next section describes the methodology and data used, while the following section presents the results and proposes some concluding remarks.

2. Methodology and data

We employ the multi-input multi-output Symmetric Generalised MacFadden cost function, originally introduced by Diewert and Wales (1987) and later modified by Kumbhakar (1994). This approach hypothesises a cost minimisation behaviour for farms, constrained by quasi-fixed inputs.

Farms are assumed to be price takers.

$$C(y,w,z,t) = \min_{x}[w'x : F(y,x,z,t) = 0] \tag{1}$$

$C(.)$ is the cost function, $F(.)$ is the production technology, w are variable input prices, x are variable input quantities, y are output quantities, z are the quasi-fixed inputs, and t is a time trend. The Shephard lemma enables to obtain farm demands for the i-th variable input:

$$x_i = \frac{C(y,w,z,t)}{w_i} \tag{2}$$

The marginal short-term cost for every output m is then as follows:

$$s_m = \frac{C(y,w,z,t)}{y_m} \tag{3}$$

The analysis is performed on a farm-level unbalanced panel data for farms in the French Farm Accountancy Data Network (FADN) during the period 1995-2006. More precisely, only farms specialised in field cropping (European nomenclature for type of farming 13 and 14), in beef cattle (type of farming 42), and in dairy (type of farming 41). Three variable inputs, for which the marginal short-term costs are derived, are considered: variable costs for crops; variable cost for animals; energy costs which also include cost of outsourcing. The quasi-fixed inputs include the land area in hectares, the total labour used on the farm in annual working units (AWU; 1 AWU equals 2,200 labour hours), and the assets value. As for the outputs, they are four: crop output; beef output; milk and milk products output (including cow, ewe and goat milk); other animal output. All variables in value were deflated by relevant national price indices extracted from Eurostat with base year 2000. These price indices were also used to proxy variable input price indices (w) which are not available at the farm-level in the FADN database.

Data were cleaned for inconsistencies, and observations with zero variable inputs were removed in the three samples (field cropping, beef cattle, dairy). However, in order to investigate the role of production specialisation on marginal costs, two additional samples were created: field crop farms including those that have no animal-specific costs (for this sample, the demand for animal-specific input is therefore not estimated); and beef cattle farms including those that have no crop-specific costs (for this sample, the demand for crop-specific input is therefore not estimated). Table 1 presents some descriptive statistics for all five samples.

The cost function that is estimated is as follows:

$$C_t = \frac{1}{2}\left(\sum_i \theta_i w_{it}\right)^{-1}\left(\sum_i \sum_j e_{ij} w_{it} w_{jt}\right)\left(\sum_m \phi_m y_{mt}\right) + \sum_i \alpha_i w_{it} + \left(\sum_m \phi_m y_{mt}\right)\left(\sum_i \beta_i w_{it} t\right)$$
$$+ \sum_i \sum_m c_{im} w_{it} y_{mt} + \sum_i \sum_f d_{if} w_{it} z_{ft} \qquad (4)$$
$$+ \left(\sum_i \theta_i w_{it}\right)\left[\sum_m \sum_n g_{mn} y_{mt} y_{nt} + \sum_f \sum_v f_{fv} z_{ft} z_{vt} + \sum_m \sum_f h_{mf} y_{mt} z_{ft}\right]$$

where subscripts *i* and *j* denote variable inputs, *m* and *n* denote outputs, *f* and *v* denote quasi-fixed inputs, *t* denotes the time period.

The estimation is carried out with the iterative Three Stage Least Squares (3SLS) method to control for endogeneity of outputs and land area; instruments employed are lagged variables.

Some restrictions are imposed in order to identify all parameters: $e_{ij} = e_{ji}$ for all *i*, *j*, $g_{mn} = g_{nm}$ for all *m*, *n*, $f_{fv} = f_{vf}$ for all *v*, *f* and $\sum_i e_{ij} = 0$. The conditions for concavity in input prices are that $e_{11} < 0$ and $e_{11}e_{22} - e_{12}e_{12} < 0$. They are imposed during the estimations when it is necessary.

3. Results

Table 2 presents goodness of fit and specification test results for the econometric estimations. The R^2 statistics are high, especially for field cropping farms (between 0.47 and 0.88) and dairy farms (between 0.52 and 0.61). All necessary conditions of concavity and symmetry are fulfilled. Heteroscedasticity was tested for with a White test. All models show that there is no longer evidence of heteroscedasticity. A Wald test was also performed to test the existence of constant returns to scale (as in Wieck and Heckelei, 2007). For dairy and field cropping farms, the null hypothesis of constant returns to scale is rejected at the 1% significance level. We can reject the constant returns to scale for beef cattle farms (in samples 3 and 4).

Elasticities of variable input demands with respect to input prices are shown in Table 3. They are all within reasonable range, and similar to the ones found in Wieck and Heckelei (2007) for dairy farms in various European regions during 1989-2000, but higher than the ones found by Baudry et al. (2008) for Belgian dairy farms during 1996-2005. All own price elasticities have the expected negative sign. All samples present a lower responsiveness of input demands with respect to energy price change, than to crop-specific and animal-specific price change. Amongst all samples, dairy farms show the lowest animal-specific input own price elasticity, and the highest crop-specific input own price elasticity. Looking at discrepancies between more and less specialised farms (sample 1 vs. sample 2, and sample 3 vs. sample 4), it appears that more specialised field crop farms (sample 2) are less responsive to crop-specific input price than less specialised ones (sample 1). By contrast, more specialised beef cattle farms (sample 4) are more responsive to animal-specific input price than less specialised ones (sample 3).

Table 4 shows the average marginal cost per sample. We comment only significant costs (the significance is established with standard errors). A few findings can be highlighted. First, our results are slightly larger than the ones found e.g. by Wieck and Heckelei (2007) for milk output for different European regions: our marginal cost of milk production for dairy farms (sample 5) is 493.7 euros per ton on average, while Wieck and Heckelei (2007) found averages of 155.5 and 115.2 in two French regions (Pays de la Loire and Brittany). This may come from the fact that our milk output not only includes milk from cows, but also from goats and ewes. This may also be explained by the fact that the price indices used Wieck and Heckelei (2007) are calculated with base year 1995, whereas our base year is 2000. Second, marginal costs of the main production (e.g. crop output for the crop samples) are on average of a similar range: 405.3 for field crop farms (sample 1), 530.8 for beef cattle farms (sample 3), and 493.7 for dairy farms (sample 5). Third, marginal costs are on average lower in the crop samples (samples 1 and 2) than in the livestock samples (samples 3, 4, 5). Fourth, the marginal cost of crop output is on average lower in the crop samples (samples 1 and 2: 405.3 and 271.1) than in the animal samples (samples 3 and 5: 1,168.5 and 715.2), while by contrast the marginal cost of milk output is higher on average in the dairy sample (sample 5: 493.7) than in the field cropping sample (sample 1: 380.6). Fifth, the marginal cost of crop output is much lower on average for the more specialised crop sample (sample 2: 271.1) than for the less specialised crop sample (sample 1: 405.3), which is an intuitive result.

Figures 1 and 2 show the evolution during the period considered of yearly marginal cost averages of crop output and of milk output respectively. Figure 1 shows that marginal costs for crop output are extremely stable over the period for the more specialised field crop sample (sample 2). They are also fairly stable for the dairy farms (sample 5), except for a drop between 2001 and 2002. By contrast, the evolution is more hatched-back for the less specialised crop sample (sample 1) and the beef sample (sample 3). Farms have experienced periods of cost increase followed by cost decrease (notably in 2001 and 2004). Interestingly, the evolution is almost parallel for the two samples. Regarding the evolution of marginal cost of milk production shown on Figure 2, it is continuously increasing for the dairy sample (sample 5), but here again hatched-back for the less specialised crop sample (sample 1). For the latter, the development is very similar to the one for marginal cost of crop output for the same sample shown on Figure 1.

Finally, we analyse the relation between marginal costs of production and various variables with the help of quintiles. In each sample, farms are separated into four quintiles based on their cost of production, with group 1 presenting the lowest cost of production and group 4 the highest. The grouping is done only for the major output, i.e. crop output for the field crop farm samples, beef output for the beef cattle samples, and milk output for the dairy sample. The results, presented in Table 5, indicate that crop direct subsidies (per output unit) are consistently higher the higher the marginal costs of crop output (i.e. from group 1 to group 4) within the two field crop samples. Regarding the beef farm samples, there is no continuous pattern, but it is clear that the highest subsidies are on average received by the medium cost farms (group 3). As for the dairy sample, the level of livestock subsidies is similar on average across all cost groups. There is no clear pattern regarding the agri-environmental subsidies per hectare. However, subsidies provided for being located in less favoured areas (and related per hectare) increase over the four groups for the beef and dairy samples, showing that subsidies seem to be positively correlated with marginal costs of production. Regarding the size in land area, the larger the farms, the higher the production cost for the more specialised crop sample. As for livestock farms, while the largest farms present the lowest production cost on average (group 1) within the beef samples, they present the highest production cost on average (group 4) within the dairy sample. The share of owned land in total land area seems to increase with cost, but there is no clear relation between cost and the share of family labour.

Our paper contributes to the production cost literature in several ways. Firstly, analyses are carried out for a long but recent period for French agriculture. Secondly, while production cost for dairy farms have been largely investigated in the literature (e.g. Baudry et al., 2008; Wieck and Heckelei, 2007; Pierani and Rizzi, 2003), research on other types of farming (crop, cattle) is rather thin. Finally, we relate our results with CAP subsidies. The main finding is that subsidies are generally related to high production costs, in particular crop direct payments within crop farms.

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Table 1: Summary statistics for the five samples: Averages over the period

	Sample 1: Field cropping farms	Sample 2: Field cropping farms including those with zero animal-specific input	Sample 3: Beef cattle farms	Sample 4: Beef cattle farms including those with zero crop-specific input	Sample 5: Dairy farms
Crop output (euros)	91,220.26	105,997.16	2,906.66	2,802.25	6,047.68
Beef output (euros)	13,928.79	4,247.10	57,734.26	56,962.43	21,386.75
Milk output (euros)	8,392.35	2,562.35	0	0	85,566.32
Other animal output (euros)	16,135.09	4,949.59	19,536.80	19,292.93	6,114.05
Crop-specific input (euros)	42,633.90	46,062.02	8,128.32	7,835.37	11,716.76
Animal-specific input (euros)	12,124.99	3,711.99	14,053.75	14,048.11	19,826.99
Energy input (euros)	14,393.78	13,277.52	7,796.03	7,675.45	14,225.25
Land (hectares)	134.90	131.88	100.83	100.59	72.12
Labor (AWU)	1.798	1.742	1.497	1.489	1.765
Capital (euros)	344,811.29	321,234.21	335,211.09	331,278.16	287,277.91
Total number of observations	**5,451**	**17,919**	**2,998**	**3,128**	**6,760**

Each farm is multiplied by its associated FADN weighting factor in order to get an approximately true representation (weight) of the farm in France.

Table 2: Summary and tests statistics of the econometric models

	Sample 1: Field cropping farms		Sample 2: Field cropping farms including those with zero animal-specific input		Sample 3: Beef cattle farms		Sample 4: Beef cattle farms including those with zero crop-specific input		Sample 5: Dairy farms	
Total number of observations		**5,451**		**17,919**		**2,998**		**3,128**		**6,760**
	R^2	*Error DF*	*R^2*	*Error DF*	*R^2*	*Error DF*	*R^2*	*Error DF*	*R^2*	*Error DF*
Input demands										
Crop-specific input	0.88	5431	0.83	17906	0.57	2979			0.52	6740
Animal-specific input	0.75	5431	-	-	0.49	2979	0.36	3111	0.61	6740
Energy input	0.59	5431	0.47	17906	0.46	2979	0.13	3111	0.63	6740
Number of significant parameters at 10% level	41		22		25		12		38	
Wald test	*Statistics*	*Probability*	*Statistics*	*Probability*	*Statistics*	*Probability*	*Statistics*	*Probability*	*Statistics*	*Probability*
	39.21	<.0001	232.83	<.0001	6.24	0.1005	4.06	0.2552	16.81	0.0008
Heteroscedasticity White test	*Statistics*	*Probability*	*Statistics*	*Probability*	*Statistics*	*Probability*	*Statistics*	*Probability*	*Statistics*	*Probability*
Input demands										
Crop-specific input	2326	<.0001	7055	<.0001	2757	<.0001			6643	<.0001
Animal-specific input	3773	<.0001			1565	<.0001	2239	<.0001	6291	<.0001
Energy input	1992	<.0001	2433	<.0001	2799	<.0001	2861	<.0001	6471	<.0001

Table 3: Input price elasticities: averages per sample

	Crop-specific input	**Animal-specific input**	**Energy input**
Sample 1: Field cropping farms			
Crop-specific input	**-1.02***	-0.06*	0.28*
Animal-specific input	-3.02*	1.21*	-0.39*
Energy input	0.31*	-0.21	**-0.66**
Sample 2: Field cropping farms including those with zero animal-specific input			
Crop-specific input	**-0.43***	-	0.24*
Animal-specific input	-	-	-
Energy input	1.51*	-	**-0.67***
Sample 3: Beef cattle farms			
Crop-specific input	**-1.96***	1.48*	-0.90*
Animal-specific input	-0.92*	**-1.75***	1.14*
Energy input	-4.44*	1.25*	**-1.79***
Sample 4: Beef cattle farms including those with zero crop-specific input			
Crop-specific input	-	-	-
Animal-specific input	-	**-2.46***	0.55*
Energy input	-	1.70*	**-0.60***
Sample 5: Dairy farms			
Crop-specific input	**-2.7***	0.61*	-1.75*
Animal-specific input	0.99*	**-0.1***	0.86*
Energy input	-2.32	-0.31*	0.03*

*: significant elasticity at 10%

Table 4: Short-term marginal costs (euros per ton): averages per sample

	Sample 1: Field cropping farms	Sample 2: Field cropping farms including those with zero animal-specific input	Sample 3: Beef cattle farms	Sample 4: Beef cattle farms including those with zero crop-specific input	Sample 5: Dairy farms
Cost for crop output	**405.3*** *(128.3)*	**271.1*** *(52.8)*	**1,168.5*** *(451.2)*	-	**715.2*** *(250.9)*
Cost for beef output	240.3 *(181.7)*	-	**530.8*** *(162.6)*	659.6 *(475.1)*	271.8 *(215.9)*
Cost for milk output	**380.6*** *(127.4)*	-	-	-	**493.7*** *(171.5)*
Cost for other animal output	526.6 *(204.9)*	-	268.3 *(228.2)*	479.9 *(447.5)*	477.9 *(339.3)*

*: significant marginal cost at 10%.

Standard errors in brackets.

Figure 1: Evolution of short-term marginal costs of crop output (yearly averages; euros per ton)

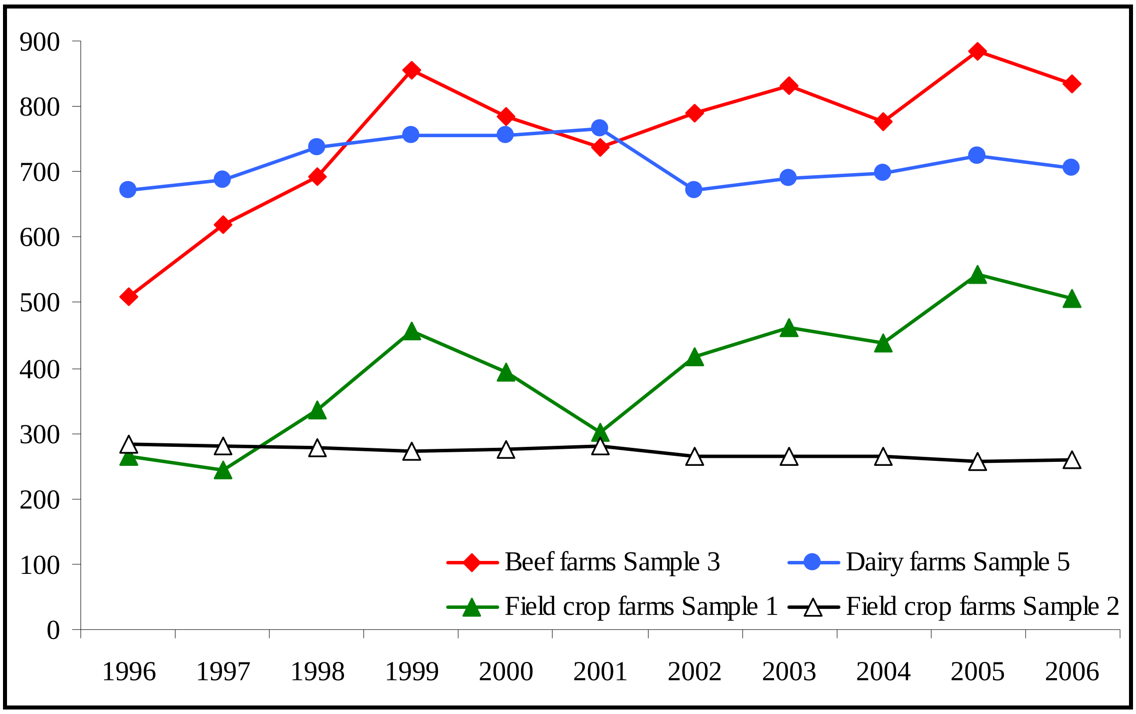

Figure 2: Evolution of short-term marginal costs of milk output (yearly averages; euros per ton)

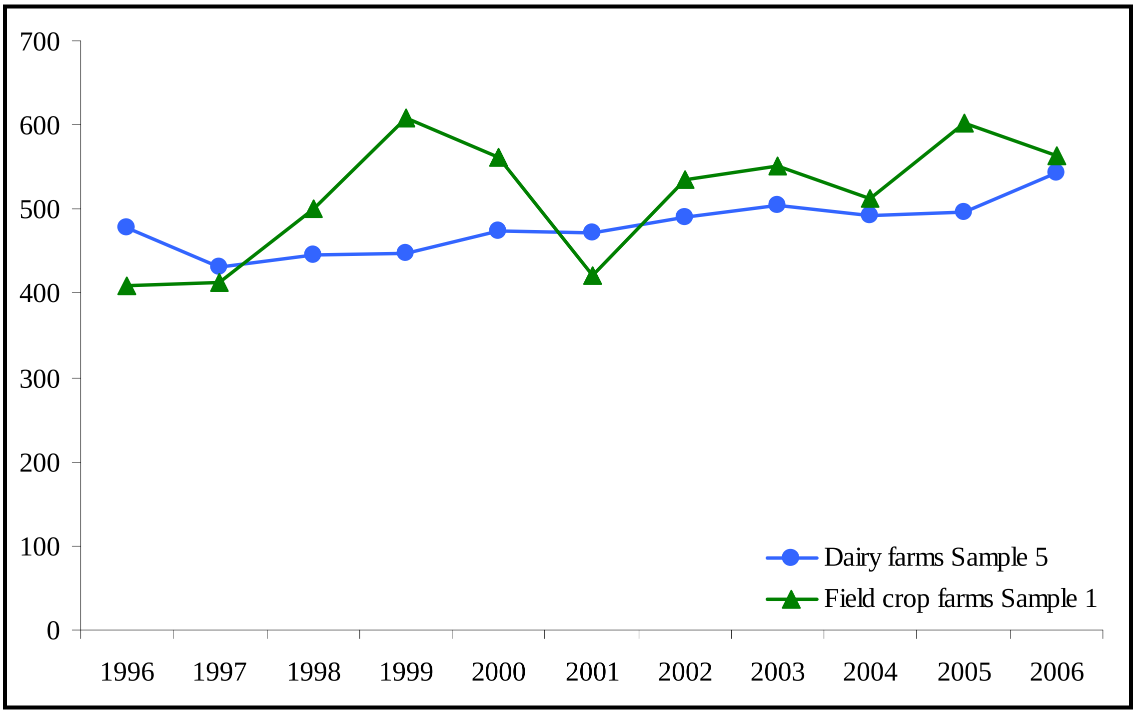

Table 5: Relation of cost with various variables: averages per marginal cost quintile

	Group 1	Group 2	Group 3	Group 4
Sample 1: Field cropping farms *(marginal cost of crop output)*				
Crop direct payments per unit of crop output	0.39	0.49	0.55	0.65
Agri-environmental subsidies (euros per hectare)	1.72	2.32	3.35	3.16
Less favoured area subsidies (euros per hectare)	0.97	1.36	2.43	2.13
Land area (hectares)	135.91	117.70	107.73	119.24
Share of owned land in total land area (%)	12.02	15.98	21.75	25.55
Share of family labour in total farm labour (%)	88.70	91.85	93.15	91.46
Sample 2: Field cropping farms including those with zero animal-specific input *(marginal cost of crop output)*				
Crop direct payments per unit of crop output	0.43	0.48	0.52	0.54
Agri-environmental subsidies (euros per hectare)	3.46	1.84	2.21	2.05
Less favoured area subsidies (euros per hectare)	0.86	0.28	0.45	0.73
Land area (hectares)	94.25	100.95	126.73	203.57
Share of owned land in total land area (%)	15.61	18.41	17.94	15.88
Share of family labour in total farm labour (%)	78.53	90.66	91.52	86.65
Sample 3: Beef cattle farms *(marginal cost of beef output)*				
Livestock direct payments per unit of beef output	0.24	0.27	0.29	0.48
Agri-environmental subsidies (euros per hectare)	15.29	21.65	18.48	18.47
Less favoured area subsidies (euros per hectare)	29.51	35.65	39.28	43.22
Land area (hectares)	123.62	97.13	81.88	85.06
Share of owned land in total land area (%)	12.81	23.30	39.83	56.21
Share of family labour in total farm labour (%)	92.86	95.06	96.87	94.73
Sample 4: Beef cattle farms including those with zero crop-specific input *(marginal cost of beef output)*				
Livestock direct payments per unit of beef output	0.41	0.39	0.51	0.42
Agri-environmental subsidies (euros per hectare)	20.68	19.97	20.49	20.74
Less favoured area subsidies (euros per hectare)	32.68	36.48	41.43	39.75
Land area (hectares)	102.68	94.05	84.14	91.51
Share of owned land in total land area (%)	21.30	28.93	44.27	54.94
Share of family labour in total farm labour (%)	95.69	97.07	96.14	92.34
Sample 5: Dairy farms *(marginal cost of milk output)*				
Livestock direct payments per unit of milk output	0.10	0.11	0.14	0.13
Agri-environmental subsidies (euros per hectare)	13.50	11.97	13.06	13.35
Less favoured area subsidies (euros per hectare)	20.92	21.33	27.01	29.84
Land area (hectares)	61.58	53.26	57.63	75.88
Share of owned land in total land area (%)	19.32	28.49	30.69	25.63
Share of family labour in total farm labour (%)	97.87	97.92	97.49	93.89

Group 1, respectively Group 4, includes farms with lowest, respectively highest, marginal cost.