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The influence of size on cost behaviour associated with tactical and operational flexibility*

Tamaño y comportamiento de los costes en situaciones de flexibilidad táctica y operativa

JOSEP Mª ARGILÉS BOSCH**
JOSEP GARCÍA BLANDÓN***

Abstract

This paper contributes with an empirical analysis, using a sample of farms, on the influence of size on cost behaviour under operational and tactical flexibility. Results indicate that small farms behave advantageously with respect to biggest farms in situations of operational and tactical flexibility. On the one hand, the increase in indirect costs with product diversification is higher in bigger farms than in smaller. On the other hand, while most farms are flexible enough to avoid cost stickiness, the biggest face considerable rigidities in downsizing indirect costs when activity decreases.

Key words: *Agricultural economics, Tactical flexibility, Operational flexibility, Cost behaviour, Size.*

Resumen

Este trabajo realiza un análisis empírico sobre la influencia del tamaño en el comportamiento de los costes ante las dos situaciones típicas de flexibilidad operativa y táctica, mediante una muestra de explotaciones agrícolas. Los resultados indican que las explotaciones pequeñas presentan ventaja comparativa en las situaciones de flexibilidad operativa y táctica. El incremento de los costes indirectos ocasionado por la diversificación de productos aumenta con

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** Department of Accounting. Facultat d'Econòmiques i Empresarials. Universitat de Barcelona. Av. Diagonal, 690. 08034 Barcelona. Spain. E-mail: josep.argiles@ub.edu

*** Department of Economics and Finance, Facultat d'Economia, IQS, Universitat Ramon Llull.

el tamaño de las explotaciones. Por otro lado, las explotaciones agrícolas más grandes presentan rigideces que impiden que los costes indirectos disminuyan en la misma medida cuando la actividad decrece que cuando ésta crece.

Palabras clave: *Economía agrícola, Flexibilidad táctica, Flexibilidad operativa, Comportamiento de los costes, Tamaño.*

JEL Classification: *M41, Q12, D24.*

1. Introduction

The survival of small firms competing with large corporations that enjoy important advantages in terms of economies of scale, has conceived the interest of economists since very long. Stigler (1939) was the first to suggest a trade-off between static-efficiency and flexibility. It is widely recognized, and empirically confirmed, that the main advantage of large firms, with respect to small ones, is that they enjoy economies of scale (*e.g.* Caves and Barton, 1990; Alvarez and Crespi, 2003). In the same vein, Noci (1994) argues that some quality-related investments are rendered unsuitable for small firms, as is for example the case in the introduction of precision machinery, staff training and the wide diffusion of statistical quality control measures. Favorable access to credit market is an additionally recognized source of advantage for large firms. They usually enjoy lower financing costs and preferential loans, while small firms growth is more constrained by inadequate or lower availability of finance (Beck and Demirguc-Kunt, 2006). There is wide empirical evidence that bank credits to small firms contract more than to large at the onset of recession and in periods of tight money (*e.g.* Martinelli, 1997; Gertler and Gilchrist, 1994). An additional recognized advantage for large firms with respect to small, is that the latter pay lower wages to their employees and workers (*e.g.* Brown and Medoff, 1989), a strategy that in the long run is likely to undermine competitiveness owing to neglect of improving the labor skill base (You, 1995). Small firms are also ill equipped to plan for and implement feedforward control systems (Busenitz and Barney, 1997) and have less sophisticated management expertise (Forbes and Milliken, 1999).

While large firms take advantage of scale economies, favourable credit market conditions, more skilled labour force, and better management and planning activities, small firms advantages relies on flexibility (You, 1995). The flexibility of small firms may stem from their responsiveness to changing circumstances or specific requirements in general. They have superior ability to cater the special needs of customers, to meet the changing tastes of consumers and to satisfy specific market niches (Piore and Sabel, 1984; Salais and Storper, 1992). They also have thinner organisation, thus allowing lower span of control and quicker response time and decision taking (Jensen and Meckling, 1976; Knight and Cavusgil, 1996), specifically Bonaccorsi (1992) and Jolly *et al.* (1992) demonstrated earlier and quicker internationalization for smaller technology-intensive firms. In terms of human resources organization, authors have distinguished between functional and numerical flexibility (*e.g.* Knox and

Walsh, 2005). With respect to decision making Colvin (2006) distinguishes between procedural and outcome flexibility. Duncan (1995) relates flexibility to information technology infrastructure, and Tatikonda and Rosenthal (2000) to the innovation process. Sethi and Sethi (1990) and Parker and Wirth (1999) review and identify different types of manufacturing flexibility.

Weiss (2001) reviewed previous studies and distinguished between tactical (the ability of a firm to adjust overall output to exogenous shocks) and operational (the ability to adjust to exogenous shocks caused by product diversification) flexibility. He found that as size increases, both types of flexibility reduce. In this vein, small firms can accommodate to market fluctuations more efficiently than large firms, thus remaining viable in the presence of larger and more efficient rivals (*e.g.* Mills, 1984; Mills and Schuman, 1985). The empirical analysis by Fiegenbaum and Karnani (1991) covering more than 3000 companies and 83 industries concluded that since small firms were more willing to adjust their output they could trade off cost inefficiency with volume flexibility. Output flexibility constitutes a more viable source of competitive advantage in volatile and capital-intensive industries, and less viable in profitable industries. Das *et al.* (1993) found an inverse relationship between size and sales variability, thus concluding that small firms adopt production technologies that permit them to adapt more readily and efficiently to changing market conditions. Similarly, Nor *et al.* (2007) reported that small firms apply more flexible methods of production, strongly based on variable costs.

Nevertheless, the review by Vokurka and O'Leary-Kelly (2000) explicitly recognises the need of future studies to better understand the complex nature of firm flexibility. Dhawan (2001) asked for more in-depth analysis about the determinants of different profitability between large and small firms. Similarly, Jack and Raturi (2003) suggested the need to investigate cost behaviour associated with flexibility for small firms.

Cost analysis is a key issue for explaining the prevalence of small firms, prevalence that is especially noteworthy in such a traditional sector as agriculture. Explanations of efficiency differences between large and small firms conventionally emphasize static production costs characteristics (Bhaskar *et al.*, 1993). As we have shown, authors have proposed different frameworks to analyze firm flexibility, being the one developed by Weiss (2001) widely followed by researchers. The author distinguishes between operational and tactical flexibility. The study of operational and tactical flexibility allows analysis on cost response to changing conditions involved in flexibility. Both kinds of flexibility are an issue of academic interest, have been considered an interesting typology to be studied, and provide a convenient framework for analyzing cost implications of flexible responses of firms, thus casting light on how they impact firm performance.

This paper contributes to the literature on small firms' flexibility with an empirical analysis of the influence of size in cost behaviour under the typical situations of operational and tactical flexibility. We have investigated an economic sector that has received little attention in the literature: agriculture. This sector is especially interesting for this study because it is characterised by the predominance of small business units with negligible market power. It is an exceptional sector in Western advanced countries with such a predominant portion of small firms persistently remaining through time (Allen and Lueck, 1998). Additionally, climate and market factors produce frequent and random fluctuations of output in the sector. There is scarcely ground for differentiated management strategies and any kind of market influence or price discrimination in small business units in agriculture. Consequently, flexibility and cost management are the most obvious competitive factors for small farms in front of bigger ones, and tactical and operational flexibility the most obvious types of flexibility to be analyzed in the agricultural sector, as there is no ground for analyzing the ability of an average farm to meet specific market niches, to evolve to a thinner organization, to manage infrastructure technology or to adopt an international strategy. Therefore, agriculture is a privileged observation field for analyzing the advantages of flexibility. Our analysis of cost response contributes to shed light on the keys of the competitive advantage of operational and tactical flexibility for small farms with respect to larger ones. We have first investigated the differential behaviour of small and large farms' costs with regard to product diversification, thus analysing cost response for operational flexibility. Secondly, we have studied the reaction of farm costs to output reduction through different farm sizes, which provides empirical evidence of cost response for tactical flexibility.

We propose the cost accounting framework to shed light into an economic research problem. Assuming that product diversification is a source of complexity for firms, this paper uses the framework provided by Activity Based Costing (ABC) to analyse how costs are affected by size in the presence of product diversity. Miller and Vollmann (1985) stated that the real driving force behind manufacturing overhead costs were transactions rather than volume. They, as well as other authors (*e.g.* Shank and Govindarajan, 1988; Cooper and Kaplan, 1991), emphasized the relevance of complexity as an overhead cost driver. While volume-related allocations of indirect costs do not reflect its real behaviour, transactions resulting from complexity do. Johnson and Kaplan (1991) concluded that firms characterized by high levels of complexity, due to product diversity, variety of flow patterns, number of inventory locations, number of shipments or set-ups, etc., will misrepresent its costs when they are allocated according to volume-related bases. A variety of flow patterns, as well as inventory items, shipments, set-ups, etc. must be programmed, operated, managed and optimised. Hayes and Clark (1985), Banker and Johnston (1993) and Banker *et al.* (1995) found empirical evidence on the influence of complexity on overhead costs. We focus on the complexity produced due to product diversity and use this approach to analyse cost response related to operational flexibility patterns.

The extant accounting research tradition on cost stickiness may help to better understand differential cost response in a typical situation involving tactical flexibility. Cooper and Kaplan (1991) alleged that overhead cost's response to an increase in volume activity is significantly stronger compared with its response to a decrease in activity. This type of cost behaviour is labelled "sticky", and "stickiness" the correspondent effect. Empirical evidence widely support cost stickiness (*e.g.* Noreen and Sonderstrom, 1997; and Anderson *et al.*, 2003). Further, Balakrishnan *et al.* (2004), Calleja *et al.* (2006) and Balakrishnan and Gruca (2008) studied different subjects related to cost stickiness. Nevertheless, none of them have investigated the importance of firm size as a determinant of cost stickiness.

Our results indicate that small farms are favoured by specific cost behaviour under technical and operational flexibility. For large farms, higher increases in costs with product diversification have been observed, compared with small ones. In addition, our results support cost stickiness only for the largest farms. Since small farms are flexible enough to avoid cost stickiness, larger ones present rigidities in downsizing resources when activity decreases. Therefore, results indicate advantages for small firms with respect to larger ones in tactical and operational flexibility. The study provides also evidence on the existence of a trade-off between efficiency and flexibility. Larger farms are more efficient at the expense of a loss in flexibility.

The remainder of the article is organized as follows: second section deals with empirical design and develops hypotheses, next section presents sample characteristics, results are explained in fourth section and concluding remarks are in fifth section.

2. Empirical Design and Hypothesis Development

2.1. Models specification

We use a Cobb-Douglas function to estimate the relationship between costs (*C*), output (*O*), and complexity for farms, with product diversity (*N*) as proxy for complexity. It has been applied to a lot of contexts to represent the relationship between output and inputs, and has been successfully tested. An important advantage of this model is that it can be estimated as a linear relationship using the log transformation of variables, it is simple, it is ease of interpretation and it satisfies the purposes of our analysis. Some of the advantages attributed to alternative functional forms refer to requirements of multiproduction and multiinput, such as the existence of economies of scope, subadditivity, independence of variable costs of all the outputs and complementarity between them, as well as the restrictions that all firms produce all products, all inputs are gross substitutes, all inputs are also nonregressive, etc. (Baumol *et al.*, 1988; Chambers, 1988). Te Fuss normalized quadratic form used by Berger *et al.* (1993) is a profit function that requires information on physical and price data on different netputs. However, for the purposes of our analysis we do not require detailed analysis of output. In fact, in our data base we have scarce information on output composition and no data on input prices. Additionally, our study does not focus on inefficiency. For the purposes of our study, and following previous similar studies, we analyse costs depending on overall output. As we have also specified a quadratic flexible form (see Appendix 2) that confirms our main results of the Cobb-Douglas function, we focus our analysis on this more simple and ease of interpretation later functional form. We then formulate the following model:

$$C = B_0 \cdot O^{\beta_O} \cdot N^{\beta_N} \quad [1]$$

Banker *et al.* (1995) also used a similar model, being a reference article for cost analysis in business literature. Taking the natural logarithm of Eq. [1] yields the following linear model:

[2] $$\ln C = \beta_0 + \beta_O \cdot \ln O + \beta_N \cdot \ln N$$

where $\beta_0 = \ln B_0$. Statistical tests about the significance of the variables in the model have been performed through the β coefficients. If costs increase with volume or product diversity, then these coefficients should be positive, and negative otherwise.

The multiplicative model reflects the notion that the impact of an increase in diversity or volume on costs ($\delta C/\delta N$ or $\delta C/\delta O$) is greater when the level of the other variable is higher. Logarithmic transformation of the variables also reduces deviations from normal distribution for our sample.

Output is defined as monetary valuation of farm output. For the purpose of our study we use number of products as a proxy for product diversity.

Farm costs also depend on other variables. Wieck and Heckelei (2007) found a significant influence of farm specialization, location and technology on cost behaviour. Thus, specific technological characteristics, such as those induced by type of farming, influence farm costs. Location in mountain zones, less-favoured or ordinaries zones influence costs through the availability and price of factors. In addition, prices, technological changes and factor endowments vary with time. Therefore, control variables have been added to the model indicating technology (*T*), geographical location (*L*) and year (*Y*).

In order to analyse the effect of product diversification across farm sizes, we define a dummy variable (*DS*) which value is 1 when the farm belongs to a certain quintile of size and 0 otherwise.

We then formulate the equation [3], where each observation refers to firm *i* in period *t*:

[3] $$\ln C_{i,t} = \beta_0 + \beta_O \cdot \ln O_{i,t} + \sum_{q=1}^{Q} \beta_N \cdot DS_{i,q} \cdot \ln N_{i,t} + \sum_{j=1}^{j} \beta_{Tj} \cdot T_{i,t,j} + \sum_{m=1}^{m} \beta_{lm} \cdot L_{i,t,m} + \sum_{n=1}^{n} \beta_{Yn} \cdot Y_{i,t,n} + \varepsilon_{i,t}$$

Values 1/e for dummy variables in the initial Cobb Douglas function (indicating the absence/existence of the attribute) transform into logarithms to 0/1 respectively.

While equations [2] and [3] provide methodological tools for testing cost behaviour in characteristic situations of operational flexibility, corresponding tests for tactical flexibility use the formulation of the basic sticky cost model used in Anderson *et al* (2003), as well as in subsequent empirical accounting studies on this subject:

[4] $$\ln \frac{C_{i,t}}{C_{i,t-1}} = \beta_0 + \beta_{O1} \cdot \ln \frac{O_{i,t}}{O_{i,t-1}} + \beta_{O2} \cdot DECR \cdot \ln \frac{O_{i,t}}{O_{i,t-1}} + \varepsilon_{i,t}$$

where $C_{i,t}$ means costs under study for farm *i* in period *t*, $O_{i,t}$ (as mentioned above) refers to the output of firm *i* in period *t*, and $DECR_{i,t}$ is a dummy variable that takes the value of 1 when output for this farm decreases between period t–1 and t, and 0 otherwise. According to the methodology of the Farm Accountancy Data Network (FADN)[1], the data source for our study, revenue is recognized at the moment of production, which provides a better link to activity than the revenue-recognition at the moment of sale, the independent variable employed in Anderson *et al.* (2003).

If the traditional fixed- and variable-cost model is valid, upward and downward changes in costs, given changes in output, will be equal, and consequently $\beta_{O2} = 0$. Because of *DECR* takes the value of 1 when output decreases between periods t–1 and t, the sum of coefficients $\beta_{O1} + \beta_{O2}$ measures the monetary value decrease in costs that follows a monetary value decrease in output. If costs are sticky, the variations of costs following output increases should be greater than under output decreases, thus being $\beta_{O2} < 0$, conditional on $\beta_{O1} > 0$.

Stickiness across farm sizes is analysed through interactive variables between output variations and dummy variables referring to decrease in output and quintiles of size.

As well as for costs, changes in costs depend also on additional factors. Therefore, we also control for changes in number of products, technological characteristics, farm location and year, thus defining equation [5]:

$$\text{[5]} \quad \ln\frac{C_{i,t}}{C_{i,t-1}} = \beta_0 + \beta_{O1}\cdot\ln\frac{O_{i,t}}{O_{i,t-1}} + \sum_{q=1}^{Q}\beta_{O2}\cdot DS_{i,q}\cdot DECR_i\cdot\ln\frac{O_{i,t}}{O_{i,t-1}} + \beta_N\cdot\ln\frac{N_{i,t}}{N_{i,t-1}} + \sum_{l=1}^{l}\beta_{fl}\cdot T_{i.t,l} + \sum_{m=1}^{m}\beta_{lm}\cdot L_{i,t,m} + \sum_{n=1}^{n}\beta_{yn}\cdot Y_{i,t,n} + \varepsilon_{i,t}$$

2.2. Variables in the equations

ABC and cost stickiness literature refer to indirect costs. Research data have been obtained from the FADN, whose cost classification (displayed in Table 1) and methodology are explained in Appendix 1. We have excluded specific costs from our analysis because they are mainly related to physical units of output, independently on product diversity and economies of scale. On the contrary, indirect costs are related to the whole farm's conditions. While the former are not interesting for our analysis, the latter are likely to be affected by economies of scale and specific conditions which allow small farms afford product diversity and output fluctuations differently with respect to larger ones. Accordingly, C, the dependent variable in equations [3], [5] and [7], is total indirect costs (*TOTINDIRECT*), which includes the sum of and opportunity cost of family work (*FW*). The latter has been calculated multiplying the annual units of family work –provided by the FADN– by the reference income of its corresponding year. The Spanish Ministry of Agriculture regards the reference income as equivalent to the gross annual earnings of non-agricultural workers, and publishes this valuation yearly. This means the income that farmers could obtain in

[1] The FADN collects accounting information from a rotating sample of farms in the European Union. Its characteristics and methodology are explained in Appendix 1.

alternative jobs. Given the predominance of small family farms in agriculture, the inclusion of opportunity costs of family work gives a more complete picture than merely registered costs. Their inclusion is necessary to compare different kinds of farms. While in some farms the householder is not apportioned with wage specified in a signed contract, in others he and/or the family are hired through a labour contract. There is a well established agreement to include this opportunity cost in the agricultural statistics in the EU (European Commission, 1991a)[2]. Additionally, we reinforce our analysis considering in the dependent variable only *INDIRECT*, which includes farming overheads, depreciation and external factors registered in FADN according to concepts included in Table 1 and explained in Appendix 1. We refer to them as registered indirect costs. As family work saves expenses on external factors, it influences registered indirect costs. We thus include *FW* as independent variable when *INDIRECT* defines the dependent variable in equation [3], expecting a negative sign between both. Logarithms of changes in both variables are also included as independent and dependent variables in equation [5].

TABLE 1
COST CLASSIFICATION IN THE FADN

Code	Description
SE270	Total inputs
SE275	• Intermediate consumption
SE281	❑ Specific costs
SE336	❑ Farming overheads
SE360	• Depreciation
SE365	• External factors
SE370	❑ Wages paid
SE375	❑ Rent paid
SE380	❑ Interest paid

Source: Community Committee for the FADN (1998).

Wages include both direct, which behaviour is similar to specific costs, and indirect costs. Thus, it is interesting to analyze wages separately from other indirect costs, as well as different components of indirect costs.

According to ABC literature, traditional costing allocates costs using volume-based criteria, assuming that high-volume products should be charged with higher costs than their low-volume counterparts. As mentioned, we included *O* (monetary valuation of farm output) in the equations, which is similar to volume-based cost allocations used in traditional cost calculation (Cinquini *et al.*, 1999; Drury and Tales, 1994; Lukka and Grandlund, 1996). It also captures product mix, and therefore it is in a certain way a measure of complexity. However,

2 More explanation on opportunity cost of family work can be found in last paragraph in the Appendix.

this drawback is minimized when we control for number of products (*N*). It is also expected a positive relationship between this variable and costs, as well as between variation of both variables. It is expected that indirect costs increase with output, as well as with other volume-based indicators.

Product diversity (*N*) is expected to be positively associated with indirect costs, as well as a positive association is also expected between product diversity and indirect costs. The same positive association is also expected between changes in product diversity and changes in indirect costs. Farms with more products must face higher indirect costs in terms of changes in tasks, monitoring, coordination of different activities, supplies and management of diverse materials and services, etc. Anderson (1995) found that manufacturing overhead costs are positively associated with product mix heterogeneity, an indicator of complexity, similar to those advocated in ABC literature. Thus, a positive relationship is expected between product diversification and costs in equation [3]. The distance between different products is a qualitative feature of product diversity that is not clearly captured with number of products. For instance, the combination of wheat and pigs could be considered a greater grade of diversity than the combination of wheat and rye. However, this feature is considered when different dummy variables control for type of farming. Then, it is expected that farms with**,** for example**,** three different products would be more complex when oriented to mixed than to any other type of farming.

Differences in hectares per product (*UAA/N*), considering that other variables control for the number of products and volume, indicates differences in applied technology in equation [3]. To a certain extent it also indicates transactions related to complexity, because it influences costs related to movements from one location to another, handling, storage, energy consumption, depreciation, etc. On the one hand, more hectares per product allow economies of scale with respect to advantageous use of resources. However, coupled with the same number of products and output it indicates less efficient technology (or its less efficient use), with consequently higher indirect costs.

Technological characteristics of farms are also approached through dummy variables, in equation [3], indicating that a farm operates the corresponding type of farming when these variables equal one, and zero otherwise: *EXTENSIVE* for farms with predominantly field extensive crops, *PERMANENT* for predominantly permanent crops, *PIGPOULTRY* for predominantly granivore (pigs and poultry) production, and *DAIRYDRYSTOCK* for dairy and drystock production, while mixed type of farming is the default category. In the geographical context of our sample, where water shortages and dry weather are frequent, agricultural land is very scarce, and livestock is usually produced in intensive capital endowed farms, mixed farms are expected to involve higher costs than field and permanent crop, though less than those specialized in livestock.

Two dummy variables indicate, in equations [3], the location in less-favoured (*LESSFAZONE*) and mountain zones (*MOUNTZONE*) when the value equals one (and zero otherwise), while the default category is for farms located in what we label as "normal zones". Farms located in these zones usually have more land available, more farmhouse consumption, some resources are less scarce, prices are lower, etc. Therefore, negative signs are expected for coefficients associated to these variables.

In equations [3] four dummy variables control for specific circumstances across the period studied (for example, climate and market conditions), indicating *YEAR90*, *YEAR91*, *YEAR92* and *YEAR93* that the observation belongs to the corresponding year when its value equals one (and zero otherwise), while the default variable is for year 1989. As monetary values were deflated and expressed in current terms of year 1989, there is no assumption about the sign of their associated coefficients.

With respect to equation [5], variations in costs are expected to be positively associated with variations in output, number of products and hectares per product. Additionally, variations in family work are expected to negatively influence variations in registered indirect costs. However, we have no expectations with respect to the influence of all considered dummy variables on cost variation based on a priori grounds. Our purpose is to reinforce our results after controlling for these variables.

2.3. Hypotheses development

Small firms enjoy lower economies of scale, but they are usually less complex than larger ones. They have less employees and few departments and organizational parts are involved to perform their activities. Therefore, they have little need for coordination and control. They mostly operate on local and regional areas rather than on national and international ones, thus being scarcely involved in differentiated legal and cultural issues. Neither will small firms need the coordination of dispersed business units that is usually associated to a holding group, nor the management of information flows that is a crucial issue for companies with branch offices that must be controlled arm's length. Diversification in terms of markets and technologies adds information-processing demands and greater need for coordination and control of activities, which is more likely to be scarce in small firms. Product diversification is an additional source of complexity, entailing higher material diversity, number of shipments received and dispatched, more inspections and setup transactions. Its development, management and coordination arguably entail higher transactions. Coupled with a bigger organization exacerbates complexity. An increasing number of products must be dispatched through wider geographical areas with respect to small firms. Higher number of workers, set ups and inspections must be performed and monitored through a wider organization. It also requires higher investments in machinery and equipment. In addition, more inputs are needed, received, controlled, distributed and handled throughout wider organization, physical spaces and geographical areas. They must be ordered from a wider array of suppliers, usually located in diverse geographical areas, with their subsequent additional monitoring and coordination needs. The same apply for products and deliveries. You (1995) states that large firms tend to be strong in standardised markets, in comparison with small firms, that have advantage in serving segmented markets. This fact suggests that the latter are better endowed to diversify products at lower cost than the former. The extant empirical evidence on higher operational flexibility for small firms suggests that small firms have cost advantages to develop a flexible response in this respect. Management of product diversity throughout a simpler organization entails lower costs than doing it in a complex organization. We thus formulate the following hypothesis:

H1. *Larger farms are more cost sensitive to product diversification than smaller ones. That is, small farms can afford stronger product diversification with lower increases in indirect costs than large farms.*

Sticky costs occur due to asymmetric adjustments of resources when volume of activity increases and decreases. Costs downward adjustment is more difficult than upward adjustment because firms face difficulties in removing committed resources. Cooper and Kaplan (1992) pointed out that managers may be reluctant to dismiss people or cut resources when demand dropped, usually delaying adjustments because they believed that the drop in demand or activity was only temporary. Anderson *et al.* (2007) distinguished three factors causing cost stickiness: fixity of costs, management failure to control costs and economic decisions to maintain resources during a downturn. There is empirical evidence that large firms usually consume more fixed factors and use more expensive and long term employment, while small firms depend more on variable factors (Nor *et al.*, 2007; You, 1995). Therefore, big firms must face more rigidities in reducing committed resources when activity decreases, with respect to small ones. On the other hand, big firms usually have more complex organizations, wider span of control and greater transaction and agency costs. Blau's (1970) and Kimberly's (1976) early research provided significant evidence that increasing size determines more complex structures in organisations. Further research (Iacobucci and Rosa, 2005; Robson *et al.*, 1993) found that small firms have important incentives to avoid complexity. In this vein, any decision requires more information gathering, involves wider organisational complexity and entails a wider array of consequences for bigger firms. Therefore, decisions are more slowly taken by these firms. They are less endowed to adjust resources in downturns, and they more likely incur in cost stickiness. Finally, uncertainty plays also a crucial rule. As bigger firms must face considerable difficulties and rigidities with decisions on downsizing committed resources, they tend to delay such decisions until the decrease in activity is more persistent, or its expectations are sounder. On the contrary, resource adjustments for small firms are more automatically decided, as they are more based on variable resources. They can advantageously face activity decrease.

Given this considerations biggest farms are less able to adjust costs when activity falls, and we thus formulate the following hypothesis:

H2. *Cost stickiness is lower for smaller farms than for bigger ones.*

3. Sample

The regional FADN office in Barcelona provided us with five year data (1989 to 1993) from 170 Catalan farms. We excluded 35 observations, corresponding to 7 farms, because there was no data about their utilized agricultural area, and therefore it was not possible to calculate their corresponding ratio of hectares per product.

Monetary values were deflated and expressed in constant values of 1989.

Graphic plots of dependent variables in terms of independent variables reveal the existence of better linear relation between these transformed logarithmic variables than with the untransformed.

Table 2 offers some descriptive magnitudes about our sample. Costs were stable for the period studied, with specific costs presenting a minor drop. Spanish farms had to make a great effort to improve competitiveness when the country joined the European Economic Community, particularly Catalan farms specialized in products scarcely protected by the Community. Output presented decreasing but variable values across the period, reflecting the influence of random market and climatic effects.

According to statistics of the *Institut d'Estadística de Catalunya* (Catalan Department for Statistics) (1992, 1998), the farms censed in Catalonia were 99,320 in 1989 and 76,126 in 1993. Distribution by farming type was very similar for both years. In 1993, 17.9% of farms were oriented to extensive crops, 6.7% to horticulture, 45.1% to permanent crops, 9.4% to dairy and drystock, 4.7% to granivores and 16.3% to mixed farming. As can be seen in Table 2, our sample approximately fits population in extensive and permanent crops, but there are certain deviations in drystock, granivores, mixed farming and horticulture, the latter not present in the sample. The regional FADN is very concerned with obtaining information about granivores, which are very important in Catalonia, in spite of the fact that their production is mainly performed by mixed farms. It can be considered that, despite certain differences, our sample is representative of population.

In accordance to expectations and data for other sectors, data reflect an increasing share of indirect costs over total costs and output across the period studied, both for total indirect and registered indirect costs. On the contrary, specific costs present a slightly decreasing proportion over output: from 58.09% at the beginning to 57.47% at the end of the period under study.

According to Schmitt's (1991) assertion that Western agriculture is characterized by the predominance of small business, all farms in the sample can be considered small business. Their workforce (including family work), measured in annual work units, range from a minimum of 0.36 to a maximum of 9.51, while deflated output range from 460.53 € to 399,131.97 €.

Table 3 displays some descriptive data by first, third and fifth quintiles of our sample. In spite that there are differences in output, indirect costs, size, annual work units and utilized agricultural area between largest and smallest farms, there are few differences in terms of number of products. In the whole spectrum of farm sizes, farmers usually try to mitigate shocks from climate and market circumstances with product diversification. Consequently, larger farms present higher hectares per product than smallest.

Size is measured with European Size Units (ESU). The ESU is a unit of measurement of the economic size of the agricultural holdings used in the EU for statistical purposes. Standard results of FADN provide data about this variable. ESU defines the economic size of an agricultural holding on the basis of its potential gross added value. It is calculated by assigning predetermined figures of gross value added to the different lines of production of the farms. One ESU equals approximately 1,200 ECU-currency of standard gross margin. This standardized measure of size is homogeneous for different types of farming and defines a method for classifying agricultural holdings which was common to all

TABLE 2
DESCRIPTIVE STATISTICS
(Monetary values expressed in € in current terms of 1989)

	Year 1989	Year 1990	Year 1991	Year 1992	Year 1993
Mean values for farm:					
Total output	52,765.15	49,439.68	47,499.69	48,161.45	47,202.43
Total costs	57,716.10	56,666.07	54,228.59	53,892.15	55,172.13
Specific costs	30,650.32	28,466.45	26,901.83	26,469.68	27,128.93
Total indirect costs	27,065.78	28,199.63	27,326.76	27,422.46	28,043.20
Opportunity cost of family work	13,652.29	13,594.97	13,881.46	14,041.96	14,501.82
Registered indirect costs	13,413.49	14,604.66	13,445.31	13,380.50	13,541.37
Utilized agricultural area (hectares)	24.71	24.51	24.51	24.91	25.01
Hectares per product	7.76	8.34	6.87	6.59	6.84
Number of products	3.71	3.50	3.77	3.83	3.79
Number of farms in the sample:					
Located in (number and %):					
Mountain	8 (4.9%)	8 (4.9%)	8 (4.9%)	8 (4.9%)	8 (4.9%)
Less-favoured	65 (39.9%)	65 (39.9%)	65 (39.9%)	65 (39.9%)	65 (39.9%)
Normal	90 (55.2%)	90 (55.2%)	90 (55.2%)	90 (55.2%)	90 (55.2%)
Type of farming (number and %):					
Field-extensive	30 (18.4%)	30 (18.4%)	26 (16.0%)	25 (15.3%)	27 (16.6%)
Permanent	83 (50.9%)	81 (49.7%)	82 (50.3%)	81 (49.7%)	79 (48.5%)
Dairy and drystock	6 (3.7%)	7 (4.3%)	6 (3.7%)	6 (3.7%)	7 (4.3%)
Pig and poultry	15 (9.2%)	16 (9.8%)	16 (9.8%)	18 (11.0%)	20 (12.3%)
Mixt	29 (17.8%)	29 (17.8%)	33 (20.3%)	33 (20.3%)	30 (18.4%)
% of specific costs over output	58.09	57.58	56.63	54.96	57.47
% of total indirect costs over output	51.29	57.04	57.53	56.94	59.41
% of registered indirect costs over output	25.42	29.54	28.31	27.78	28.68

TABLE 3
DESCRIPTIVE STATISTICS BY TENTH, FIFTH AND FIRST PERCENTILES OF SIZE
(Monetary values expressed in € in current terms of 1989)

	Number of products	Output	Registered indirect costs	Total indirect costs	Utilized agricultural area	Hectares per product	Annual work units	Family work units
5th quintile								
Mean	4.41	120,803.43	31,985.76	49,257.51	42.63	10.95	2.38	1.65
St. Dev.	1.24	99,768.01	23,191.03	26,613.06	39.23	13.64	1.37	.84
Median	5	90,752.83	25,255.62	42,310.83	28	5.9	2	1.44
Minimum	2	6,334.67	4,156.19	12,489.12	1.6	0.5	0.77	0
Maximum	8	399,072.04	200,738.04	221,773.47	164.8	82.4	9.51	4
3th quintile								
Mean	3.53	36,951.40	10,145.06	23,337.30	22.56	7.12	1.46	1.27
St. Dev.	1.39	39,964.94	7,314.59	7,325.23	14.07	4.99	.55	.50
Median	3	22,509.07	7,767.34	22,426.36	21.84	6	1.28	1.04
Minimum	1	5,130.63	1,214.75	10,664.19	0	0	0.7	0.1
Maximum	10	215,162.33	37,585.00	51,679.10	68.3	22.77	3.12	2.9
1st quintile								
Mean	3.01	9,846.52	4,216.60	14,741.38	10.57	3.71	1.06	0.99
St. Dev.	1.22	15,669.45	5,455.91	6,817.13	6.24	2.51	0.37	0.32
Median	3	6,128.00	2,661.49	12,880.72	10.43	3.77	1	1
Minimum	1	460.53	136.83	5,964.76	0	0	0.36	0.3
Maximum	8	120,803.43	35,690.15	48,155.30	27.5	12.7	2.8	2.37

TABLE 4

PEARSON CORRELATIONS (WITH SIGNIFICANCES BELOW) BETWEEN VARIABLES IN EQUATION (3)

Panel A: continuous variables

	ln(*N*)·*DS* (1st quintile)	ln(*N*)·*DS* (2nd quintile)	ln(*N*)·*DS* (3rd quintile)	ln(*N*)·*DS* (4th quintile)	ln(*N*)·*DS* (5th quintile)	ln(*O*)	ln(*UAA/N*)	ln(*FW*)
ln(*N*)·*DS* (1st quintile)	1							
ln(*N*)·*DS* (2nd quintile)	–0.1995 ***	1						
ln(*N*)·*DS* (3rd quintile)	–0.2236 ***	–0.2096 ***	1					
ln(*N*)·*DS* (4th quintile)	–0.2095 ***	–0.1965 ***	–0.2202 ***	1				
ln(*N*)·*DS* (5th quintile)	–0.2236 ***	–0.2097 ***	–0.2350 ***	–0.2202 ***	1			
ln(*O*)	–0.4917 ***	–0.1769 ***	0.0144	0.1655 ***	0.4883 ***	1		
ln(*UAA/N*)	–0.2602 ***	–0.0384	0.0008	–0.0257	0.1142 ***	–0.0692 **	1	
ln(*FW*)	–0.1900 ***	0.0676 **	–0.0243	0.0992 ***	0.2272	0.3172 ***	–0.0249	1
YEAR90	–0.0679 **	–0.0612 *	0.0392	–0.0059	0.0040	0.0200	0.0448	–0.0276
YEAR91	–0.0373	–0.0260	0.0037	0.0528	0.0197	–0.0037	–0.0164	–0.0032
YEAR92	0.0744 **	0.0749 **	–0.0399	–0.0356	–0.0115	–0.0039	–0.0203	0.0054
YEAR93	0.0947 ***	0.0146	–0.0352	–0.0361	0.0022	–0.0347	–0.0120	–0.0054
EXTENSIVE	–0.0854 **	0.0023	0.0857 **	0.0356	0.0678 **	–0.0283	0.1216 ***	–0.1202 ***
PERMANENT	0.3635 ***	0.1359 ***	–0.0256	–0.1457 ***	–0.2839 ***	–0.6181 ***	0.1207 ***	–0.1425 ***
DAIRYDRYSTOCK	–0.0767 **	–0.0672 **	–0.0766 **	0.0303	0.1933 ***	0.2191 ***	0.0982 ***	0.2860 ***
PIGPOULTRY	–0.1797 ***	–0.0875 **	–0.0145	0.0444	–0.0311	0.3888 ***	–0.3199 ***	–0.0003
MOUNTZONE	–0.0236	–0.0321	–0.0111	0.0121	–0.0551	–0.0680 **	0.1692 ***	–0.1962 ***
LESSFAZONE	0.0114	0.1546 ***	0.0453	–0.0834 **	–0.1398 ***	–0.1949 ***	0.2522 ***	0.0365

TABLE 4 (cont.)

Panel B: dummy variables

	YEAR90	*YEAR91*	*YEAR92*	*YEAR93*	*EXTENSIVE*	*PERMANENT*	*DAIRYDRYSTOCK*	*PIGPOULTRY*	*MOUNTZONE*	*LESSFAZONE*
YEAR90	1									
YEAR91	–0.2500 ***	1								
YEAR92	–0.2500 ***	–0.2500 ***	1							
YEAR93	–0.2500 ***	–0.2500 ***	–0.2500 ***	1						
EXTENSIVE	0.0175	–0.0064	–0.0223	–0.0064	1					
PERMANENT	–0.0012	0.0047	–0.0012	–0.0130	–0.4228 ***	1				
DAIRYDRYSTOCK	0.0093	–0.0062	–0.0062	0.0093	–0.0875 **	–0.1891 ***	1			
PIGPOULTRY	–0.0122	–0.0122	0.0052	0.0226	–0.1722 ***	–0.3725 ***	–0.0771 **	1		
MOUNTZONE	0.0000	0.0000	0.0000	0.0000	0.1271 ***	–0.1013 ***	0.1020 ***	–0.0044	1	
LESSFAZONE	0.0000	0.0000	–0.0000	–0.0000	–0.2441 ***	0.2962 ***	–0.1489 ***	–0.0838 **	–0.1814 ***	1

*Significant at a 10% level. **Significant at a 5% level. ***Significant at a 1% level.

TABLE 5

PEARSON CORRELATIONS (WITH SIGNIFICANCES BELOW) BETWEEN VARIABLES IN EQUATION (5)

Panel A: continuous variables

	DECR· ln (O_t/O_{t-1})·*DS* (1st quintile)	*DECR*· ln(O_t/O_{t-1})·*DS* (2nd quintile)	*DECR*· ln (O_t/O_{t-1})·*DS* (3rd quintile)	*DECR*· ln(O_t/O_{t-1})·*DS* (4th quintile)	*DECR*· ln(O_t/O_{t-1})·*DS* (5th quintile)	ln (O_t/O_{t-1})	ln (N_t/N_{t-1})	ln (FW_t/FW_{t-1})	ln $[(UAA/N)_t/(UAA/N)_{t-1}]$
DECR·ln (O_t/O_{t-1})·*DS* (1st quintile)	1								
DECR· ln *(Ot/Ot–1)·DS* (2nd quintile)	–0.0687 *	1							
DECR· ln *(Ot/Ot–1)·DS* (3rd quintile)	–0.0718 *	–0.0612	1						
DECR· ln *(Ot/Ot–1)·DS* (4th quintile)	–0.0676 *	–0.0576	–0.0602	1					
DECR· ln *(Ot/Ot–1)·DS* (5th quintile)	–0.0694 *	–0.0592	–0.0618	–0.0582	1				
ln(O_t/O_{t-1})	0.4797 ***	0.3647 ***	0.2808 ***	0.1964 ***	0.2301 ***	1			
ln(N_t/N_{t-1})	0.0787 **	–0.0320	0.0064	0.1070 ***	0.0519	0.0951 **	1		
ln(FW_t/FW_{t-1})	0.0273	0.0418	–0.0142	–0.0071	–0.0449	0.0096	0.0892 **	1	
ln$[(UAA/N)_t/(UAA/N)_{t-1}]$	–0.0698 *	0.1036 ***	0.0257	–0.1035 ***	–0.0335	–0.0336	–0.8365 ***	–0.0277	1
YEAR91	0.0551	–0.0122	0.0072	–0.0298	–0.0787 **	–0.0317	0.1810 ***	0.0391	–0.1723 ***
YEAR92	0.0159	0.0330	–0.0306	0.0472	0.0558	0.0471	0.0142	–0.0021	–0.0046
YEAR93	–0.0600	–0.0667 *	0.0472	0.0275	0.0307	0.0562	–0.0540	0.0270	0.0309
EXTENSIVE	0.0783 **	0.0082	–0.0590	–0.0018	–0.0503	0.0055	–0.0214	–0.0570	0.0269
PERMANENT	–0.1920 ***	–0.0667 *	0.0193	0.0629	0.1159 **	0.0065	–0.0125	–0.0151	–0.0163
DAIRYDRYSTOCK	0.0233	0.0031	0.0504	0.0008	–0.1242 ***	–0.0305	0.0461	0.0108	–0.0407
PIGPOULTRY	0.0467	0.0351	–0.0240	–0.0103	0.0138	0.0026	–0.0407	0.0436	0.0044
MOUNTZONE	–0.0334	–0.0234	0.0070	0.0051	0.0334	–0.0203	–0.0074	–0.0627	0.0015
LESSFAZONE	0.0074	–0.0915 **	–0.0025	0.0702 *	0.0817 **	0.0855 **	0.0498	0.0512	–0.0293

TABLE 5 (cont.)

Panel B: dummy variables

	YEAR91	*YEAR92*	*YEAR93*	*EXTENSIVE*	*PERMANENT*	*DAIRYDRYSTOCK*	*PIGPOULTRY*	*MOUNTZONE*	*LESSFAZONE*
YEAR91	1								
YEAR92	–0.2500 ***	1							
YEAR93	–0.2500 ***	–0.2500 ***	1						
EXTENSIVE	–0.0064	–0.0223	–0.0064	1					
PERMANENT	0.0047	–0.0012	–0.0130	–0.4228 ***	1				
DAIRYDRYSTOCK	–0.0062	–0.0062	0.0093	–0.0875 **	–0.1891 ***	1			
PIGPOULTRY	–0.0122	0.0052	0.0226	–0.1722 ***	–0.3725 ***	–0.0771 **	1		
MOUNTZONE	0.0000	0.0000	0.0000	0.1271 ***	–0.1013 ***	0.1020 **	–0.0044	1	
LESSFAZONE	0.0000	–0.0000	–0.0000	–0.2441 ***	0.2962 ***	–0.1489 ***	–0.0838 **	–0.1814 ***	1

*Significant at a 10% level. **Significant at a 5% level. ***Significant at a 1% level.

the countries of the EU (Community Committee for the FADN, 1998). Such a method was established in 1985 by Commission Decision EEC/85/377.

Size (ESU) indicates potential regardless of the volume of output yielded by a farm. This potential can be used intensively or inefficiently, thus giving different levels of output. Climatic and market conditions may also influence volume (output) for a given size.

Table 4 displays Pearson correlations between independent variables in equation (3). All correlations between continuous independent variables are under 0.5, suggesting that collinearity does not affect results. The highest coefficient (–0.6181) is between a continuous (ln(O)) and a dummy variable (*PERMANENT*).

Pearson correlations between independent variables in equation 5 are displayed in Table 5. The high coefficient (–0.8365) between transformed logarithmic continuous independent variables indicating variations in number of products and hectares per product indicates that both variables contain similar information. We thus removed one of these variables from the estimations: $\ln[(UAA/N)_t/(UAA/N)_{t-1})]$. All other coefficients are under 0.5. Once removed this mentioned variable, collinearity unlikely affect estimations.

4. Results

We estimated linear regressions for every dependent variable for equation [3] The highest value of variance inflation factors is 3.72, indicating that collinearity is unlikely to affect our inferences. Variance inflation factors, condition indexes and variance proportions of variables suggest that multicollinearity does not likely affect estimations. As the Durbin-Watson statistic determines the typical autocorrelation pattern for independent variables throughout the studied period, we have performed panel regression estimations correcting autocorrelation disturbances. Thus, the estimation method assumes disturbances to be heteroscedastic and contemporaneously correlated across panels.

Plots between logarithmic transformed dependent and independent variables showed a better linear relationship than between untransformed ones. The former fitted normality tests better than the latter. Linear regressions with untransformed variables did not fulfil other linear regression requirements about independence and distribution of residuals, homogeneity of variances, etc., thus confirming that the Cobb Douglas function is more appropriate than the linear with untransformed variables for this study and data sample.

Panel regression estimations for equation [3] are displayed in Table 6. We analyzed total indirect costs and its different component because of its likely different nature. We performed regressions for total indirect costs (column (A)), as well as for their both components: opportunity costs of family farm work (column (B)) and registered indirect costs (column (C)). Columns (D) to (G) display results for different components of registered indirect costs. All models present a significant goodness-of-fit, explaining more than 70% of the total variability of total indirect, registered indirect and overhead costs, but with a minimum of 25.5% for opportunity costs of family work.

TABLE 6

ESTIMATIONS WITH PANEL-CORRECTED STANDARD ERROR RELATING INDIRECT COSTS TO VOLUME AND PRODUCT DIVERSITY BY QUINTILES OF SIZE

(t-statistics in parentheses)

Variables	Coefficient (pred. sign)	(A) ln(*TOTINDIRECT*)	(B) ln(*FW*)	(C) ln(*INDIRECT*)	(D) ln(*OVERHEAD*)	(E) ln(*DEPRECIATION*)	(F) ln(*EXTERNALFAC*)	(G) ln(*WAGES*)
Constant	?	10.85108 ***	13.2064 ***	5.921055 ***	2.681039 ***	8.116904 ***	–17.34228 ***	–.9692695
		(28.41)	(23.10)	(7.82)	(4.05)	(7.08)	(–3.80)	(–0.59)
Product diversification by quintiles of size::								
1st Quintile·ln(*N*)	+	.0507731	.146011	–.069277	.0218643	–.111417	.4103299	–.2361779
		(0.79)	(1.51)	(–0.55)	(0.19)	(–0.57)	(0.55)	(–0.85)
2nd Quintile·ln(*N*)	+	.1476228 ***	.288322 ***	.1212521	.1853882 *	–.0022632	.8906221	–.409534
		(2.65)	(3.48)	(1.11)	(1.91)	(–0.01)	(1.41)	(–1.63)
3rd Quintile·ln(*N*)	+	.1284782 **	.1866844 **	.1846444 *	.1792016 **	.0762816	1.451628 **	–.0499703
		(2.48)	(2.42)	(1.82)	(2.00)	(0.50)	(2.49)	(–0.21)
4th Quintile·ln(*N*)	+	.1881373 ***	.2182518 ***	.3112582 ***	.2329707 ***	.1915065	2.249514 ***	.1184574
		(3.78)	(2.93)	(3.17)	(2.72)	(1.31)	(4.05)	(0.53)
5th Quintile·ln(*N*)	+	.3199107 ***	.2192909 ***	.5202379 ***	.3467682 ***	.316202 **	2.55621 ***	.1686169
		(6.14)	(2.82)	(5.07)	(3.88)	(2.07)	(4.50)	(0.81)
Control variables:								
ln(O)	+	.2614147 ***	.0723988 **	.5140114 ***	.6356698 ***	.3447956 ***	1.703551 ***	.8603183 ***
		(10.86)	(2.01)	(10.77)	(15.25)	(4.78)	(6.00)	(8.28)
ln(*UAA/N*)	+	.1020325 ***	.0095078	.186917 ***	.2627404 ***	.0901418	.4291228	.0293819
		(3.85)	(0.24)	(3.57)	(5.78)	(1.13)	(1.51)	(0.26)
ln(*FW*)	–			–.1884638 **			–.7989569 *	–.506914 ***
				(–2.31)			(–1.77)	(–3.63)
YEAR90	?	–.0107422	–.0047342	–.0386128	.033215	–.106076 ***	–1.38333 ***	–.0393682
		(–0.55)	(–0.21)	(–1.24)	(0.83)	(–3.49)	(–7.47)	(–0.43)
YEAR91	?	.0012412	.0016083	–.0616097 *	.1301268 ***	–.2455328 ***	–2.137423 ***	.2220321 **
		(0.06)	(0.07)	(–1.66)	(2.83)	(–4.93)	(–7.51)	(2.25)
YEAR92	?	.0118516	.0016424	–.0385387 *	.1050068 **	–.3382473 ***	–2.258847 ***	.4304131 ***
		(0.54)	(0.05)	(–0.92)	(2.08)	(–5.14)	(–7.13)	(4.22)
YEAR93	?	.0423315 *	.0387573	–.0332884	2068715 ***	–.4210918 ***	–2.316251 ***	.4992587 ***
		(1.83)	(1.21)	(–0.76)	(4.16)	(–5.87)	(–6.75)	(4.49)
EXTENSIVE	–	–.0684129	–.1618319 *	–.017483	.1448714	–.2466193	.9858139	.4536832 *
		(–1.09)	(–1.73)	(–0.14)	(1.34)	(–1.32)	(1.43)	(1.67)
PERMANENT	–	.0962197 *	–.0547337	.1766186	–.0257625	.0168677	2.419328 ***	.8890416 ***
		(1.67)	(–0.64)	(1.56)	(–0.26)	(0.10)	(3.76)	(3.77)
DAIRYDRYSTOCK	+	.2815286 ***	.5748148 ***	.1117476	.1566238	.0237569	.26167	–.1074391
		(2.81)	(3.82)	(0.55)	(0.91)	(0.08)	(0.24)	(–0.24)
PIGPOULTRY	+	.107737	–.0483023	.263381 **	.2249463 **	.4615469 **	.4306126	–.1298553
		(1.64)	(–0.49)	(2.05)	(1.97)	(2.35)	(0.59)	(–0.42)
MOUNTZONE	–	–.3711643 ***	–.3583302 **	–.3629664 *	–.3646401 **	–.2862509	2.135077 **	–.5554189
		(–3.98)	(–2.55)	(–1.95)	(–2.30)	(–1.03)	(2.19)	(–1.60)
LESSFAZONE	–	–.1638561 ***	.0571472	–.5080886 ***	–.2439844 ***	–.582066 ***	–1.653607 ***	–.0754488
		(–3.74)	(0.86)	(–5.86)	(–3.26)	(–4.42)	(–3.49)	(–0.43)
R–square:		0.7228 ***	0.2552 ***	0.7283 ***	0.7681 ***	0.4560 ***	0.2882 ***	0.5567 ***

*Significant at a 10% level. ** Significant at a 5% level. *** Significant at a 1% level.

As expected, output significantly influences any kind of indirect costs with $p < 0.01$. Almost all other coefficients of control variables present the expected sign. Location in mountain and less-favoured zones significantly influence most indirect costs with $p < 0.01$, 0.05 or 0.1. The significant positive sign for permanent farms for total indirect costs (with $p < 0.1$) and for external and wage costs (with $p < 0.01$) suggest the importance of work intensive fruit farming in our sample.

With few exceptions, coefficients of the interactive terms of size and number of products increase in value and significance level as the size goes up, due to the influence of opportunity costs of family work (column (B)). For this cost, the coefficient corresponding to the second quintile of size departs from this trend. It must be considered that this is not a registered but calculated cost in the accounting of farms, and that it depends on specific circumstances such as part time farming. It includes two components, direct or operational labour and the management function. Wages paid by farms (column (G)) depend greatly on available family work. They depart from the general trend, which suggest the predominance of direct and temporary work in this kind of cost. Results suggest that its behaviour is mainly variable with respect to output, and that all farms hire temporary work at similar price. The influence of product diversity on total indirect costs depends on farm size (column (A)). Coefficients for product diversity variables in the smallest quintile of size in this column do not significantly influence total indirect costs with $p < 0.1$, while the corresponding coefficients for the other sizes significantly influence them. For the sum of registered indirect costs (column (C)) coefficients for the two smallest farm size are not significantly different from zero with $p < 0.1$, while significance levels and value of the coefficient in the third quintile are lower than in the fourth, and these lower than in the fifth. Therefore, the smallest farms are able to manage increasing number of products with no additional registered indirect cost, while the significantly higher slope for biggest farms indicates that as size increases the cost to manage product diversity is greater. The pattern is persistent also for most components of registered indirect costs. Overhead costs (column (D)) and external factors (column (F)) present a very similar pattern. Estimations for depreciation (column (E)) yield also the general pattern of no significant coefficient for the smallest farm size with $p < 0.1$ and significant positive sign for the biggest farms with $p < 0.05$. Therefore, results strongly suggest that biggest farms must afford higher indirect costs to deal with product diversification with respect to smallest farms. Indirect costs of the latter behave advantageously in situations of operational flexibility. Hypothesis 1 is thus confirmed for total indirect costs and most of its components.

We rerun all estimations from Table 6 removing the dummy variable for permanent crops (*PERMANENT*), because of its Pearson correlation (–0.6181) with the variable of the transformed logarithmic of output ($\ln(O)$). Results (not displayed) are very similar to those of Table 6 for all kind of indirect costs. Coefficients of the interactive terms of size and number of products are very similar, while there is no change in their relative position across sizes, as well as in their level of significance.

A common concern with level regression is omitted variables correlated with both the dependent and independent variables. Arellano and Bover (1995) proposed a robustness check consisting in running regressions with changes in variables. Accordingly, we defined continuous dependent and independent variables as the difference between the observation and the annual mean value for these variables. Table 7 displays results for total indirect and registered indirect costs with variables in mean differences for the enlarged model. Results are very similar to those of Table 6 with respect to coefficients of interaction terms of number of products and quintiles of size, showing an increase in values and levels of significance as size increases. Hypothesis 1 is thus strongly confirmed with variables in mean-differences.

We also performed cross-section robustness tests running regressions for total indirect and registered indirect costs each year. Estimations (not displayed) for each year are very similar to those of Table (6), confirming positive and increasing values as well as significance levels, of coefficients for the interactive terms of number of products and quintiles of size as size increases. Regressions for registered indirect costs yielded positive and increasing coefficients for complexity in fourth and fifth quintiles (with $p < 0.01$, $p < 0.05$ or $p < 0.1$) for all years, and in third quintile in 1992 (with $p < 0.05$) and 1990 (with $p < 0.1$). A similar pattern was found for total indirect costs. Hypothesis 1 is thus also confirmed with cross-section robustness tests.

We also specified an adapted quadratic flexible cost function (see Appendix 2). Estimations, displayed in Appendix 2 for total indirect costs, confirm previous results with respect to tactical flexibility across size. Coefficients of the interactive terms of size and number of products increase in value and significance level as the size goes up. They are significant with $p<0.01$ for the 4th and 5th quintiles of size. Negative significant (with $p < 0.05$ for the 4rt and with $p < 0.01$ for the 5th) coefficients for the quadratic interactive terms of size and number of products reveal the existence of a maximum for these quintiles of size, that also increases as size goes up (see quotient φ/θ). Coefficient for output is not significant. However, the coefficient for interactive term of output and complexity is significant with $p < 0.01$, thus revealing the fixed pattern of indirect costs. Indirect costs increase with the interaction of output with number of products.

We also run estimations for equation [5]. The highest value of variance inflation factors is 3.42, indicating that collinearity is unlikely to affect our inferences. Variance inflation factors, condition indexes and variance proportions of variables suggest that multicollinearity does not likely affect estimations. The estimation method also assumes disturbances to be heteroscedastic and contemporaneously correlated across panels.

Estimations performed for equation [5] are displayed in Table 8. Columns (A) to (C) correspond to total indirect costs, while columns (D) to (F) correspond to registered indirect costs. Columns (A) and (D) display results for the reduced models usually used in empirical research on cost stickiness. Columns (B) and (E) display results adding variation in number of products, while results for the full models with all control variables are displayed in columns (C) and (F). Changes in all indirect costs in all models are significantly influenced by changes in output with $p < 0.05$. Focusing on control variables, the significant negative signs of the coefficient associated to extensive type of farming, with $p < 0.1$ (columns C and F of Table 8) indicates a lower indirect costs increase for this type of farming, which can be explained in terms of its relatively low capital endowments compared with the default category. Extensive farms have comparatively lower technology, investments and capital intensity. Therefore,

TABLE 7
MODEL STABILITY: ESTIMATIONS WITH MEAN-DIFFERENCE VARIABLES

Variables	Coefficient (pred. sign)	(A) Changes in ln(*TOTINDIRECT*)	(B) Changes in ln(*INDIRECT*)
Constant	?	.0344143	.1038427
		(0.68)	(1.07)
Complexity by quintiles of size:			
Mean-differences 1st Quintile·ln(N)	+	.0784786	.0056769
		(1.32)	(0.05)
Mean-differences 2nd Quintile·ln(N)	+	.1751784 ***	.1852888 *
		(3.48)	(1.87)
Mean-differences 3rd Quintile·ln(N)	+	.1577106 ***	.2431023 ***
		(3.35)	(2.62)
Mean-differences 4th Quintile·ln(N)	+	.2165513 ***	.3636493 ***
		(4.80)	(4.07)
Mean-differences 5th Quintile·ln(N)	+	.3486808 ***	.5622241 ***
		(7.24)	(5.90)
Control variables:			
Mean-differences ln(O)	+	.255833 ***	.5265454 ***
		(11.18)	(11.60)
Mean-differences ln(UAA/N)	+	.1076511 ***	.2032321 ***
		(4.27)	(4.09)
Mean-differences ln(FW)	–		–.1906957 **
			(–2.37)
YEAR90	?	.0065165	.0089345
		(0.35)	(0.29)
YEAR91	?	–.0165367	–.0235473
		(–0.87)	(–0.63)
YEAR92	?	.0019709	.027897
		(0.09)	
			(0.65)
YEAR93	?	–.0004234	.0232161
		(–0.02)	(0.50)
EXTENSIVE	–	–.0751718	–.0190844
		(–1.21)	(–0.16)
PERMANENT	–	.0899369	.1900437 *
		(1.59)	(1.71)
DAIRYDRYSTOCK	+	.2825652 ***	.1024823
		(2.85)	(0.51)
PIGPOULTRY	+	.0942647	.2205044 *
		(1.49)	(1.77)
MOUNTZONE	–	–.3629132 ***	–.3433198 **
		(–3.93)	(–1.86)
LESSFAZONE	–	–.1580681 ***	–.5117958 ***
		(–3.68)	(–6.06)
R-square:		0.7226 ***	0.7242 ***

*Significant at a 10% level. ** Significant at a 5% level. *** Significant at a 1% level.

TABLE 8

ESTIMATIONS WITH PANEL-CORRECTED STANDARD ERROR FOR VARIATIONS OF TOTAL INDIRECT COSTS BY QUINTILES OF SIZE

(t-statistics in parentheses)

Variables	Total indirect costs: $\ln[C_t/C_{t-1}]$			Registered indirect costs: $\ln[C_t/C_{t-1}]$		
	(A)	(B)	(C)	(D)	(E)	(F)
Constant	–0.0018967	–0.0025885	0.0088005	–0.0316661 *	–0.0304272 *	0.034831
	(–0.21)	(–0.28)	(0.49)	(–1.94)	(–1.85)	(0.99)
Stickiness:						
β_{O1} [variable: $\ln(O_t/O_{t-1})$]	0.0797911 **	0.0791512 **	0.0868724 **	0.1169065 **	0.1180524 **	0.1438306 **
	(2.43)	(2.40)	(2.59)	(2.14)	(2.16)	(2.58)
β_{O2} (1st quintile of size)	–0.0159171	–0.0185345	–0.0320603	0.0040183	0.0087058	–0.0404601
	(–0.30)	(–0.35)	(–0.58)	(0.04)	(0.09)	(–0.43)
β_{O2} (2nd. quintile of size)	0.0163805	0.0178482	0.0087198	0.0712939	0.0686654	0.003713
	(0.28)	(0.30)	(0.14)	(0.66)	(0.64)	(0.03)
β_{O2} (3rd. quintile of size)	–0.0158836	–0.0164266	–0.0368194	0.0296597	0.0306321	–0.0104977
	(–0.21)	(–0.22)	(–0.48)	(0.23)	(0.24)	(–0.08)
β_{O2} (4th. quintile of size)	0.0041682	–0.0048341	–0.0154693	0.045768	0.0618904	0.0647282
	(0.04)	(–0.05)	(–0.15)	(0.27)	(0.34)	(0.39)
β_{O2} (5th. quintile of size)	–0.220922 **	–0.2248167 **	–0.2288996 **	–0.2808111 *	–0.273836 *	–0.2797952 *
	(–2.27)	(–2.31)	(–2.33)	(–1.87)	(–1.82)	(–1.86)
Control variables:						
$\ln(N_t/N_{t-1})$		0.0240749	0.0209402		–0.0431162	–0.0428544
		(0.80)	(0.69)		(–0.94)	(–0.91)
$\ln(FW_t/FW_{t-1})$						0.067112
						(1.13)
YEAR91			0.118163			–0.0303317
			(0.37)			(–0.74)
YEAR92			0.002016			–0.0209002
			(0.09)			(–0.57)
YEAR93			0.0202336			–0.0261435
			(0.99)			(0.492)
EXTENSIVE			–0.0343274 *			–0.0658473 *
			(–1.80)			(–1.86)
PERMANENT			–0.0122318			–0.0520916 *
			(–0.80)			(–1.82)
DAIRYDRYSTOCK			0.0460735			0.0448729
			(1.58)			(0.79)
PIGPOULTRY			0.0364642 *			0.0139676
			(1.86)			(0.38)
MOUNTZONE			–0.0054248			–0.0020598
			(–0.24)			(–0.05)
LESSFAZONE			0.0089603			–0.0490519 **
			(0.83)			(–2.34)
R-squarre	0.0291 ***	0.0303 ***	0.0440 ***	0.0288 ***	0.0302 ***	0.0480 ***

Significance levels: *p < 0.1. **p < 0.05. ***p < 0.01.

when activity grows their costs increase relatively less. The same pattern is found for permanent type of farming for registered indirect costs (column F). The significant positive sign for pig and poultry type of farming for total indirect costs (column C) indicates a higher increase in total indirect costs of this type of farming with respect to the default category, explained in terms of intensive work farming, frequently covered by family work in pig and poultry farms, as well as in terms of its higher investment and capital intensity. Registered indirect costs of farms located in less-favoured zones increase less than in normal zones (column F), because prices of some factors are lower in these zones.

Results report a significant and positive β_{O1} coefficient with $p < 0.05$ and a significant negative β_{O2} coefficient only for the biggest farms, with $p < 0.05$ for total indirect costs and with $p < 0.1$ for registered indirect costs, while the coefficient is not significant for the first, second, third and fourth quintiles of size. As this results indicate the existence of a cost stickiness pattern only for the biggest farms, hypothesis 2 is thus confirmed. Combined values of $\beta_{O1} + \beta_{O2}$ indicate that the biggest farms can not avoid increasing total indirect costs when activity decreases. For example, the estimated value of β_{O1} (0.1438, with t-statistic of 2.58) in column (F) indicates that registered indirect costs increased 0.1438% per 1% increase in output. In the same column, the combined value of $\beta_{O1} + \beta_{O2}$ (–0.1359) indicates that even when output decreases 1%, registered indirect costs increase 0.1359%. Results are similar for the reduced models and total indirect costs. Therefore, results reveal the existence of disadvantageous cost behaviour for the biggest farms in situations of tactical flexibility. When farm output decreases, biggest farms are unable to adjust resources, while the rest of farms do it immediately.

We applied more robust estimations using the Paks-Kmenta method that estimates through feasible generalized least squares based on less restrictive assumptions about the behaviour of the error term, such as autocorrelation within panels and cross-sectional correlation and heteroskedasticity across panels. Results displayed in Table 9 (compared with those in Table 8) present a clearer pattern of stickiness for biggest farms. Coefficients of β_{O1} are significant with $p < 0.01$ for total indirect costs, with $p < 0.05$ for registered indirect costs (with $p < 0.01$ for registered indirect costs with enlarged model). Coefficients of β_{O2} are significant with $p < 0.01$ for total indirect costs (columns (A) to (C)) and with $p < 0.05$ for registered indirect costs (columns (D) to (F)). These results reinforce findings from Table 8 and demonstrate its robustness across different estimation methods.

We then estimated stochastic production frontier functions with panel data and calculated the corresponding technical efficiency for each firm (see Appendix 3). Size is positively correlated with efficiency in our sample: Spearman correlation of 0.717 and Pearson correlation of 0.5792 for the time-varying decay model and 0.6818 and 0.5633 respectively for the time-invariant model, all significant with $p < 0.01$. These results suggest that the reason of the cost stickiness observed in large farms is that they are more efficient than small farms, perhaps as a consequence of an economic calculus. As Fuss and McFadden (1978) argue, there is a tradeoff between flexibility and efficiency. The improvement in efficiency is usually a loss in flexibility. The authors identify many cases, including agriculture (that provides several examples of this phenomenon), in which flexibility is achieved at the expense of a loss of efficiency, an issue that

TABLE 9

ESTIMATIONS FOR VARIATIONS OF TOTAL INDIRECT COSTS BY QUINTILES OF SIZE

(t-statistics in parentheses). Estimations with generalized least squares assuming autocorrelation within panels and cross-sectional correlation and heteroskedasticity across panels

Variables	Total indirect costs: $\ln[C_t/C_{t-1}]$			Registered indirect costs: $\ln[C_t/C_{t-1}]$		
	(A)	(B)	(C)	(D)	(E)	(F)
Constant	–0.0021919 ***	–0.0026485	–0.0003517	–0.0309363 **	–0.0303789 *	0.0474809
	(–0.27)	(–0.33)	(–0.02)	(–1.99)	(–1.94)	(1.40)
Stickiness:						
β_{O1} [variable: $\ln(O_t/O_{t-1})$]	0.1035285 ***	0.101548 ***	0.1169172 ***	0.1218516 **	0.122639 **	0.1776257 ***
	(3.79)	(3.71)	(4.23)	(2.39)	(2.40)	(3.46)
β_{O2} (1st quintile of size)	–0.0250202	–0.0255783	–0.0570958	0.0282187	0.0301497	–0.0627999
	(–0.56)	(–0.57)	(–1.25)	(0.33)	(0.35)	(–0.73)
β_{O2} (2nd. quintile of size)	0.0019093	0.0034599	–0.0195477	0.0490386	0.0486024	–0.0704987
	(0.04)	(0.07)	(–0.38)	(0.49)	(0.48)	(–0.70)
β_{O2} (3rd. quintile of size)	–0.0071147	–0.0076245	–0.0371314	0.0194717	0.0209332	–0.0505314
	(–0.11)	(–0.12)	(–0.59)	(0.16)	(0.17)	(–0.43)
β_{O2} (4th. quintile of size)	–0.0167073	–0.0218472	–0.0342379	0.0525942	0.0569195	0.0550301
	(–0.20)	(–0.26)	(–0.41)	(0.34)	(0.36)	(0.36)
β_{O2} (5th. quintile of size)	–0.2242646 ***	–0.2270948 ***	–0.2566372 ***	–0.2897304 **	–0.2852868 **	–0.2980607 **
	(–2.90)	(–2.93)	(–3.35)	(–2.08)	(–2.05)	(–2.19)
Control variables:						
$\ln(N_t/N_{t-1})$		0.0224274	0.0181429		–0.0183853	–0.0104128
		(0.90)	(0.73)		(–0.42)	(–0.24)
$\ln(FW_t/FW_{t-1})$						
YEAR91			0.013258			–0.0295029
			(0.41)			(–0.72)
YEAR92			0.0022287			–0.0198153
			(0.10)			(–0.54)
YEAR93			0.0214589			–0.0222716
			(1.06)			(–0.59)
EXTENSIVE			–0.0450476 ***			–0.0795546 **
			(–2.60)			(–2.39)
PERMANENT			–0.0291092 **			–0.0809332 ***
			(–2.07)			(–2.99)
DAIRYDRYSTOCK			–0.0168546			–0.0411903
			(–0.61)			(–0.78)
PIGPOULTRY			0.0270193			0.0165768
			(1.49)			(0.47)
MOUNTZONE			–0.0012809			0.0035511
			(–0.06)			(0.08)
LESSFAZONE			0.00637			–0.0506212 **
			(0.60)			(–2.47)
Log Likelihood	193.7571 ***	194.1443 ***	205.237 ***	–10.441.6 ***	–10.440.95 ***	–10.441.28 ***

Notes:

1. Variable $\ln(FW_t/FW_{t-1})$ removed because the estimation method requires balanced panels.
   Significance levels: *p < 0.1. **p < 0.05. ***p < 0.01.

has been of academic and practitioner interest (*e.g.* Adler *et al.*, 1999, Ebben and Johnson, 2005).

5. Conclusions

This study provides a cost accounting approach to the discussion of flexibility as a competitive advantage for small farms. It reviews economic research on flexibility reporting empirical evidence that cost behaviour helps to explain more flexible responses of small farms to market fluctuations compared with large ones. Previous research in economics has reported that small firms flexibility relies on their greater capacity to absorb demand fluctuations, manifested in greater production and profit variability. Previous empirical research reported higher operational and tactical flexibility for small firms with respect to larger. Our study supports these findings providing empirical evidence on favourable cost behaviour towards higher flexibility for small firms. Therefore, this study contributes to the understanding of the complex process surrounding flexibility, by analysing the influence of size in costs through product diversification and output adjustments. In addition, we have focused on a sector. Agriculture is characterised by the predominance of small business units with negligible market power and no ground for differentiated decision-taking. Their economic advantages stem mainly from their flexibility. Therefore, this sector is specially interesting for this study.

The study starts with the traditional distinction used in economics between operational and tactical flexibility. Further, it performs separate tests to investigate the existence of different farm cost behaviour under typical situation of both types of flexibility.

Our results on the significant positive influence of product diversity on indirect costs support previous findings in accounting research about the influence of complexity on indirect costs. Moreover, we report evidence that product diversification is a more important driver for indirect costs in large farms than in small ones. The increase in costs due to product diversification depends strongly on farm size. Most farms increase indirect costs with diversification, but the increase is higher for large than for small farms. While the smallest farms are able to produce and manage different products with no additional indirect cost, the biggest ones are comparatively poorly endowed for product diversification, with higher increase in indirect costs related to product diversification. Therefore, cost behaviour under operational flexibility depends strongly on size. Smallest farms behave advantageously in situations of operational flexibility with respect to biggest ones. The tests on cost behaviour for operational flexibility reveal that coefficients of the interactive terms of size and number of products increase in value and significance level with size. Results are robust to stability tests, across years and to most kinds of indirect costs.

This study does not find stickiness in indirect costs for the whole sample. This is the common pattern for most quintiles of size in the sample. However, farms in the biggest quintile of size present a pronounced sticky behaviour in their indirect costs. While most farms are flexible enough to avoid cost stickiness, the biggest ones face considerable rigidities in downsizing indirect costs when activity decreases. It should be considered, that farms in advanced Western countries are predominantly small family farms, a fact that makes it easier to adjust committed resources. As they invest less in fixed resources, they find easier to adapt to demand slowdowns or decreases. They adjust the supply of resources by using temporary employees, outsourcing functions and applying contracting decisions that allow employed resources varying with output. However, biggest farms are unable to immediately adjust resources at the same level as most farms do. Results thus reveal disadvantageous cost behaviour associated with typical situations of tactical flexibility. Results are robust to different estimation methods.

The ability showed by small farms to avoid cost stickiness, as well as for managing a variety of products at lower costs, constitutes a cost advantage that may balance their disadvantages in terms of economies of scale. Previous empirical research in economics reveals the existence of more operational and tactical flexibility for small with respect to big firms. Our research provides an explanation, for this persistent behaviour. Small farms are better endowed to avoid costs in typical situations of operational and tactical flexibility.

Our study reinforces previous arguments on the predominance of small firms in agriculture in Western advanced countries (Allen and Lueck, 1998) and provides additional explanations on the existence of wide farm size inequality in agriculture (Miljkovic, 2005). Most farms in agriculture are small family business lacking economies of size, but enjoying advantages in terms of flexibility. They can afford product diversification at lower costs with respect to big farms, and are able to cut expenses more easily when activity decreases. Considering that diversification is commonly used in agriculture to reduce risk, and that climate and market factors produce frequent and random output fluctuations, flexibility is a crucial competitive advantage that explains the persistent dominance of family farms in agriculture in most Western advanced countries. Small farms are able to compete successfully with large ones, behaving more cost efficiently in situations of technical and operational flexibility. Further research extending our investigation to other economic sectors, and deepening in the cost behaviour analysis of small and big firms under operational and tactical flexibility, would be particularly welcome.

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APPENDIX 1

The Farm Accountancy Data Network

FADN was created in 1965 by Regulation (EEC) 79/65 of the Council in the context of the Common Agricultural Policy (CAP), which has been one of the cornerstones of the European economic and political integration process. Today FADN collects accounting information at the level of individual farms, gathering annual data from a rotating sample of professional farms across all member states.

FADN data are collected through a questionnaire called the "Farm Return", from a variety of sources, such as bank statements, invoices, etc. The Farm Return is the core of the FADN data collection procedure and is filled out by the farms with the assistance of specialised local accounting offices.

The information obtained through the Farm Return is coded and transmitted to the European Commission. It is then summarised in reports similar to balance sheets and income statements and published by the European Commission at aggregated terms.

Table 1 displays the classification of costs employed by the FADN. Definitions used in FADN are detailed and explained in Community Committee for the FADN (1997, 1998). Thus, total inputs reflect costs linked to the agricultural activity of the holder and related to the output of the accounting year. They include intermediate consumption, depreciation and external factors.

Intermediate consumption includes specific costs and overheads. Specific costs represent crop-specific inputs –seeds and seedlings, fertilizers, crop protection products and other specific crop costs–, livestock-specific inputs –feed for grazing stock and granivores, other specific livestock costs– and specific forestry costs. These costs can be considered direct and variable because they can be easily linked to specific lines of production. They basically include raw materials and the relation with the units of farm production is obvious. Farming overheads include supply costs linked to productive activity but not linked to specific lines of production.

Code SE360 corresponds to depreciation of capital assets over the accounting year. It is determined on the basis of the replacement value.

"External factors" correspond to remuneration of work, land and capital. Wages and social security charges of wage earners, including insurance, are summarized as "wages paid"**.** Rent paid for farm land and buildings and rental charges are the second item of external factors, being the last interest and financial charges paid on loans obtained for the purchase of land, buildings, machinery and equipment, livestock, circulating capital, and interest and financial charges on debts. Interest subsidies are not included in this item.

FADN was only conceived as a complementary source of statistical information about farm income for the Common Agricultural Policy in the EU, not as a tool to be used by farmers or other stakeholders, or to fulfil accounting standards (European Commission, 1991a). However, it has started to keep the role of standard-setter in practice (Poppe and Beers, 1996: 18), and for a considerable part of those farms cooperating in the network, it has revealed itself as a useful tool for other purposes, including management decisions (Argilés and Slof, 2001).

The cost classification employed in FADN has not been conceived according to the traditional criteria of direct/indirect or fixed/variable. However, the labelled "specific costs" can be considered as direct and mainly variable, while the rest as indirect. We will refer to them as specific and indirect respectively. More precisely, we will label as "registered indirect costs" the sum of farming overheads, depreciation and external factors obtained from FADN's classification. Specific costs are considered as direct in the FADN, with respect to specific crop or livestock production, while the rest, which we have labelled as "registered indirect costs", can be assigned to products through the application of allocation criteria. Although accurate cost accounting would improve this identification of direct and indirect costs, it seems reasonably representative of both types of costs in the specific case of farms, and the more appropriate data to perform the study proposed in this article. May be a part of wages, or any other cost, could be considered direct and variable, or may be not, but it would require a more elaborate cost classification than that used by FADN, or than that usually performed by any standard small firm such as a farm.

Schmitt (1991) stated that agriculture is still predominantly organized by family farms in advanced western economies, and consequently family work is an important share of total work in farms. Different authors (Hopkins and Heady, 1982; Bublot, 1990; Malassis, 1958; Launay, Beaufrere and Debroise, 1967) discussed the need of including family work in farm costs, and suggested some methods for its valuation. FADN offers data about the work employed in the farm (expressed in annual work units), distinguishing the part corresponding to the work put in by the members of the family, but considers only costs corresponding to non-family work. In spite of the fact that the need of including family work in cost valuation is widely recognized, FADN does not usually do it. It just offers information on annual units of family work employed in the farm, and requires any country the yearly publication of the reference income for this kind of work, as equivalent to the gross annual earnings of non-agricultural workers. The valuation of the opportunity cost of family work casts essential information to complete the total amount of indirect costs incurred to perform the overall operations and management tasks in a farm. It has been recognized its usefulness (European Commission, 1991a) and used in rapports of the European Commission (*e.g.* 1991b), as well as in research studies (*e.g.* Argilés 2001).

APPENDIX 2

Estimations with Quadratic Flexible Form

While the Cobb-Douglas function is a simple and useful functional form for the purposes of our analysis, in order to confirm our results we also use an adapted quadratic flexible cost function. Costs are given by *c* and are affected by *z*, the vector of outputs:

$$c = \alpha_0 + \sum_{z=1}^{k} \varphi_r \; z_r \; + \frac{1}{2} \sum_{z=1}^{k} \theta_r \; z^2{}_r \; + \sum_{r=1}^{k} \; \sum_{s=1}^{k} \phi_{rs} z_r z_s \qquad [4]$$

Given the type of costs analysed in this study, that the relevant and available outputs for our analysis are overall amount of output (*O*) and complexity (*N*), our purpose to analyse the effect of product diversification across farm sizes, and the rest of control variables used in equation [3], we then formulate the following equation to be estimated:

$$\begin{aligned} C_{i,t} = {} & \alpha_0 + \varphi_O \cdot O_{i,t} + \sum_{q=1}^{Q} \varphi_N \cdot DS_{i,q} \cdot N_{i,t} + \frac{1}{2}\theta_O \cdot O^2_{i,t} + \frac{1}{2}\sum_{q=1}^{Q} \theta_N \cdot DS_{i,q} \cdot N^2_{i,t} + \\ & \phi \cdot O_{i,t} \cdot N_{i,t} + \sum_{j=1}^{j} \beta_{Tj} \cdot T_{i,t,j} + \sum_{m=1}^{m} \beta_{lm} \cdot L_{i,t,m} + \sum_{n=1}^{n} \beta_{Yn} \cdot Y_{i,t,n} + \varepsilon_{i,t} \end{aligned} \qquad [5]$$

Table 1 of this Appendix displays panel regression estimations correcting for autocorrelation disturbances, assuming them to be heteroscedastic and contemporaneously correlated across panels.

TABLE 1 IN APPENDIX 2
ESTIMATIONS OF QUADRATIC FLEXIBLE FUNCTION WITH PANEL-CORRECTED STANDARD ERROR RELATING TOTAL INDIRECT COSTS TO VOLUME AND PRODUCT DIVERSITY BY QUINTILES OF SIZE
(t-statistics in parentheses)

Variables	Coefficient (pred. sign)	*TOTINDIRECT*
Constant	?	1880570 *** (2.67)
Product diversification by quintiles of size:		
φ_N: 1st Quintile·*N*	+	17515.38 (0.05)
φ_N: 2nd Quintile·*N*	+	436153.6 (1.08)
φ_N: 3rd Quintile·*N*	+	477159.4 (1.61)

Variables	Coefficient (pred. sign)	*TOTINDIRECT*
φ_N: 4th Quintile·N	+	758696.6 ***
		(2.62)
φ_N: 5th Quintile·N)	+	1290423 ***
		(4.21)
Quadratic term of product diversification by quintiles of size:		
θ_N: 1st Quintile·N		–9459.759
		(–0.08)
θ_N: 2nd Quintile·N		–100816.3
		(–0.075)
θ_N: 3rd Quintile·N		–88653.07
		(–1.20)
θ_N: 4th Quintile·N		–161880.1 **
		(–2.25)
θ_N: 5th Quintile·N		–232248.1 ***
		(–2.74)
Output		
O	+	0.0001904
		(0.00)
O^2	+	1.02e-09
		(0.90)
$O \cdot N$	+	0.0233152 ***
		(3.13)
Control variables		
UAA/N	+	21444.73
		(1.37)
YEAR90	?	249624.5
		(1.40)
YEAR91	?	86772.29
		(0.76)
YEAR92	?	246176.1
		(0.54)
YEAR93	?	.0423315 *
		(1.89)
EXTENSIVE	–	–35132.75
		(–0.10)
PERMANENT	–	521100.4
		(1.55)
DAIRYDRYSTOCK	+	3342420 ***
		(5.69)
PIGPOULTRY	+	669748.2 *
		(1.80)
MOUNTZONE	–	–1364764 **
		(–2.50)
LESSFAZONE	–	–521071.3 **
		(–2.11)
R-square:		0.6424 ***

*Significant at a 10% level. **Significant at a 5% level. ***Significant at a 1% level.

APPENDIX 3

Estimation of Production Frontier Function and Firm Efficiency

According to Battese and Coelli (1992) we formulate a stochastic production frontier, where each firm *i* potentially produce in a period *t* less output (*O*) than might due to a degree of inefficiency (ξ):

$$O_{it} = f\left(z_{it}, \beta\right)\xi_{it}$$

When ξ_{it}<1 the firm is not making the most of the inputs z_{it}, given the technology embodied in the production function $f(z_{it}, \beta)$.

Output is assumed to be subject to random shocks, implyig that

$$O_{it} = f\left(z_{it}, \beta\right)\xi_{it}e^{v_{it}}$$

where v_{it} is the idiosincratic error. Taking the natural logarithm, assuming that there are *K* inputs, that the production function is linear in logarithms and defining u_{it}=–ln(ξ_{it}) yields the following function:

$$\ln\left(O_{it}\right) = \beta_0 + \sum_{k=1}^{K} \beta_k \ln\left(z_{kit}\right) + v_{it} - u_{it}$$

Technical efficiency is given then by $\xi_{it} = e^{-u_{it}}$

We estimated the time-invariant and the time-varying decay model considering work (proxied by annual work units) and capital (proxied by depreciation) as input variables. In the time-varying decay specification

$$u_{it} = e^{-\eta\left(t-Ti\right)}u_i$$

where T_i is the last time period in the *i*th panel and η is the decay parameter.