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Vertical integration and profitability of the agrifood industry in an economic crisis context

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Abstract

In a setting of economic and financial crisis, most companies experienced a reduction in their profitability. Thus, our study allows us to identify vertical integration strategies developed by companies to overcome the crisis. This paper is aimed at unveiling the determining factors of the profitability of Spanish agrifood firms, depending on whether they are backwards vertically integrated or not. In order to attain our objective, we implemented a first difference regression model. The main contributions of the article lie in the incorporation of a variable that distinguishes integrated firms from the rest and the separate analysis of the two groups of firms. The results suggest that firms that seek to differentiate themselves, either through offering a specific product or through providing higher quality with a view to maintaining their reputation, are more likely to adopt vertical integration due to the higher transaction costs of relations with suppliers. The grouping carried out in this study is shown to be highly relevant as asset structure implies different strategies for actions aimed at increasing profitability.

Additional key words: integration strategy, return on assets, transaction costs, specificity of assets.

Abbreviations used: EBIT (earnings before interest and taxes); COSTEFFY (cost efficiency); CREGRANT (trade credit granted); DUMACT (dummy of the activity); GROASS (growth of asset); GROMARSHA (growth in market share); INDEB (indebtedness); LIQUID (liquidity); LOGASS (logarithm of total assets); MARSHA (market share); OLS (ordinary least squares); R+D (research and development); ROA (return on assets); TURNOV (asset turnover); VIF (variance inflation factor); WLS (weighted least squares).

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Introduction

In the strict sense of the term, vertical integration means carrying out more than one activity within the value creation chain. The value chain includes all the stages in the process that transform raw materials into the finished product that is fit for consumption, and it thus includes activities related to supply, production and distribution.

Here, we focus on the vertical integration of manufacturing firms. If such firms are only devoted to the second link in the chain, they purchase raw materials from third parties and sell the products to distributors. On occasions, the manufacturing firm may be interested in diversifying its primary exploitation and/or distribution activities. If the manufacturing firm undertakes the activity of supplying raw materials, this results in a backwards vertical integration, whereby the firm becomes its own supplier. By the same token, if the manufacturing firm takes over the distribution of its products, this constitutes a forward vertical integration, where the firm becomes its own customer[1].

According to transaction cost theory (Williamson, 1986), the cost of organizing transactions represents the crucial factor in the choice of one organizational form or another. From this standpoint, the objective of vertical integration is the reduction of transaction costs or costs incurred by economic agents with a view to

[1] For a more in-depth description of the concept of vertical integration, see Salinas & Huerta (1999).

ensuring that agreements reached with other agents are adequately respected. Such advantages and cost saving will depend upon, among other factors, the characteristics of the sector and the type of goods being manufactured. In terms of the disadvantages, firms have to invest more and withstand higher fixed costs in order to carry out another activity, which may involve a higher level of risk and greater operational leverage. In short, vertical integration is desirable if the advantages inherent in "doing things yourself" outweigh the transaction costs or costs of operating in the market with another firm.

This study allows us to uncover some of the reasons behind the decision to integrate vertically. In this sense, the literature points to the desire to maintain or reach a certain level of distinction or differentiation in the sector as a determining factor, either with a view to increasing reputation, or to offering specific or higher quality products. Several studies identify the adoption of vertical integration to this end, arguing that, if the objective of the manufacturer is to obtain a differentiated product in terms of quality and brand reputation, then the firm must engage in greater specific investment (see, among others, Bhuyan, 2005; Fernández-Olmos *et al*., 2009). A higher level of specificity of assets triggers, as we will go on to see, higher transaction costs due to the nature of the contractual relations with suppliers, which favors the decision to integrate vertically.

This paper studies the agrifood industry. Several studies, such as those of Frank & Henderson (1992), Bhuyan (2005) and Fernández-Olmos *et al*. (2009) identified factors that explain the vertical integration decision in agrifood firms[2]. We therefore considered this research to make significant contributions to the field, as these previous studies do not examine the effect of the vertical integration decision on firm profitability.

Among the more notable studies that analyze the determinants of the profitability of this sector are those of Chaddad & Mondelli (2013) or Hirsch *et al.* (2014), which analyze the US food sector and, in the case of Spanish firms, Pindado & Alarcón (2015) produce findings on the meat industry. Out of these studies, only Chaddad & Mondelli introduced diversification of the firm's activity as an explanatory factor of profitability, using a dummy with a value of 1 if the firm has more than one business unit within the food sector. However, it did not distinguish between firms that carry out exploitation, manufacturing or distribution activities.

Thus, our study allows us to identify vertical integration strategies developed by companies to overcome the crisis. This paper is aimed at identifying the determining factors of the profitability of Spanish agrifood firms, depending on whether they are backwards vertically integrated or not.

Our results suggest that firms that seek to differentiate themselves, either through offering a specific product or through providing higher quality with a view to maintaining their reputation, are more likely to adopt vertical integration due to the higher transaction costs of relations with suppliers. The grouping carried out in this study is shown to be highly relevant as asset structure implies different strategies for actions aimed at increasing profitability.

Material and methods

Theoretical framework

Vertical integration involves carrying out more than one activity within the value "creation chain". When a firm is vertically integrated, it diversifies its activity, which affects the composition of its assets, along with the firm's return on assets. The aim of this study is to analyze the factors that determine the profitability of firms in the agrifood industry based upon whether they are vertically integrated or not.

This research examines these notions from the perspective of transaction cost theory, which states that economic activity is organized according to the costs implied in contractual relations within which business activity develops. Organizations adopt vertical integration if the costs involved in carrying out the activity themselves are less than the transaction costs, including the agency costs derived from the relationships between firm and supplier when purchasing the raw materials, or between firm and customer when distributing the finished product.

Given the varying nature of the relationship with different stakeholders (suppliers and customers), we focused on the firm's relationships with suppliers, leaving the analysis of the firm's relationship with customers and distributors for subsequent research.

In the other hand, given that the decision to integrate vertically depends upon transaction costs and these depend, to a large extent, on the link in the value creation chain of the sector in which the firm operates, we isolated the effect of this factor by focusing our research on a single sector: the agrifood industry. The agrifood industry only includes manufacturing firms from the food sector which transform raw agricultural, livestock and fishing materials. This research thus

[2] The study by Fischer & Hartmann (2010) takes a more in-depth look at the relations between the different stages of the agrifood chain.

focuses on a key, highly strategic sector for the Spanish economy. As shown in the report 2012 from the Spanish Federation of Food and Drink Industries (FIAB) (Muñoz & Sosvilla, 2013), this industry is the prime industrial sector in the Spanish economy due to the high level of foreign investment, the number of people it employs and its global turnover in the sector.

A part of transaction costs are the agency costs (Jensen & Meckling, 1976) that represent the costs of overseeing, motivating and providing incentives in order to align the interests of the different parties in an agency relationship. The greater the divergence of these interests and the asymmetrical information passed between the parties, in this case between the manufacturing firm and the supplier, the greater the supervision and motivation costs, which means that backwards vertical integration becomes increasingly attractive in eliminating conflicts of interest and the costs derived from the agency relationship. Other aspects that affect transaction costs are the specificity of the assets to be exchanged, the frequency of those exchanges and uncertainty.

With regard to asset specificity, an investment is specific if its best alternative usage implies a sizeable loss in value. We can talk about the specificity of fixed assets, of specialized employees or dedicated assets (Fernández-Olmos *et al*., 2009), that is to say, raw materials that are cultivated and produced and that, due to their characteristics and quality, are made for specific customers. According to Grant (1991), when specificity is high, in terms of productive factors or with regard to distinctive competences, integration adds value. Some empirical studies conclude that specificity is related to vertical integration (Monteverde & Teece, 1982; Hennart, 1988; Lieberman, 1991; Ohanian, 1994). Vicente (2000) also identifies vertical integration as a specific asset measure and believes that firms adopt vertical integration when the transaction involves certain specific assets whose profitability is subject to opportunistic expropriation by one of the parties.

Another important factor related to transactions is uncertainty; a fundamental factor in the agrifood sector. Uncertainty refers to the ability of the parties in a transaction to ascertain and specify any possible contingencies that might arise. This concept includes environmental uncertainty (climate, insect plagues, demand elasticity, price variation for raw materials, etc.) and behavioral uncertainty (difficulty in anticipating the behavior of the other party in the relationship and of verifying the extent to which they comply with the contractual conditions).

As transaction cost theory states, environmental uncertainty is notable if specificity is high, as it is more important to maintain the relationship between the parties. Several authors (Leiblein & Miller, 2003; Díez, 2007) point to the fact that, when environmental uncertainty rises, the likelihood of vertical integration increases if the assets are specific. Fan (2000) reaches the same conclusion when studying the effect of price uncertainty on vertical integration in petrochemical companies.

Lastly, another factor underlined by Williamson (1986) is the frequency of transactions. The greater the frequency, the more necessary it becomes to take on uncertainty and specificity risks, which would increase the likelihood of vertical integration.

As we know, transaction costs will be higher in the firm-supplier relationship in accordance with the divergence of interests and the asymmetry of information between the parties, along with environmental uncertainty, specificity and the frequency of transactions. Hennessy (1996) concludes that information asymmetry on crop quality and uncertainty are fundamental reasons for backwards vertical integration in the food sector. As agrifood products are fast-moving consumer goods, the frequency of transactions is high. In addition, this sector is characterized by a high level of environmental uncertainty (climate, insect plagues, etc.). As previously indicated, these two factors are more important if they are combined with asset specificity. We therefore considered firms that seek to differentiate themselves to be more likely to control the process of obtaining raw materials to a greater extent and thus they minimize the risk of a drop in quality in the final product. These firms undertake a greater moral risk, which will lead to greater costs in the relationship with suppliers and more reasons to vertically integrate. Some of the empirical studies that demonstrate that transaction costs are determining factors of vertical integration in the food sector include those of Frank & Henderson (1992), Bhuyan (2005) and Fernández-Olmos *et al*. (2009).

We used economic-financial data for firms in this sector for the years 2008 and 2011; 2008 was a year of financial uncertainty, but the effects of the crisis had not yet reached all industries. Sectors that are less volatile and depend to a lesser extent on economic evolution, such as the food sector, tend not to be among the first to suffer the effects of any economic crisis[3]. An analysis of the subsequent evolution of firms in the

[3] The FIAB 2008 economic report (Muñoz & Sosvilla, 2009) shows the effect of the crisis that year to be minimal due to the comparatively low market risk of the sector. Production in the Spanish food industry underwent an increase of 1.3%., net sales went up and employment in the sector rose by 2.99%.

sector between 2008 and 2011 reveals the true effect of the economic-financial crisis, as well as the factors that have helped firms to overcome these adverse conditions. We could also verify whether backwards vertically integrated firms have managed to withstand the effects of the crisis better than others.

Sample and variables

The sample is made up of firms from the Spanish agrifood industry. We obtained the data from the *Bureau van Dijk* SABI database (http://www.bvdinfo.com/es-es/our-products/company-information/national-products/sabi), which provides information on firm activity using four-digit CNAE-2009 codes from the Spanish National Institute of Statistics (INE).

The main activity of these firms consists of manufacturing agrifood products whose 4-digit code of activity begins with 10, 11 or 12 (food, drink and tobacco production, respectively). From these classifications, on the one hand, we selected only manufacturing firms that do not carry out secondary activities, in other words, those that are not vertically integrated, and on the other, those that were backwards vertically integrated throughout the chosen period; *i.e*. those that carry out secondary activities in the primary sector alongside their main activity and whose CNAE code begins with 01 or 03 (agriculture, livestock, game, fishing and aquiculture) or with 023 (harvesting of forest products, not including timber[4]).

We used economic-financial firm-level data for the years 2008 and 2011 for the following reasons: 2008 is a year in which the effects of the crisis had still not shown up in the agrifood industry; and 2011 was a year in which there was notable recession within the period of the crisis, producing devastating economic data for the Spanish economy (Bank of Spain, 2011[5]). We can therefore draw conclusions about the action strategies adopted by food production firms during the crisis according to whether they are backwards vertically integrated or not.

Table 1 shows the number of firms in the sample, classified into three groups: "Complete sample", made up of all the agrifood manufacturing firms considered in the study; "Non-integrated" which shows firms that are not vertically integrated and only carry out transformation activities; and "Integrated", a group made up of agrifood manufacturing firms with backwards vertical integration, that is to say, they carry out transformation activities in the primary sector[6]. This way of grouping the firms allows us to analyze the relationship between economic profitability and vertical integration to greater depth. As we can see in Table 1, there is a only small percentage of vertically integrated firms, but we believe that this is not sufficient cause to consider the results non-relevant, as we are taking into account the entire sample size for the group.

From the chosen sample, we firstly eliminated the firms whose data were unavailable for some of the figures. We secondly excluded any firms whose figures indicated extreme accounting data (net sales figures or total asset value) which could skew the results. We eliminated the observations that exceeded 95% or fell below 5% of the sample distribution. This dual filtering process implied the loss of 9.26% of the original sample, ending up with a final total of 5,402 firms.

Analysis of profitability

The decision to integrate vertically implies carrying out new activities, which involves investment in assets with the hope that the costs of this investment will be lower than the profit it generates. For this reason, the variable we want to explain is return on assets, which relates the benefits of exploitation with total assets, depending upon whether the firm is vertically integrated or not. Chaddad & Mondelli (2013) also introduced vertical integration to explain the economic profitability of firms in the food sector, although they did not distinguish between firms that are backwards integrated, forwards integrated or both.

Table 1 shows the descriptive statistics of return on assets (ROA) for all the groups considered in this study. It should be noted that, on average, all the groups obtained a positive balance for the year 2008, though this was lower for vertically integrated firms. Once the crisis had begun to show its full effects (in 2011), average profitability underwent a sizeable reduction, and was most notable in the group of non-integrated firms.

[4] The remaining activities with codes pertain to forest and timber-related activities).

[5] The worsening of the sovereign debt crisis impeded the slight recovery of the Spanish economy, immersing it in a period of recession; internal demand dropped sharply (1.7%), countering the measures taken since 2008; supply in all sectors has become weaker while the employment shortage has intensified since the summer, taking the economic crisis to new depths; the high level of debt does not allow for reforms that might allow for the imbalances that hinder economic recovery to be corrected.

[6] They are diversified and carry out both an activity that begins with the CNAE-2009 code 10, 11 or 12 and those that start with 01, 03 or 023.

Table 1. Sample and descriptive statistics of profitability. Panel A presents the size of the sample (N) and the descriptive statistics for the years 2008 and 2011 for the profitability variable (ROA): the average, the standard deviation (SD) and the *Jarque-Bera* (J-B) test for contrasting normality. Panel B provides the results of the averages contrasts that are equal to zero.

		Panel A. Descriptive statistics						Panel B. Average contrasts equal to zero	
	N	ROA (2008)			ROA (2011)			ROA (2008)	ROA (2011)
		Average	SD	J-B	Average	SD	J-B		
Complete sample	5402	0.03289	0.10897	568665.80**	0.00025	0.15970	3540631.00**	22.78415**	34.87523**
Non-integrated	5195	0.03338	0.10996	549189.10**	–0.0000014	0.16179	3312333.00**	29.09241**	29.55377**
Integrated	207	0.02067	0.07969	381.51**	0.00644	0.09296	498.67**	37.95703**	41.60736**

Level of significance of the contrasts: 5% (*) and 1% (**).

While average return on assets of the "integrated" firms continued to be positive, those of "non-integrated" firms went from having higher average profitability in 2008 to negative average profitability. Both the number of firms from each subsample and the standard deviation differ greatly, and thus definitive conclusions cannot yet be drawn.

These initial results lead us to reflect on and analyze the possible effects of vertical integration more deeply, and also to examine the characteristics that affect the profitability of these firms, along with the reasons that lead them to integrate. We questioned whether integrated firms are more secure and less volatile due to the fact that they incorporate the supply of agrifood raw materials into their activity, and thus better withstand the conditions of the economic-financial crisis that is the framework for this research. For the period studied here, vertically integrated firms showed statistically significant stable averages of profitability throughout the crisis, while firms that are not vertically integrated went from a positive average profitability to a negative one.

Analysis of the explanatory variables

This section presents the variables that we believe explain the return on assets of firms in the agrifood sector. Table 2 shows the variables considered here and the economic-financial dimensions used to construct them. As in other studies that analyze economic profitability in the agrifood sector[7], we used variables of productivity, size, liquidity and debt, along with indicators of specificity. The novel aspect we introduced in this type of study is a dummy variable that distinguishes between backwards vertically integrated and non-integrated firms.

We went on to show the descriptive statistics of all of these explanatory variables (see Table 3), in 2008 (Panel A) and in 2011 (Panel B). We are unable to draw definitive conclusions from these data. However, we can highlight specific data that explain the expected relation between the explanatory variables and profitability, as indicated in Table 2.

We firstly analyzed the variables cost efficiency (COSTEFFY) and asset turnover (TURNOV). The former indicates the proportion represented by operating costs over income so that the greater the value of this variable, the less efficient the firm is in term of costs and thus a negative relation can be expected between the variable COSTEFFY and profitability. The results in Table 3 show that, on average, integrated firms are less efficient.

TURNOV indicates the relation between the net sales and the total assets. The profitability of assets is the outcome of the product of two factors: turnover and margin[8]; in such a way that the firm can increase profitability by taking action on either or both of these factors. Turnover is an indicator of the period of manufacturing, as longer periods imply lower turnover. Selling & Stickney (1989) studied 22 sectors in the US and concluded that fast-moving consumer goods sectors tend to have high turnover and low margins. As a result, this variable indicates that firms in this sector that have a low turnover follow product differentiation strategies, resulting in higher quality and a longer manufacturing period. When analyzing the profitability of the agrifood sector, Pindado & Alarcón (2015) observe that firms

[7] See, among others, Chaddad & Mondelli (2013), Hirsch *et al*. (2014) and Pindado & Alarcón (2015). Other studies that examine vertical integration in the sector also used these variables.

[8] EBIT/Asset (ROA) = EBIT/Sales (Margin) × Sales/Asset (Turnover).

Table 2. Description of the explanatory variables.

Variables	Description	Relation[a]
	Productivity variables	
COSTEFFY	*Cost efficiency*: Operating costs / Net sales	(−)
TURNOV	*Asset turnover*: Net sales / Total assets	(+)
	Variables of size	
LOGASS	*Logarithm of total assets*.	(+/−)
MARSHA	*Market share*: Net sales for the firm *j*/∑Net sales for the set of firms.	(+)
GROASS	*Growth of assets:* (Total yearly assets *j*–j_{-1})/Total yearly assets j_{-1}.	(+)
GROMARSHA	*Growth in market share*: (Total yearly market share *j*–Total yearly market share j_{-1})/ Total yearly market share j_{-1}.	(+)
	Variables of liquidity and leverage	
LIQUID	*Liquidity*: Current assets/Liquid liabilities	(+)
INDEB	*Indebtedness*: (Liquid liabilities+Fixed liabilities)/Total liabilities and own equity.	(−)
	Other variables	
DUMACT	*Dummy variable of the activity*: has a value of 1 when the firm is backwards vertically integrated and a value of 0 if it is not vertically integrated.	(+)
CREGRANT	*Trade credit granted*: Receivable accounts with customers / Net sales.	(+)

[a] Expected relation between profitability and the explanatory variable being studied. The expected relation between LOGASS and profitability could be either positive or negative.

that adopt product differentiation strategies have lower asset turnover.

Table 3 shows that, on average, the asset turnover of integrated firms is lower. This suggests that these firms adopt product differentiation, which would confirm the suggestion that quality products result in higher transaction costs with suppliers and a higher chance of vertical integration. In the period of time from 2008 to 2011, average efficiency and the level of asset turnover is lower for all groups, which can be expected due to the influence of the crisis throughout this period.

We went on to analyze the size of the firms using the following variables: the logarithm of the total asset (LOGASS), the market share (MARSHA) and the quotient between the net sales of each firm and the net sales for the whole sector, as well as the variables of growth for the year, both in asset size (GROASS) and in market share (GROMARSHA).

We expect the relationship between all these variables and profitability to be positive, except for LOGASS. Asset size does not necessarily imply greater profitability if it does not involve efficiency and productivity, which will depend on, among other things, the characteristics and structure of the sector in which firms operate. As Table 3 indicates, vertically integrated firms have, on average, greater assets (LOGASS) and market share (MARSHA) is somewhat lower, which ties in which the fact that average turnover is also lower, as firms have to make larger investments in fixed assets.

Some studies argue that smaller firms adapt to changes to product demand more easily and at lower cost while being able to reach higher levels of quality by vertically integrating (Fernández, 2000). In addition, larger firms make more purchases and have greater negotiation power over their suppliers, which means they have less need to undertake the exploitation of raw materials to obtain supplies[9]. However, certain studies did not find a relationship between size and vertical integration, while others point to a positive relationship between the two variables (Ohanian, 1994; Fan, 2000; Leiblein & Miller, 2003).

We expect the relationship between all these variables and profitability to be positive. Asset size generated a notable number of contradictions in terms of its capacity to explain profitability, as a larger asset does not imply greater profitability if it does not involve efficiency and productivity, which depends, among other things, on the characteristics and structure of the sector

[9] Bhuyan (2005) and Fernández-Olmos *et al*. (2009) demonstrated a negative relationship between size and vertical integration explained by diseconomies of scale.

Table 3. Descriptive statistics of the explanatory variables. This table presents the descriptive statistics, averages and standard deviation (SD) and *Jarque-Bera* (J-B) test for contrasting normality, for all the variables defined in Table 2 for the years 2008 (Panel A) and 2011 (Panel B). The grouping "Non-integrated" is made up of exclusively manufacturing firms from the database; "Integrated" manufacturing firms engage in a secondary activity from the primary sector; and "Complete sample" is the sum of the previous two.

		N	Average	SD	J-B	Average	SD	J-B	Average	SD	J-B
			COSTEFFY			TURNOV			LOGASS		
Panel A. 2008	Complete sample	5402	1.01531	0.41581	93161496**	1.44315	1.19473	32972.43	2.95160	0.71316	168.0594**
	Non-integrated	5195	1.01115	0.40960	108000000**	1.45754	1.19525	33390.93	2.93924	0.71434	183.911**
	Integrated	207	1.11970	0.53984	11939.39**	1.08197	1.12557	119.3868	3.26189	0.60688	0.083267
			MARSHA			GROASS			GROMARSHA		
	Complete sample	5402	0.00013	0.00100	471000000**	0.08659	0.36306	2210951**	0.07593	1.00036	38391295**
	Non-integrated	5195	0.00013	0.00102	421000000**	0.08471	0.36393	2244537**	0.07760	1.01786	34722979**
	Integrated	207	0.00008	0.00021	7466.936**	0.13355	0.33804	1448.525**	0.03399	0.33634	216.1527**
			LIQUID			INDEB			CREGRANT		
	Complete sample	5402	2.20413	3.42923	617841**	0.6557	0.3476	92653.6**	0.23837	0.54866	337000000**
	Non-integrated	5195	2.22642	3.48100	565510**	0.6540	0.3501	91508.83**	0.22850	0.40403	61860883**
	Integrated	207	1.64477	1.57152	1438.566**	0.6987	0.2777	0.463174	0.48605	1.92681	273773.3**
	DUMACT (complete sample)	% firms with dummy = 1: 4.34%									
		N	COSTEFFY			TURNOV			LOGASS		
Panel B. 2011	Complete sample	5402	1.05933	0.55088	30129268**	1.33396	1.18101	171689.1	2.97130	0.72519	107.6825**
	Non-integrated	5195	1.05679	0.55440	29770968**	1.34846	1.18648	170016.5	2.95878	0.72713	121.6277**
	Integrated	207	1.12305	0.44997	2616.318**	0.96999	0.96777	97.90858	3.28532	0.59508	0.222963
			MARSHA			GROASS			GROMARSHA		
	Complete sample	5402	0.00012	0.00087	253000000**	0.03073	0.25307	11484182**	0.09253	1.06004	15334985**
	Non-integrated	5195	0.00013	0.00089	227000000**	0.03097	0.25597	10893565**	0.09637	1.07871	13840757**
	Integrated	207	0.00008	0.00021	15587.26**	0.02463	0.16461	173.9545**	-0.00378	0.33566	4044.294**
			LIQUID			INDEB			CREGRANT		
	Complete sample	5402	2.61749	4.51273	858123.5**	0.65471	0.44939	341739.1**	0.28284	1.15060	796000000**
	Non-integrated	5195	2.64110	4.58575	780377.8**	0.65415	0.45392	327844.8**	0.27892	1.16989	725000000**
	Integrated	207	2.02497	1.82907	191.3094**	0.66875	0.31579	35.26463**	0.38144	0.43751	1870.949**
	DUMACT (complete sample)	% firms with dummy = 1: 3.86%									

in which the firms operate. However, Chaddad & Mondelli (2013) and Hirsch *et al*. (2014) coincide in their findings on a positive effect on the agrifood sector. They attribute this conclusion to the fact that price competitiveness is extremely important in this sector, and thus exploiting economies of scale is crucial for success. Chaddad & Mondelli (2013) also explain it from the point of view of transaction costs, as larger assets are in a better position to avoid contract costs and counteract the superiority of a highly concentrated distribution sector. As shown in Table 3, vertically integrated firms have, on average, larger assets (LOGAC) and market share (MARSHA) is somewhat lower, which is linked to the fact that average turnover is also lower, as greater investment in fixed assets is necessary.

The following group of variables deals with liquidity and debt: liquidity (LIQUID) as the quotient between the current assets and the liquid liabilities, and the level of debt (INDEB) as a quotient between the total liabilities and the total financial resources We can expect a positive relationship between liquidity and profitability and a negative one between debt and profitability due to the negative leverage effect as a consequence of the crisis.

If we examine the statistical results (see Table 3), in general, the firms in our sample are extremely liquid and

show a high level of debt that has remained stable throughout the period chosen. The fact that the average debt level is similar in the three groups is unsurprising, as arguments exist that justify greater debt among firms that are vertically integrated while there are others that suggest the opposite (Balakrishnan & Fox, 1993). On the one hand, firms with more specific assets, because they have a greater tendency towards risk-taking, do not provide security to loan agents, but on the other, if specificity can be identified with a good reputation and quality, the firm can be seen in a positive light by the loan agent.

We went on to introduce trade credit granted to customers as an explanatory variable of profitability (CREGRANT). We measured it as the quotient between receivable accounts and net sales (Hernández de Cos & Hernando, 1999; Bahillo, 2000; Rodríguez, 2008; García & Martínez, 2010). By calculating the variable in this way, it measures the amount of trade credit granted to customers while also indicating the average period of payment. Agency theory argues that allowing an extension to the payment period for customers is a means of publicizing and establishing the characteristics of quality products (Smith, 1987; Freixas, 1993; Long *et al*., 1993; Rodríguez, 2008) and, by offering advantages to customers, it becomes a way of creating a good reputation.

As previously deduced theoretically, firms that manufacture specific products, that is to say, differentiated, higher quality products and those that want to maintain a good reputation are more likely to vertically integrate, and we can therefore expect them to offer greater trade credit. As shown in Table 3, the average value of this variable is notably higher in the sample of integrated firms for the two years considered.

With regard to the relationship between CREGRANT and return on assets, we can expect a positive relation, *i.e*. firms that extend a greater amount of trade credit will be more profitable, as extending more trade credit is used here as a proxy for establishing a high quality product and the desire to create a good reputation. Several studies show that offering extended payment periods to customers becomes more common in accordance with the quality and lack of public knowledge about the product (Chee *et al*., 1999; Hernández de Cos & Hernando, 1999; Bahillo, 2000; Bastos & Pindado, 2007; García & Martínez, 2010; Grau & Reig, 2014; Martínez *et al*., 2014). Chaddad & Mondelli (2013) use investment in intangible assets (R+D and advertising) as a measurement of specificity and also observe a positive relationship. We have not included this variable in the study due to lack of data.

However, if the context is a period of crisis, certain studies (Grau & Reig, 2014; Martínez *et al*., 2014) show that an increase in customer accounts may be involuntary due to the increase in indebtedness created by the economic situation. Together with trade credit, the evolution in the level of debt in the firm may indicate whether it has been able to create a good reputation or not[10]. Alternatively, if the firm, during a crisis, is more profitable but its level of debt has not been reduced, it may indicate that credit entities have no problem with lending them money due to the guarantees the firm can offer.

Lastly, we introduced a dummy variable into our study (DUMACT) with a view to examining the potential effects of backwards vertical integration. The variable has a value of 1 when the firm is in the "integrated" group in Table 1, which means it carries out a combination of activities of transformation and the exploitation of raw materials, and has a value of 0 if the firm is in the "non-integrated" group, which only carries out transformation activities. Bearing in mind the arguments laid down in the previous section, we expect a positive relationship between this variable and profitability.

Empirical analysis

This section contains the econometric analysis that will enable us to examine the relationship between the profitability of Spanish manufacturing firms from the agrifood sector and vertical integration among these firms. The proposed methodology allows us to obtain robust results, not only due to the characteristics of the regression model itself and the method of estimation and contrast, but also due to the implementation of the variance inflation factor as a means of identifying potential problems of multicollinearity.

In order to attain our objective, we chose a multivariate regression model that studies the explanatory capacity of the variables proposed in the previous section on the evolution of return on assets. By using cross-sectional data, we can verify the effects of the final crisis from 2008 to 2011 on the behavior and evolution of the profitability of Spanish manufacturing firms in the agrifood sector.

To analyze the consequences of a group of firms carrying out activities linked with the primary sector within the agrifood industry, we propose different regression models. A first model that only includes firms that are not vertically integrated and are devoted ex-

[10] For a more detailed analysis of the effects of reputation on profit, see Martínez & Olmedo (2010).

clusively to manufacturing (Model 1); a second regression where we only analyze firms that adopt backwards vertical integration or who, in other words, carry out first and second step activities in the value chain together (Model 2); and a third regression (Model 0) in which all firms are included from the two previous models and where a dummy activity variable is introduced (DUMACT). We can thus verify whether vertical integration is a determinant of profitability or not.

We aim to measure the behavior of economic profitability using two key periods as a points of reference: the beginning of the crisis (2008) and a later date when the crisis was at its height (2011). To this end, we implement a first difference regression model (please see the complete model in Fig. S1 [online supplement]), with the following structure:

$$\begin{aligned}\Delta ROA_{jt} &= \alpha + \beta_{COSTEFFY} \cdot \Delta COSTEFFY_{jt} + \\ &+ \beta_{CREGRANT} \cdot \Delta CREGRANT_{jt} + \\ &+ \beta_{TURNOV} \cdot \Delta TURNOV_{jt} + \beta_{LOGASS} \cdot \Delta LOGASS_{jt} + \\ &+ \beta_{MARSHA} \cdot \Delta MARSHA_{jt} + \beta_{GROASS} \cdot \Delta GROASS_{jt} + \\ &+ \beta_{GROMARSHA} \cdot \Delta GROMARSHA_{jt} + \beta_{LIQUID} \cdot \Delta LIQUID_{jt} + \\ &+ \beta_{INDEB} \cdot \Delta INDEB_{jt} + \beta_{DUMACT} \cdot DUMACT_{jt} + \varepsilon_{jt}\end{aligned} \quad [1]$$

$$\Delta ROA_j = ROA_{2011} - ROA_{2008} \; ; \; \Delta F_j = F_{2011} - F_{2008}$$

where "Δ" represents the change from the year 2008 to the year 2011. More precisely, shows the change in the firm's economic profitability j (j = 1, …, N), calculated as the quotient between profit before interest and taxes and total assets; δ_0 represents the intercept (constant) of the regression; the $\beta_j \forall j$ = COSTEFFY, CREGRANT, TURNOV, LOGASS, MARSHA, GROASS, GROMARSHA, LIQUID, INDEB and DUMACT[11], represent the estimated values of the regression coefficients in a cross-section for the incremental variables studied here. As with the explained variable, the explanatory variables are also expressed in incremental terms, that is to say, $\Delta F_j = F_{2011} - F_{2008}$, for F = COSTEFFY, CREGRANT, TURNOV, LOGASS, MARSHA, GROASS, GROMARSHA, LIQUID and INDEB. Finally, μ_{jt} is the independent idiosyncratic error and is equally distributed using N $(0, \sigma_j^2)$.

We selected a first difference regression model for several reasons: (i) it eliminates problems of unobserved heterogeneity; as it is defined in terms of differences, this component is completely removed (see eq. [S1.4] in Fig. S1). This term encompasses all the unobserved factors that do not change over time and (ii) it ensures that the idiosyncratic error $\forall t$, μ_{jt}, is not correlated with the explanatory variable at both moments in time, and therefore guarantees that $\Delta\mu_j$ is not correlated to ΔX_j.

The regression model proposed in the eq. [1] is estimated and contrasted using the Weighted Least Squares (WLS) method. This procedure lends greater weighting to the more exact estimations, in other words, those that have a lesser degree of variability, when determining the coefficient regressions. In addition, this method was preferred to the more classical Ordinary Least Squares (OLS), for the following reasons: (i) non-compliance with homoscedasticity; (ii) the presence of stylized facts in the financial data; and (iii) we incorporated the dummy variable DUMACT in our model, therefore, j refers to a firm and X_{jt} to a vertical integration vs. no vertical integration dummy variable, so that $\Delta X_j = \forall j$, which justifies the fact that OLS are not used here.

After the regression procedure, we calculated the estimator of the β_j coefficients for the *first differences model*, and carried out the individual contrasts (de Wald) and sets (betas equal to each other and equal to zero) of the parameters for each model, obtaining the series of errors. As a measurement of goodness of fit, we present the determination coefficient (adjusted R^2). The estimation error is calculated by the sum of the squared average (errors due to estimation bias) added to the variance of the residuals from the model.

The use of explanatory variables in the regression process could lead to multicollinearity problems, given the high degree of interrelation that could be established between them. Therefore, implementing techniques that allow us to identify and correct these problems is fundamental for obtaining statistics that allow for an objective argument. We can observe in Table 4 that many of our variables are significantly correlated and it is therefore advisable to confirm the presence/absence of multicollinearity. To this end, we applied the variance inflation factor (VIF) for the three groupings we propose and the two economic years. Neter *et al.* (1989)[12] suggest that individual values for the VIF that are greater than ten indicate problems of multicollinearity, as do average values of higher than six. The VIF values shown in Table 4 (see the end columns) indicate that this problem is not manifested in the models used either at an individual level or as an average for any of the groupings considered or the economic years addressed (2008 and 2011).

[11] The variable DUMACT only appears in Model 0, which includes both vertically integrated and non-integrated firms.

[12] Alternatively, see the manual of Hair *et al.* (1999).

Table 4. Bivariate correlations and diagnosis of multicollinearity of the explanatory variables. Data are provided of all the firms considered in the year 2008 (Panel A) and 2011 (Panel B): bivariate correlations with a level of significance and the variance inflation factor (VIF) to diagnose the presence/absence of multicollinearity for the largest group "Total sample".

		ROA	COSTEFFY	CREGRANT	TURNOV	LOGASS	MARSHA	GROASS	GROMAR-SHA	LIQUID	INDEB	VIF All	VIF Non-integ.	VIF Integ.
Panel A. 2008	ROA	1										1.15205	1.48202	1.16105
	COSTEFFY	-0.23693**	1									1.13855	1.46395	1.14886
	CREGRANT	-0.00577	0.31872**	1								1.14953	1.19665	1.1522
	TURNOV	-0.01532	-0.05284**	-0.06675**	1							1.30673	1.47029	1.30188
	LOGASS	0.18937**	-0.09939**	-0.01497	-0.45750**	1						1.06129	1.34939	1.06069
	MARSHA	0.00861	-0.00934	-0.00645	0.08467**	0.08973**	1					1.00332	1.07893	1.01573
	GROASS	0.09623**	-0.03685**	0.06315**	-0.24065**	0.28104**	0.00393	1				1.01194	1.10806	1.01222
	GROMARSHA	-0.00822	0.01421	-0.00308	-0.01179	0.00807	-0.00079	0.0924**	1			1.08877	1.16731	1.09037
	LIQUID	0.03344*	-0.04543**	0.00156	-0.03367*	0.01179	-0.00206	-0.00753	0.00838	1		1.15075	1.27474	1.15314
	INDEB	-0.39614**	0.11412**	0.01614	0.05101**	-0.08586**	0.01698	-0.01853	-0.00054	-0.15349**	1	1.10187	1.14958	1.10094
	Average VIF											1.11648	1.27409	1.11971
Panel A. 2011	ROA	1										1.16879	1.49876	1.17779
	COSTEFFY	-0.28230**	1									1.15529	1.48069	1.16565
	CREGRANT	-0.00266	0.32879**	1								1.16627	1.21339	1.16894
	TURNOV	-0.07861**	-0.10807**	-0.12808**	1							1.32347	1.48703	1.31862
	LOGASS	0.18300**	-0.02207	0.04078**	-0.33609**	1						1.07156	1.35966	1.07096
	MARSHA	0.04308**	-0.02024	-0.01261	0.05924**	0.30771**	1					1.01359	1.0892	1.02670
	GROASS	0.19864**	-0.09983**	-0.00632	-0.05488**	0.08250**	0.00340	1				1.02221	1.11833	1.02249
	GROMARSHA	0.02400	-0.01494	-0.01745	-0.01314	0.01997	-0.00748	0.01313	1			1.09904	1.17758	1.10064
	LIQUID	0.04776**	0.01975	0.03157**	-0.10945**	-0.01403	-0.02886*	-0.0307**	0.00437	1		1.16102	1.28501	1.16341
	INDEB	-0.39657**	0.12683**	0.01433	0.13776**	-0.18693**	-0.01878	-0.02562	-0.00687	-0.31440**	1	1.11214	1.15985	1.11121
	Average VIF											1.12934	1.28695	1.13257

Level of significance of the contrasts: 5% (*) and 1% (**).

Results and discussion

Table 5 shows the results of the regressions carried out to explain the profitability of firms in the agrifood industry, depending upon whether they are backwards vertically integrated or not. The results of the study are presented as follows: we begin by analyzing the results obtained via the model that includes all the firms in the sample (Model 0); we then discuss and compare the results from Models 1 and 2, which allow us to observe the effect of the decision to adopt backwards vertical integration on the determining factors of profitability.

When analyzing the first results from the regression shown in Table 5 (Panel A), we noted that, for Model 0, as we expected, the dummy variable (DUMACT) is significantly not null and is positive. Chaddad & Mondelli (2013) also concluded that diversification has a positive effect on economic profitability in this sector, although they did not distinguish between different forms of diversification.

Our result indicates that the majority of the firms whose profitability has not gone down during the period considered are backwards vertically integrated. Indeed, agrifood firms that have to acquire raw materials from third parties are more exposed to the economic situation, and have experienced a reduction in their economic profitability to a greater extent during the crisis. However, backwards vertically integrated firms have scarcely seen a change in the profitability obtained before and after the crisis; demonstrating greater stability and less dependency on the economic climate.

From the results obtained with the other variables, we can see that the firms that are least vulnerable to the economic situation, *i.e*. they have not undergone a reduction in economic profitability during the crisis period, are characterized by having increased cost

Table 5. Determinants of firm profitability. Panels A, B and C present the regression results (using Weighted Least Squares: WLS) of the *first differences model* described in the Eq. [1], where the dependent variable is return on assets of the firm (ROA). The same number of regressions was carried out as proposed models. Regression coefficients are provided and the standard deviation (SD) is given in brackets. In addition, Panel D shows the combined significance contrast (F statistic), the goodness of fit of each model (adjusted R^2), and the estimation error of each model, calculated as the sum of the squared average (error due to bias) and the variance of the residuals of the model.

	c	$\beta^{COSTEFFY}$	β^{TURNOV}	β^{LOGASS}	β^{MARSHA}	β^{GROASS}	$\beta^{GROMARSHA}$	β^{LIQUID}	β^{INDEB}	$\beta^{CREGRANT}$	β^{DUMACT}
Panel A: Regression using WLS for "Complete sample" (Model 0). N=5402											
Coefficient	-0.04282**	-0.09306**	0.19874**	0.03154**	-7.75248	0.02947**	2.02762	-0.00216	-0.10943**	0.01205**	0.01806**
SD	(0.00188)	(0.00054)	(0.00279)	(0.02828)	(8.13491)	(0.01678)	(0.00325)	(0.00611)	(0.00479)	(0.00194)	(0.01009)
Panel B: Regression using WLS for "Non-integrated" (Model 1). N=5195											
Coefficient	-0.03178**	-0.10252**	0.15178**	0.02775**	-9.57474	0.03843**	2.01984	-0.00233	-0.12701**	0.01340**	
SD	(0.00175)	(0.00063)	(0.00287)	(0.02828)	(8.06871)	(0.01678)	(0.0036)	(0.00437)	(0.00519)	(0.00212)	
Panel C: Regression using WLS for "Integrated" (Model 2). N=207											
Coefficient	-0.00141	-0.11067**	0.09927	-0.03675	46.03766*	0.00672*	-0.06734	1.86420	-0.17864**	0.02034**	
SD	(0.00094)	(0.00643)	(0.09375)	(0.01793)	(29.90762)	(0.01294)	(0.04157)	(0.47672)	(0.02645)	(0.00311)	

Panel D: Other statistics for the three sets

	Complete sample	Non-integrated	Integrated
F statistic	237.96478**	226.87511**	21.97042**
Adjusted R^2	0.36196	0.35675	0.40531
Error estimation	0.03578	0.03109	0.02142

Level of significance of the contrasts: 5% (*) and 1% (**).

efficiency (COSTEFFY)[13] and asset turnover for the period analyzed (TURNOV); by having grown in size (LOGASS and GROASS), reduced their level of debt (INDEB) and finally by having increased trade credit granted to customers (CREGRANT).

The results are consistent with the forecast and discussion made previously when presenting the explanatory variables. With regard to asset turnover (TURNOV), in line with the results obtained by Selling & Stickney (1989), we observed that, as this is a sector with fast-moving consumer goods, firms act on their asset turnover to increase profitability and given that we are undergoing a period of crisis with a general reduction in sales margins, firms that make an effort to increase the turnover of their assets and those that have increased their profitability tend to fare better. In addition, firms that have put their financial structure in order and have reduced leverage (INDEB) have suffered less of a reduction in profitability.

Firms that have been able to make investments in production and create growth (LOGASS and GROASS) by investing their own resources have also demonstrated better performance, as shown by the previous variable. Chaddad & Mondelli (2013) and Hirsch *et al*. (2014) obtained the same finding with regard to size, which we attribute to the fact that price competitiveness is so important in this sector, and thus benefiting from economies of scale is essential for success.

The result obtained with the variable CREGRANT is consistent with the school of thought that indicates that business credit can be interpreted as a sign of a good reputation (Smith, 1987; Freixas, 1993; Long *et al.,* 1993; Rodríguez, 2008). We also posited previously that if the context is one of a period of crisis, an increase in customer accounts may be involuntary due to the indebtedness created by the financial situation. Our results appear to indicate that the firms that have reduced the amount of commercial credit receivable by customers have not been able to maintain their levels of sales, and consequently, the loss of customers has been greater than the increase in indebtedness brought about by the financial crisis. Consequently, the reduction of this variable, in general terms, leads to a decrease in profitability.

[13] It should be remembered that a higher value of this variable indicates less cost efficiency, which is why it is negative in Table 5.

We went on to analyze the differences in the results obtained with firms that are not vertically integrated (Model 1, Panel B) and those that are backwards vertically integrated (Model 2, Panel C), shown in Table 5. Firstly, it should be highlighted that the estimated error of the model is less for vertically integrated firms, indicating that the results of the variables considered here are more precise and reliable in terms of the profitability of these firms (see Panel D).

The determinant variables for profitability in Model 1 are exactly the same as those obtained in Model 0 (except for the DUMACT variable, which only appears in the latter model). In other words, firms in the agrifood sector that are not vertically integrated and that have not undergone a reduction in profitability during the crisis are those that have increased in the efficiency and turnover of their assets, have undergone greater growth, are less indebted and have increased the amount of commercial credit they can grant to their customers.

However, when applying the study exclusively for firms in the sample that are backwards vertically integrated, the results are notably different. The only variables that continue to show up as determinants of profitability are COSTEFFY, CREGRANT and INDEB, while market share MARSHA becomes a significant variable. The variables TURNOV and LOGASS cease to be significant and the variable GROASS loses a degree of significance.

The reason why the asset turnover (TURNOV) and size (LOGASS) are not significant variables in this model could lie in the fact that vertically integrated firms are generally larger and more intensive in terms of fixed assets. We have already discussed the fact that backwards integrated firms have less turnover because they generally make products with a longer manufacturing period. As a result, it is more difficult for them to act on turnover to increase profitability, and it can therefore be deduced that they act on their operating margin. The reason why market share (MARSHA) becomes significant can be found in the fact that sales in non-integrated firms have, to a lesser or greater extent, become smaller, while integrated firms have been able to maintain or increase sales and their market share, and have become more profitable.

Lastly, we highlight the fact that the results we obtained justify the separation carried out in this study between the two groups of firms, whereby we are able to detect different determining factors of profitability in accordance with the activities in which the firm engages. On the one hand, the firms from the agrifood sector that have increased profitability between the years 2008 and 2011 have in common the fact that they have increased cost efficiency, reduced the level of debt by putting the financial structure in order and have increased the amount of customers, granting greater business credit. However, if firms are not vertically integrated, they have had to make more of an effort and act upon asset turnover when faced with a reduction in margins during a period of financial crisis, while vertically integrated firms have acted on the margin, as TURNOV is not significant. However, if firms do not carry out additional activities, they are less vulnerable to the effects of the crisis if they have been able to increase investments or, alternatively, if they are backwards vertically integrated firms that have attempted to increase their market share.

The main conclusions obtained from the study are as follows. Firstly, one factor that has determined whether or not the firm has maintained, or even increased its profitability during the period of crisis is the adoption of backwards vertical integration itself. We have also demonstrated the existence of a direct relationship between integration and specificity, and can thus state that firms who manufacture more specific, differentiated products have a greater chance of diminishing the effects of an adverse economic situation. Secondly, another conclusion to highlight is the relevance of the grouping of firms carried out in this study. By analyzing the whole sample together, it can be observed that the heterogeneity of the group is not taken into account and obtaining conclusive results becomes more difficult. In fact, analyzing the two groups of firms separately reveals that the same set of variables does not determine their profitability.

In order to continue this research and examine the phenomenon in greater depth, we believe it would be appropriate to complement this study with an analysis of forwards vertical integration, which includes the third link in the value creation chain: distribution.

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