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# The effect of management accounting practices and ICT on the efficiency of organic farms

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ABSTRACT

The contribution of organic farming to sustainability in its different environmental, economic, and societal facets underlines the importance of studying the viability of this type of farming and the factors that influence it. This work focuses on factors under farmers' control, particularly the use of two management tools, namely Management Accounting Practices (MAP) and Information and Communication Technologies (ICT). Using survey data from a sample of Spanish organic farms, we employ Data Envelopment Analysis (DEA) to measure efficiency and analyze its determinants. Our findings reveal that a higher intensity in the use of MAP and ICT is associated with improved farm efficiency and, therefore, contributes to their economic sustainability. The study also identifies additional factors affecting organic farm efficiency, notably diversification and direct marketing strategies.

## 1. Introduction

Organic farming is widely acknowledged as a pivotal component in establishing a sustainable food system (e.g., Jouzi et al., 2017; European Commission, 2021) and is associated with greater environmental performance than non-organic practices (van der Werf et al., 2020). Its strategic importance is reflected in European Union policy, especially the European Green Deal, which aims for 25% of agricultural land to be organic by 2030 (Wesseler, 2022). Besides environmental benefits, organic farming may enhance economic viability and social well-being through increased revenue from differentiated products and conditional subsidies (Jouzi et al., 2017), underscoring the need of studying its efficiency and productivity determinants.

Efficiency is central to a farm's *economic sustainability* (Lebacq et al., 2013), defined as the ability to be profitable and ensure prosperity to the farming community (Van Cauwenbergh et al., 2007). Technical efficiency is achieved by producing maximum output using the minimum necessary inputs. As this implies eliminating excess use of costly resources such as fertilizers, pesticides, animal feed, energy, and land, it benefits both the economy and the environment. Greater efficiency can also enhance social well-being, as higher incomes enable farmers to engage in community activities and improve their quality of life (Van Cauwenbergh et al., 2007). Thus, enhancing efficiency contributes simultaneously to economic viability, environmental protection, and social well-being.

Consequently, scholarly interest in factors affecting organic farm efficiency has expanded in recent years (Lakner and Breustedt, 2017). These factors can be categorized based on the level of control exercised over them by farmers. Particularly relevant from a policy perspective are *management variables*, which are under the direct control of farmers and

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can be influenced by policymakers. These include production and business decision-making factors (e.g., diversification[1] and direct marketing strategies[2]), training, and management capacity. Management capacity involves using management tools (Mäkinen, 2013), such as Management Accounting Practices[3] (MAP) and Information and Communication Technologies (ICT), which have received little attention in the literature despite well-documented advantages of MAP for small businesses (Lavia López and Hiebl, 2015) and the significant influence of ICT on farmers' decision-making processes (Ndemewah et al., 2019; Tingey-Holyoak and Pisaniello, 2021).

MAP, which include cost analysis, budgeting, indicator systems and benchmarking (comparing farm results with best practice), and ICT help improve decision-making, resource management, and product marketing, thereby enhancing farm efficiency. Although agricultural producers often rely on informal, non-financial management methods (Hayden et al., 2022), technological advancements are driving them towards more structured practices (Melzer et al., 2023). Therefore, exploring the impact of MAP and ICT on farmers' efforts to develop and transform business models within the agricultural sector warrants further investigation (Hayden et al., 2021).

Our aim is to evaluate how MAP and ICT improve organic farm efficiency. By providing a detailed quantitative assessment of these management tools' impact on farm efficiency, our study contributes novel empirical evidence to an area that has received limited attention in the existing literature. Unlike prior studies, which have relied on very simplified indicators, we use a multidimensional measure of MAP, including both financial and non-financial aspects, in order to get a deeper insight into their impact on farm efficiency. We focus on small business owner-managers who have started or converted to organic farming, hypothesizing that these tools may be particularly beneficial given the entrepreneurial orientation (EO) often found among organic producers. EO involves taking risks and proactively seeking new market opportunities, making farmers that possess it more likely to adopt, and benefit from, management tools.

For our empirical study, we collected data from 50 organic farmers in Asturias and Galicia (northern Spain). We measured farm performance using the frontier methodology of Data Envelopment Analysis (DEA), a popular tool in the production economics literature, to calculate productive efficiency, and we analyze the factors associated with efficiency using a truncated regression model, where the efficiency scores are regressed on a set of carefully-chosen explanatory variables (Simar and Wilson, 2007).

The paper proceeds as follows: the next section reviews the literature on the determinants of efficiency in organic farms, focusing on the role of MAP and ICT and highlighting the entrepreneurial nature of organic farmers. Section 3 describes the data and methodology and Section 4 presents the results. The findings are discussed in Section 5 and Section 6 concludes.

## 2. Literature background

Based on previous literature analyzing efficiency in organic farms[4] (Lakner and Breustedt, 2017), the determinants of efficiency can be divided into two categories according to the degree of farmer influence: 1) *management variables,* directly controlled by farmers, such as diversification, direct marketing strategies, training, and the less-explored concept of management capacity; and 2) *social and structural variables*, where farmers have limited or no influence (e.g., gender, age, family labour, and land ownership). Our research focuses on management capacity, which refers to decision-making skills, the use of management tools, and information analysis (Mäkinen, 2013), all of which influence resource allocation and farm performance. We focus specifically on the use of two management tools - MAP and ICT - which can be particularly important for organic farms in light of their characteristics, such as their entrepreneurial nature, regulatory demands, certification requirements, and the complexities of organic production and marketing.

### 2.1. Organic farmers as entrepreneurs

Organic producers have been shown to exhibit a higher EO, characterized by risk-taking, proactiveness, and innovation (Väre et al., 2021; Wiklund and Shepherd, 2005). This results from the specific risks of organic farming, including complex certification, costly inputs, and delayed returns during transition periods (Uematsu and Mishra, 2012). To succeed, organic farmers must integrate business elements, such as value creation and cost structure, and behave proactively to create value in niche markets and establish alternative sales channels, such as direct sales or online platforms (Rikkonen et al., 2013). Innovation is crucial for adapting to changing regulations and market demands, requiring new practices and diversification (Verburg et al., 2022).

Organizations with a higher EO are often more inclined to adopt management practices such as MAP, which improve decision-making and efficiency (Bisbe and Malagueño, 2015). In the context of organic farming, MAP and ICT could play a key role in managing resources efficiently and ensuring compliance with organic standards. These tools provide valuable metrics for regulatory compliance and subsidies, while also improving decision-making in different aspects such as product presentation, packaging, sales channels, distribution, pricing, and so on. Given the entrepreneurial nature of organic farmers, it is plausible that they are more likely to adopt MAP and ICT, which could improve farm financial performance. In our study, we measure financial performance through the efficiency achieved by the farms.[5]

[1] In this research, diversification includes activities such as product transformation, commercialization of this produce, and rural tourism (Barbieri and Mahoney, 2009).

[2] We use the terms "direct marketing strategies", "short-chain sales" and "short marketing channels" interchangeably to refer to direct sales at the farm itself, to grocery stores, to restaurants, and over Internet (Uematsu and Mishra, 2012).

[3] The term "management accounting practices" (MAP) is used here in line with the key work of Chenhall and Langfield-Smith (1998). In the literature on farming, terms such as "management accounting practices", "management accounting techniques", "management accounting tools", and "management and control practices" (MAC) are frequently used interchangeably to refer to similar concepts (Jack, 2009; Gottlieb et al., 2021; Jakobsen, 2024).

[4] Our research focuses on MAP and ICT, but it is worth briefly considering key findings from the literature on factors influencing efficiency. Lakner and Breustedt (2017) provide a comprehensive review, highlighting that: (i) education and experience improve technical efficiency, though ecological motivations may lower it; (ii) farm structure and specialization typically enhance efficiency, while diversification may reduce it; (iii) less rented land is associated with higher efficiency; (iv) subsidies often have a negative impact; and (v) location, especially soil conditions, plays a significant role, with regional variations observed, particularly in Germany.

[5] Financial performance refers to the farm's financial health and its ability to generate profits. Financial performance can be assessed using traditional financial indicators, such as Return on Equity (ROE), Return on Assets (ROA), Return on Sales (ROS) or Operating Profit Margin, Price/Cost Margin, and Stakeholder Return (Vanhuyse et al., 2021) or through economic sustainability indicators, which include measures like farm income, efficiency, and productivity (Lebacq et al., 2013). In our study, we chose to measure financial performance by efficiency. We understand that the most efficient farms make better use of their resources, many of which have environmental impacts (e.g., land, materials, energy, etc.). Therefore, factors that contribute to the improvement of efficiency will generally also have positive economic and environmental effects.

### 2.2. Management accounting practices in farms

MAP include financial activities, such as cost analysis and budgeting, and tools that integrate financial and non-financial aspects, such as performance indicator systems and benchmarking (Chenhall and Langfield-Smith, 1998). Research on MAP in farming is limited. Farmers often rely on non-accounting information and informal practices, spending little time on formal financial management[6] (Ndemewah et al., 2019; Hayden et al., 2022). This is likely due to limited resources, simple structures, and lack of specialized staff (Lavia López and Hiebl, 2015). Despite this, farmers incorporate financial considerations into their management practices. Farms with small budgets find budgeting and costing particularly relevant, often mixing formal (e.g., structured budgeting) and informal (e.g., rough estimates) techniques. This is evident in contexts like subsidized agriculture, such as the EU's Common Agricultural Policy (CAP), or organic certification.

MAP in farms can be defined as using tools, processes, and information - formal (e.g., budgeting) or informal (e.g., quick calculations, cash flow management in Excel) - for decision-making, governance, control, and accountability (Gottlieb et al., 2021; Hayden et al., 2022). Quantitative studies suggest that using MAP enhances farm performance. Puig-Junoy and Argilés (2004) found that the use of detailed accounting information and formal controls, such as benchmarking, improves efficiency. Business planning and benchmarking also positively impact financial performance (Vanhuyse et al., 2021). However, reliance on dummy variables in these studies precludes a more precise understanding of their full impact. Other studies use more nuanced variables related to MAP, focusing on managerial behaviour. For example, Manevska-Tasevska and Hansson (2011) found that production planning, supported by monitoring outcomes and employing bookkeeping, enhances technical efficiency. Conversely, Mäkinen (2013) found that management process effectiveness, measured by information gathering and analysis, was not significantly linked to financial success.

In addition, recent qualitative research has shed light on farmers' use of MAP. Jakobsen (2017) found that small Danish farms dealing with non-differentiated commodities focus on non-financial measures due to their limited bargaining power. Jakobsen (2024) highlighted how farmers rely on locally-developed, informal decision models rather than formal accounting systems, emphasizing the need for MAP to adapt to these informal practices to improve farm efficiency.

Overall, previous studies show that MAP use in agriculture is multifaceted, influenced by factors including farm orientation, size, decision type (Hayden et al., 2021), and engagement with business logic (Gottlieb et al., 2021). External stakeholders also significantly influence MAP use (Gottlieb et al., 2021). However, much of the literature focuses on conventional or mixed farms, often overlooking organic farming's unique aspects. This study addresses this gap by examining the impact of MAP on organic farms. Organic farmers face specific challenges, including the need to comply with regulatory standards (European Union Regulation, 2018/848)[7] and make cost-effective decisions for specialized products and short-chain sales. Hence, they must navigate legal constraints while ensuring profitability. MAP can support strategic and operational decisions while also helping to ensure compliance, manage inputs, and engage stakeholders such as certifiers, suppliers, customers, and public administrations (Gottlieb et al., 2021).

Building on this, we hypothesize that MAP significantly impact organic farm efficiency. Unlike previous studies, this research uses a construct reflecting the joint use of major MAP to provide clearer evidence of their impact based on the degree of usage.

### 2.3. ICT in farms

ICT encompass technologies such as hardware, software, networks, and media for collecting, storing, processing, transmitting, and presenting information. This includes devices such as radios, TVs, telephones, computers, Internet technologies, and databases (El Bilali and Allahyari, 2018). ICT development has given rise to smart farming, aiming to improve the efficiency, quality, and sustainability of agriculture and livestock through technologies such as sensor nodes, control systems, robotics, satellites, data storage and analysis, advisory systems, and drones (Bacco et al., 2019).

ICT enhance efficiency by reducing the use of agricultural inputs such as fertilizers, pesticides, energy, and water, thereby minimizing environmental impact and associated economic costs (Lehmann et al., 2012). Additionally, ICT improve food chain organization by reducing transaction costs and increasing both transparency and traceability, ensuring food safety and quality. They also provide farmers with better access to information, strengthen their bargaining power, and foster more equitable relationships with consumers (El Bilali and Allahyari, 2018). By connecting farmers with consumers and creating alternative food networks, ICT promote sustainable practices and empower small-scale farmers through knowledge sharing and community-building (Svenfelt and Carlsson-Kanyama, 2010).

Furthermore, technology adoption allows for the collection and processing of operational and financial data through agricultural management software (Melzer et al., 2023). This software ranges from basic tools, like Microsoft Excel, to advanced platforms such as Google Forms integrated with Excel for real-time data synchronization. ICT facilitate planning, implementation, and control, optimizing resource allocation and efficiency (Melzer et al., 2023). Among the key functionalities of ICT for farm management are procurement, inventory management, finance, quality assurance, and field operation management. These systems support regulatory compliance and enhance decision-making.

Despite its benefits, however, significant challenges remain in enhancing the effectiveness of ICT, including limited rural connectivity, implementation costs, fragmented ICT solution development, regional and cultural barriers, data management complexity, as well as the need for farmers to acquire new skills (El Bilali and Allahyari, 2018).

Overall, farmer decision-making occurs in a dynamic environment influenced by rapid technology adoption in farm management (Ndemewah et al., 2019; Hayden et al., 2021). Thus, we hypothesize that ICT will significantly impact how agricultural and commercial operations are performed.

## 3. Methodology

### 3.1. Sample and data collection

The target population of this research was organic farms in the northern Spanish regions of Asturias and Galicia. We collaborated with entities with significant influence in the organic sector in Northern Spain, namely the Regulatory Council for Organic Farming in Asturias (COPAE), the Campoastur farm cooperative, and the EDES foundation, to select a suitable sample from the total population of organic producers. This approach, similar to those used in previous farm sector studies (Manevska-Tasevska and Hansson, 2011; Hayden et al., 2021), permitted the construction of a database of sufficient quality and richness to be able to address the research objectives.

Certified organic farmers, with different sizes and types of production, were selected with the aim of reflecting the productive structure of the sector in the regions considered, where dairy and beef farms

[6] Farm financial management can be defined as the informed decision-making process that seeks to improve the efficiency and profitability of the farm. MAP are tools that facilitate financial management (Hayden et al., 2022).

[7] European Union Regulation 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No 834/2007. https://eur-lex.europa.eu/legal-content/ES/ALL/?uri=CELEX:32018R0848 (accessed August 7th, 2024).

**Table 1**
Constructs used in the analysis.

| Construct | Items (from 1 to 5) | Factor loadings | Statistics and tests |
|---|---|---|---|
| Use of MAP | Calculation and analysis of costs of products/services | 0.830 | Cronbach Alpha: 0.886 |
| | Budgets and variance analysis | 0.670 | Factorial: 1 factor |
| | Management indicators system | 0.892 | Explained variance: 63.4% |
| | Analysis of the profitability of products/services | 0.856 | Sig. Bartlett: 0.000 |
| | Comparative studies with other farms are conducted to identify opportunities for improvement and implement best practices in farm management (benchmarking) | 0.709 | KMO: 0.663 |
| Use of ICT | To consult information about the farm (databases) | 0.836 | Cronbach Alpha: 0.893 |
| | To make the farm known to current and potential customers | 0.844 | Factorial: 1 factor |
| | For the commercialization of the products | 0.937 | Explained variance: 76.2% |
| | For productive agricultural/livestock activities | 0.870 | Sig. Bartlett: 0.002 |
| | | | KMO: 0.783 |

predominate. We designed a survey that provided comprehensive data on organic farms, including input and output values, farm and farmer characteristics, and decision-making practices and procedures. Some of the questions required respondents to provide a single number or check a box, while others were formatted using Likert-type scales. Additionally, the questionnaire also included open-ended questions about the weaknesses and strengths of farms, as well as the opportunities and threats facing this sector in the regions under study. The survey was implemented by qualified technicians from COPAE and the Campoastur cooperative who were familiar with both the farmers and their farms, which helped minimize the likelihood of biased responses. The questionnaires were handed over in person to the farm owners during one of the regular visits that the technicians make to the farms, with all the necessary explanations provided. The data, collected in 2020 and 2021, referred to the year 2019.

We obtained 80 responses, though some surveys lacked economic data. Additionally, despite the technicians' efforts, some operators were either reluctant to share their economic information, especially regarding the quantification of income and expenses, or provided this information in a manner that was unclear or overly concise, potentially distorting the results. After a thorough data cleaning process, we worked with a final sample of 50 farms that contained all the necessary data to assess their efficiency and analyze its determinants.

We use DEA to estimate technical efficiency, selecting inputs and outputs based on existing studies about agri-food firms and farms (Manevska-Tasevska and Hansson, 2011; Soboh et al., 2012; Ait Sidhoum et al., 2020). For the *output* variable, we used the total sales revenue from agricultural production, which provides a convenient way of aggregating outputs for multiproduct farms and for expressing different outputs in the same unit of measurement, as well as potentially capturing unobservable differences in production quality. As *inputs*, we selected four variables that reflect the resources used in the organic farms: the number of workers; the total amount of investment in buildings and machinery; the total land used expressed in hectares; and the costs of raw materials.

The focus of our work is on the use of MAP and ICT, which were assessed using a principal component analysis (PCA) based on Likert-style questions (from 1 to 5). The other variables used, which comprise social and farm structure characteristics and a series of control variables, were obtained through the questionnaire.

The constructs or factors used to capture MAP and ICT use are presented in Table 1 and were measured through various items based on previous studies. We measure MAP using a construct that includes five practices, three of which are financially oriented (costing, budgeting and profitability analysis of products) and two that integrate financial and non-financial information (indicator systems and benchmarking) (Chenhall and Langfield-Smith, 1998). Indicator systems allow for the control of both financial (e.g., margins, costs) and non-financial performance measures (e.g., production volume, quality, animal health, sustainability metrics). These systems are holistic and can encompass financial metrics. Benchmarking in agriculture goes beyond financial metrics by incorporating collaborative groups that share operational data to improve farm practices, process benchmarking to enhance efficiencies, and set environmental standards to promote sustainability. This comprehensive approach helps farmers make strategic decisions and adopt best practices that extend beyond basic financial analysis (Jack, 2009; Jakobsen, 2017). Additionally, the measures include MAP identified in recent qualitative research based on multiple comparative case studies (Jakobsen, 2017; Gottlieb et al., 2021; Hayden et al., 2022).

Taking into account the literature review presented in the second section, and considering the entrepreneurial nature of organic farmers (Väre et al., 2021) as well as the use of ICT in both operational and commercial tasks (El Bilali and Allahyari, 2018), a construct consisting of four items is utilized. Specifically, two items refer to the use of ICT in the operational domain (to consult information about the farm and for productive/agricultural activities), while the other two reflect its use in customer relations (to make the farm known to current and potential customers and for the commercialization of the products).

For measurement purposes, the farmers were asked to value the degree of implementation/use of the different practices over the previous three years on a scale ranging from 1 ('very little implementation') to 5 ('very high implementation'). Finally, the value of the factors has been normalized to take values between 0 and 1.

Table 1 shows that the Kaiser–Meyer–Olkin (KMO) and Sphericity tests passed for the factors 'use of MAP' and 'use of ICT' (Hair et al., 2014). The KMO index is a measure of sampling adequacy that ranges from 0 to 1, with a value greater than 0.5 considered to indicate suitability for factor analysis. Bartlett's Test of Sphericity should be significant ($p < 0.05$) for factor analysis to be suitable, which occurred for both factors. Table 1 shows that, for both factors, the explained variance exceeded 60%. Factor loadings presented values greater than 0.7, except in the case of budgets and variance analysis related to MAP (0.670), and Cronbach's alpha coefficient exceeded 0.8 in the two constructs.

### 3.2. *Efficiency analysis*

We use non-parametric DEA to estimate technical efficiency, as it suits small samples better and does not impose a functional structure (Tovar and Wall, 2019). Further advantages of DEA are that it generates a set of peers for the decision-making units (i.e., farms), which allows each farm to learn from comparable best performers, and that the efficiency scores are easy to interpret (Bogetoft and Otto, 2010). In order to overcome the disadvantage of DEA that it is deterministic in that it assumes that there is no noise in the data (i.e., all deviations from the frontier are attributed to inefficiencies), the methodology proposed by Simar and Wilson (2007) will be applied. In relation to the sample size,

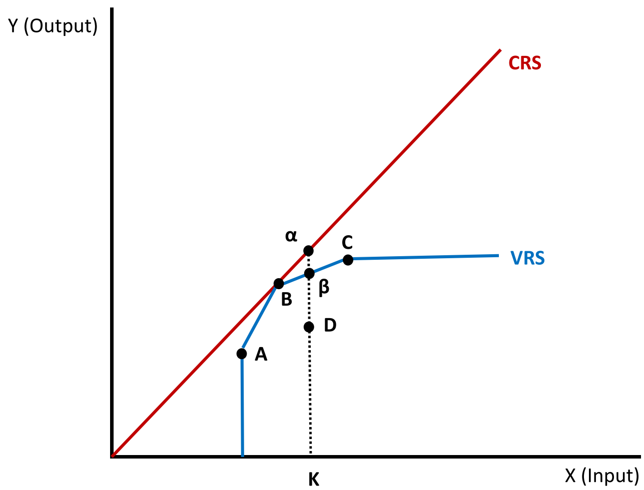


**Fig. 1.** DEA frontiers. Observations for four firms are represented by input–output combinations A, B, C and D. K represents the input of the inefficient firm D. α and β represent the efficient input-output combinations achievable by firm D under Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) assumptions.

Banker et al. (1989) indicate that it is advisable that the number of observations should be at least three times the sum of the number of inputs (number of workers, total amount of investment in buildings and machinery, number of hectares land, and the costs of raw materials) and outputs (total sales). As we have 50 observations our sample amply complies with this rule ($50 \geq 3 \times [4 + 1]$).[8]

Since we consider that farms seek to generate the maximum possible value from existing inputs, we choose an output orientation to measure efficiency. In DEA models we can assume constant returns to scale (CRS) (Charnes et al., 1978) or variable returns to scale (VRS) (Banker et al., 1984). Fig. 1 illustrates the frontiers and the efficiency calculations under CRS and VRS assumptions for the simplest case of a single output (y) being produced with a single input (x):

Points on the reference frontier (CRS or VRS) are efficient, while those below the frontier are inefficient. Thus, for the CRS frontier, firm B is efficient, whereas firms A, C and D are inefficient. For the VRS frontier, on the other hand, firms A, B and C are efficient, while firm D is inefficient. Output-oriented efficiency is calculated as the ratio of actual output to maximum output attainable so that efficiency scores range from zero to one, with a value of one representing efficiency in production and values lower than one representing the degree of inefficiency. Focusing on firm D, which is inefficient under both CRS and VRS specifications, efficiency under CRS $(Eff_{CRS})$ can be calculated as:

$$Eff_{CRS} = \frac{\overline{KD}}{\overline{K\alpha}} < 1 \tag{1}$$

Under VRS, efficiency for firm D is calculated as:

$$Eff_{VRS} = \frac{\overline{KD}}{\overline{K\beta}} < 1 \tag{2}$$

We carry out a two-step procedure with a double bootstrap proposed by Simar and Wilson (2007). In the first stage, the efficiency values

**Table 2**
Descriptive statistics of the 50 organic farms included in the study: output, inputs, and determinants of efficiency.

| Variable | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|
| **Output and inputs** | | | | |
| **Output**: | | | | |
| Sales (€) | 55,720 | 53,159 | 5,000 | 212,500 |
| **Inputs:** | | | | |
| Number of workers | 1.62 | 0.89 | 1 | 5 |
| Investment (€) | 237,807 | 467,294 | 30 | 3,000,000 |
| Land (ha) | 40.6 | 29.3 | 0.8 | 115.5 |
| Materials costs (€) | 19,835 | 17,464 | 600 | 61,000 |
| **Determinants of efficiency** | | | | |
| **Management variables:** | | | | |
| Use of MAP | 0.540 | 0.264 | 0 | 1 |
| Use of ICT | 0.445 | 0.312 | 0 | 1 |
| Diversification (dummy) | 0.26 | 0.443 | 0 | 1 |
| % Industry sales | 47.8 | 47.6 | 0 | 100 |
| Manager with certified organic training (dummy) | 0.220 | 0.418 | 0 | 1 |
| **Social and farm structure variables:** | | | | |
| Female manager (dummy) | 0.220 | 0.418 | 0 | 1 |
| Manager age (years) | 47.3 | 8.6 | 32 | 70 |
| % Hired labour | 27.0 | 41.3 | 0 | 100 |
| Assured continuity (dummy) | 0.360 | 0.485 | 0 | 1 |
| % Own land | 40.1 | 34.6 | 0 | 100 |
| **Control variables:** | | | | |
| Asturias (dummy) | 0.760 | 0.431 | 0 | 1 |
| Galicia (dummy) | 0.240 | 0.431 | 0 | 1 |
| Vegetable farms (dummy) | 0.160 | 0.370 | 0 | 1 |
| Dairy farms (dummy) | 0.340 | 0.479 | 0 | 1 |
| Beef farms (dummy) | 0.420 | 0.499 | 0 | 1 |
| Other livestock farms (dummy) | 0.080 | 0.274 | 0 | 1 |

[8] Due to the costs involved in collecting survey data such as ours, it is not unusual to have relatively small samples to deal with, but this does not preclude us from carrying out a meaningful empirical analysis. The Simar and Wilson (2007) methodology has been sucessfully implemented for farm samples of comparable size to ours (see, for example, Pérez-Urdiales et al., 2016).

**Table 3**
Standard and bias-corrected DEA efficiency scores of the farms.

| Variable | CRS | | VRS | |
|---|---|---|---|---|
| | Scores | Corrected Scores[a] | Scores | Corrected Scores[a] |
| Mean | 0.54 | 0.46 | 0.62 | 0.53 |
| Standard Deviation | 0.33 | 0.27 | 0.33 | 0.28 |
| Minimum | 0.08 | 0.07 | 0.09 | 0.07 |
| Maximum | 1.00 | 0.85 | 1.00 | 0.92 |
| Number of efficient farms | 10 | | 14 | |

[a] These are the bias-corrected scores from the first stage of the Simar and Wilson (2007) procedure.

corrected by the bias were determined under both CRS and VRS assumptions (2000 replications), while in the second stage we studied the factors that could influence the efficiency levels by employing a truncated bootstrap regression (2000 replications) (Badunenko and Tauchmann, 2019). The following equation is estimated to determine the effect of efficiency determinants on farms' efficiency scores:

$$Eff_i = \beta_0 + \sum_{j=1}^{J} \beta_j z_{ji} + e_i \tag{3}$$

where $Eff_i$ are the efficiency scores of farm $i$, $z_j$ are the variables considered as efficiency determinants, $e_i$ is the error term, and the $\beta$s are the parameters to be estimated.

## 4. Results

The econometric methodology has been carried out using the Stata 17.0 package. Table 2 shows descriptive statistics of the variables: output, inputs, management variables, social and farm structure aspects, as well as certain relevant control variables.

Regarding the representativeness of the sample, the average workforce size of 1.62 aligns with representative samples of organic farmers in Spain (Sáenz et al., 2024a). The gender balance in our sample, with 22% of farms managed by women, is similar to the profile of farms in Spain at large, which had 28.6% of farms managed by women (National Institute of Statistics, 2020). The average age of participants was 47 years old, which is consistent with the fact that 65% of farms in Spain as a whole are led by professionals over the age of 45 (2020 Agricultural Census). Within our sample, 84% of producers are involved in livestock farming and 16% in vegetable farming, which captures the diversity of organic production (Ministry of Agriculture, Fisheries and Food, 2020). However, it should be noted the livestock activity may be overrepresented compared to Spain as a whole due to its predominance in northern Spain. The sample shows an average farm size of 40 ha, which approximately coincides with the average observed for this type of farm in Galicia (39 ha in 2020) and which exceeds the average observed in Asturias (25 ha in 2020) (Ministry of Agriculture, Fisheries and Food, 2020).

There is significant dispersion in the output and input variables, reflecting size differences explained by factors such as production types, years of operation, farmers' future outlook, and land ownership.

Correlations between the variables are generally weak, with correlation coefficients lower than 0.50 in most cases (see Appendix). These levels of correlations among the variables used as determinants of efficiency suggest that we will avoid potential multicollinearity issues in our regression and will be more likely to obtain relatively precise estimates of the parameters of the variables of greatest interest, especially the management variables.

Table 3 presents the efficiency scores from the CRS and VRS DEA models, showing significant variability among the farms. The CRS model identifies 10 efficient farms, while there are 14 efficient farms when the VRS model is used. Efficient farms, located on the frontier, act as benchmarks for others. A mean efficiency score of 0.62, as in VRS, implies that, on average, farms only achieve 62% of their potential income, indicating significant scope to boost income by improving efficiency.

Table 4 shows the results of the truncated regressions, where it

**Table 4**
Determinants of efficiency of the farms (n = 50).

| Variable | CRS | | | VRS | | |
|---|---|---|---|---|---|---|
| | Coefficients | *p*-value | | Coefficients | *p*-value | |
| **Management variables**: | | | | | | |
| Use of MAP | −3.632 | 0.255 | | −7.599 | 0.050 | ** |
| Use of ICT | −49.226 | 0.048 | ** | −61.986 | 0.039 | ** |
| Use of ICT × Manager age | 0.939 | 0.059 | * | 1.294 | 0.035 | ** |
| Diversification (dummy) | −4.829 | 0.062 | * | −7.947 | 0.028 | ** |
| % Industry sales | 0.115 | 0.000 | *** | 0.148 | 0.000 | *** |
| Certified organic training (dummy) | −3.864 | 0.126 | | −4.744 | 0.119 | |
| **Social and farm structure variables:** | | | | | | |
| Female manager (dummy) | 3.701 | 0.086 | * | 4.179 | 0.118 | |
| Manager age (years) | −0.207 | 0.276 | | −0.279 | 0.196 | |
| % Hired labour | 0.065 | 0.038 | ** | 0.082 | 0.033 | ** |
| Assured continuity (dummy) | −8.537 | 0.000 | *** | −8.524 | 0.001 | *** |
| % Own land | −0.170 | 0.001 | *** | −0.247 | 0.000 | *** |
| **Control variables:** | | | | | | |
| Asturias (dummy) | −2.385 | 0.406 | | −2.493 | 0.435 | |
| Dairy farms(dummy) | −4.677 | 0.447 | | −9.119 | 0.235 | |
| Beef farms (dummy) | 21.025 | 0.000 | *** | 24.710 | 0.002 | *** |
| Other livestock farms (dummy) | 19.952 | 0.001 | *** | 25.510 | 0.003 | *** |
| Constant | 5.023 | 0.686 | | 3.994 | 0.777 | |

Note: ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels respectively.

**Table 5**
Effects of Increased Use of Management Accounting Practices and Information and Communication Technologies (VRS model).

| Δ Use of MAP | Δ Efficiency (%) | Δ Sales (€) | Δ Margin (%) |
|---|---|---|---|
| Q1 → Q2 | 3.39% | 1,887 | 5.26% |
| Q1 → Q3 | 6.74% | 3,757 | 10.47% |
| **Δ Use of ICT (age = 39 years)** | **Δ Efficiency (%)** | **Δ Sales (€)** | **Δ Margin (%)** |
| Q1 → Q2 | 2.65% | 1,447 | 4.12% |
| Q1 → Q3 | 5.61% | 3,127 | 8.71% |

should be noted that positive coefficients indicate increases in inefficiency (i.e., efficiency disimprovements), whereas negative coefficients indicate reductions in inefficiency (i.e., efficiency improvements).

The CRS and VRS models yield similar results. The main differences are that *Use of MAP* is not significant in the CRS model but is significant at the 5% level in the VRS model, while the *Female Manager* variable is significant at the 10% level in the CRS model but not significant in the VRS model. The CRS model captures scale inefficiency due to farms not operating at optimum scale, and assumes that firms can easily rescale their operations (Bogetoft and Otto, 2010). As our sample is heterogeneous in terms of size and production and it is likely not easy for the farmers to change scale,[9] the VRS model can be considered to be more appropriate. We therefore focus on the VRS results to analyze the inefficiency determinants.

Beginning with the *management variables*, both MAP and ICT are positively associated with efficiency, though ICT's impact diminishes with the manager's age. Overall, these results suggest that increased use of MAP and ICT helps organic farms approach their production frontier, enhancing efficiency and income from their resources. The results also show that diversification is associated positively with efficiency, while selling to an industry negatively impacts it, indicating that short marketing channels such as direct sales, local stores, and restaurants, enhance efficiency.

Regarding the *social and farm structure variables*, the percentage of own land and the dummy variable capturing assured continuity are positively associated with efficiency, while the percentage of hired labour had a negative effect.

Turning to the *control variables*, no efficiency differences are observed between regions. However, there are differences between types of production. Dairy farms show no significant differences in efficiency from vegetable farms (the reference category), but beef cattle farms and other livestock farms are less efficient. Each production system has unique characteristics, and beef cattle production generates less added value per worker than dairy cattle in the analyzed regions, according to the Spanish National Agrarian Accounting Network (RECAN).[10]

To quantify the effect of an increase in the use of MAP and ICT, we carry out a simulation exercise based on the results of the VRS model, taking as reference the average farm of the sample, which presents an income figure of €55,720 and supply costs of €19,836. In the simulation, the reference farm is (i) a vegetable production farm, (ii) located in the region of Asturias, (iii) run by a male, (iv) without diversification activities, (v) without an organic training certificate, and (vi) guaranteed continuity for the next 10 years. In our simulations, we calculate the effect on efficiency, sales and contribution margin (defined as the difference between sales and supply costs) of increases in the intensity of MAP and ICT use. Concretely, these increases in MAP (ICT) correspond to changing MAP (ICT) use from its first quartile (Q1) value to its second (Q2) and third quartile (Q3) values, which we can consider as slight and moderate increases respectively.

Table 5 shows that increasing the use of MAP from the first quartile to the second quartile improves efficiency by 3.39%. This corresponds to an increase in sales of €1,887 for the average (representative) farm of the sample, and a positive effect on the contribution margin of 5.26%. Going from a use of MAP corresponding to the first quartile intensity to the third quartile improves efficiency by almost 7%. Sales increase by €3,757, which translates into a positive effect on the contribution margin of just over 10%.

With regard to changing the use of ICT, the first quartile age of the farmers (39 years old) has been taken as the reference age to control for the reduction that older age produces in the positive effect of ICT. Increasing the intensity of ICT use from its first quartile to second and third quartile values increases efficiency by 2.65% and 5.61% respectively, which translates into increases in the contribution margin of 4.12% and 8.71%.

## 5. Discussion

The focus of this study is on MAP and ICT, two management tools that farmers can control, in a context recognizing the need for organic farmers to adopt a more business-oriented approach.

According to our results, a greater use of MAP is associated with a higher level of efficiency. This is in accordance with previous quantitative studies, which have shown that farm performance benefits from the use of appropriate MAP (Puig-Junoy and Argilés, 2004; Vanhuyse et al., 2021), and with recent case-based research that has suggested that MAP provide support to farmers when it comes to operational decision-making (Gottlieb et al., 2021; Hayden et al., 2022). Our methodology extends the previous quantitative literature by offering greater insight into MAP measurement as well as quantifying the effect of MAP use on economic performance.

Farmers employ diverse tools tailored to their specific needs, such as standard costing and performance indicators, which are critical for cost control and financial evaluation. Benchmarks are essential not only for producers but also for customers, companies, and regulatory bodies. Key metrics include crop type per hectare, carcass weight per animal, and milk yield per day, which influence decisions on taxes, subsidies, and organic conversion targets.

Our results show a positive link between ICT use and efficiency. To be viable, organic farmers must use ICT to enhance operations, meet organic certification requirements, and engage customers through various marketing channels. While MAP organize data and frames managerial heuristics and reasoning (Malagueño et al., 2018), ICT facilitate the information process and connection tools (Ndemewah et al., 2019; Tingey-Holyoak and Pisaniello, 2021). For instance, web applications provide updated information for indicator systems and benchmarking (Jakobsen, 2017) and organic farmers' entrepreneurial approach leads to ICT use for advertising and commercialization purposes. The results also indicate that the positive effect of ICT on efficiency diminishes with the farmer's age. Age is a key factor in the adoption of technology and the effectiveness of its use: younger farmers are more adept, while older farmers may resist due to established routines, skill gaps, perceived risks, and shorter investment horizons (Michels et al., 2020; Giua et al., 2022).

ICT tools also play a crucial role in ensuring compliance and management efficiency. For example, specialized software for animal production, such as COPAE's viewer and SIMOGAN (Livestock Movement System), monitors milk quality, manages livestock, and ensures adherence to health regulations, including veterinary prescriptions. Spreadsheet tools from SIGPAC (Geographic Information System for Agricultural Parcels) determine agricultural areas, which links them to CAP subsidies. Additionally, field notebooks for tracking fertilizers and

[9] There are many reasons why this may be so, including restrictions on land use, the availability of land, desire to maintain the farm a strictly family affair, and so on.

[10] RECAN: National Agrarian Accounting Network of Spain. https://www.mapa.gob.es/es/estadistica/temas/estadisticas-agrarias/economia/red-contable-recan/(accessed September 30th, 2024).

feed are essential for cost optimization and compliance.

Farm size significantly influences the use of MAP and ICT tools. Smaller farms often rely on external consultancy, while larger ones are more likely to use proprietary systems or standards such as Global GAP.[11] These tools optimize operations and enable engagement with stakeholders (e.g., certifiers, suppliers, customers, banks, and public administrations), ensuring that organic farms comply with regulatory requirements while optimizing their operation. Furthermore, stakeholders also shape farm operations by promoting a business ethos (Gottlieb et al., 2021).

MAP and ICT play a key role in transforming organic farm business models, integrating local resources, such as landscape, culture and tradition, to enhance product value and exploit entrepreneurial opportunities (Korsgaard et al., 2015). Collaborating entities (EDES, Campoastur, COPAE) promote cost studies and benchmarking projects among farmers. In this context, MAP stand out as a tool to share and disseminate knowledge about the economic viability of certified organic production and to legitimize the role of these entities in rural areas. Moreover, MAP and ICT provide producers with resources to highlight their contributions to society (including social and environmental contributions, animal and human health and welfare considerations, maintenance of local traditions, etc.), strengthening both their social responsibility and commercial appeal.

Although our findings indicate that MAP positively impact organic farm efficiency, it is important to address potential concerns highlighted in the literature regarding the unintended, potentially adverse, consequences of these management tools (Franco-Santos and Otley, 2018). For instance, these practices often result in selective attention, where managers focus on easily measurable aspects while neglecting other important, but less quantifiable, factors. This can drive managers to prioritize short-term goals at the expense of long-term benefits. An instructive example is provided by Jakobsen (2017), who describes how an excessive focus on production volume among Danish farmers led to a neglect of economic rationality, creating an "un-economic utopian reality". This highlights the risk of focusing solely on productivity without balancing it with sustainable economic goals.

In the context of organic farming, some literature suggests that intensive use of MAP and ICT could lead to an excessively economic approach or conventionalization of organic farms, potentially undermining organic values, including environmental considerations (Lehtimäki and Virtanen, 2020). However, this risk is likely mitigated by stringent regulatory frameworks for organic certification (European Union Regulation, 2018/848), which enforce environmental standards and practices. Future research should explore these potential issues further, ensuring that MAP implementation supports both economic and environmental sustainability, with regulatory frameworks continuing to play a critical role in maintaining organic principles.

Our findings align with prior studies that have concluded that diversification plays a significant role in sustainability (de Roest et al., 2018). The importance of diversification initiatives lies in their potential to ensure the economic viability of small farms, while also contributing to generating additional employment opportunities, and maintaining rural populations. However, some studies find a negative association between diversification and technical efficiency in organic farms (Lakner and Breustedt, 2017). In the specific context of our study, diversification involving activities such as product transformation, commercialization of this produce, and rural tourism has been found to enhance efficiency.

We found no significant differences in MAP and ICT use between diversified and non-diversified farms, possibly because these tools relate more to the EO of farmers rather than diversification itself. EO, along with MAP and ICT, appears to be essential for growing and commercializing organic production through short channels, regardless of whether farms diversify their products. Two cases illustrate this: (i) a dairy farm diversifying products (e.g., yogurt) and selling through short channels and distributors; and (ii) a vegetable producer selling directly in local markets. Both cases show high EO, using MAP and ICT for decisions on sales formats, distributor negotiations, marketing, client communication, and collaborations with other producers. The dairy farm also partnered with a renowned chef to create branded products under the chef's name.

Regarding the distribution channel of production, industry sales negatively affect efficiency, while direct marketing strategies (to end consumers, grocery shops, restaurants, and hotels) positively influence it. This highlights that local food markets offer viable opportunities for organic producers (Stickel and Deller, 2020). This strategy allows farmers to capture a larger share of consumers' budgets by avoiding intermediaries in the supply chain (Uematsu and Mishra, 2011). In particular, vegetable farms rely heavily on short marketing channels, which account for an average of 72% of their sales. We have found significant differences in ICT use in favor of these farms (at the 10% level), which suggests that the use of ICT could be a relevant tool for managing production and efficiently handling customer relationships on vegetable farms.

Another important aspect of this work is the incorporation of social and farm structure variables affecting efficiency. Specifically, the gender variable was not significant in the VRS model but was positively related to inefficiency in the CRS model (statistically significant at 10%). While previous studies have found gender-productivity relationships, the results have been contradictory, probably because the nature of the relationship depends on the type and context of the activity analyzed (Gkiza and Nastis, 2017).

We also found that a greater share of hired labour is negatively associated with efficiency. This is in line with previous studies that have found that family-operated farms perform better due to reduced agency problems, insofar as they evade issues such as moral hazard (suboptimal effort) commonly associated with hired labour (Tzouvelekas et al., 2002; Alvarez et al., 2018; Quaicoe et al., 2023).

Regarding the effect of the ratio of owned to total land used, previous studies have found contradictory results because the interpretation depends on the type of agricultural activity, the level of intensification, and the geographichal and temporal context (Pérez-Méndez et al., 2020). Our results show that land ownership is positively related to efficiency. This supports previous studies that have argued that owner-operators are likely to have greater control over land, cultivating the most fertile areas. Tenant-farmers, by contrast, often lease poorer-quality land, have less operational control, and have fewer possibilities to introduce state-of-the-art farming practices (Quaicoe et al., 2023).

We also observe a positive relationship between the perspective of continuity and efficiency. This is consistent with previous studies that have shown how farmers' attitudes and behaviour, such as having business goals and a growth-oriented mindset, are positively associated with profitability (Rikkonen et al., 2013; O'Leary et al., 2018).

## 6. Conclusions

This study contributes to the relatively limited existing literature on the factors influencing the economic efficiency of organic farms through a production frontier model, paying particular attention to the role played by the management tools MAP and ICT. MAP and ICT contribute to sustainable rural food businesses by improving data organization, information processing, and operational efficiency. Their complementary use facilitates more informed decision-making and the evaluation of complex business alternatives. Whereas previous research has utilized dummy variables to measure MAP use, we applied a comprehensive measure that includes both financial and non-financial dimensions, offering a more detailed understanding of its impact. In our study of small Spanish organic farms, we find a positive impact, with our results suggesting that increasing the use of MAP and ICT from their first to third

[11] https://www.globalgap.org/.

quartile levels could increase the contribution margin of a representative farm by approximately 10% and 9%, respectively.

In addition, we found that other management decisions within the farmer's control - such as diversification through produce transformation, commercialization and rural tourism, as well as direct sales - positively influence efficiency. Structural factors beyond the farmer's direct control, including business continuity, land ownership percentage, and the family nature of the business, also contribute positively to efficiency.

Given the significant role of MAP and ICT in enhancing efficiency, policy measures such as those outlined in the new CAP supporting the adoption of digital tools in agriculture are particularly welcome. In general, aligning CAP subsidies with effective management practices can improve cost supervision and accountability, fostering a more sustainable agriculture. This would involve employing standardized cost-accounting-based indicators, periodically updated for benchmarking purposes. Additionally, simplifying and unifying administrative processes could reduce bureaucracy, an issue highlighted in recent studies on the digitization of agriculture (Forney and Epiney, 2022). Separate CAP and regional organic certification processes can lead to errors and penalisable discrepancies, underscoring the need for a more unified system. Incentivizing rather than mandating the adoption of management tools, especially among lower-income farms, would enhance efficiency without imposing obligatory costs. Also, as older farmers may be more reluctant to adopt digital tools (Michels et al., 2020), there is a crucial role to be played by sectoral organizations, such as cooperatives, in disseminating technical knowledge and promoting environmental sustainability in organic farming (Sáenz et al., 2024b).

Overall, our study has provided empirical evidence that the use of MAP and ICT can significantly enhance economic efficiency and sustainability in organic farming, and thereby contribute to environmental and social sustainability in rural areas.

### 6.1. Limitations and future research

This study has several limitations. First, the DEA approach itself has the limitation that it is deterministic in nature, although this has been addressed to some extent here by applying a bootstrapping model. Furthermore, very few efficiency studies to date have included managerial capacity variables, which limits the comparability of our findings. The absence of qualitative interviews and the need to target farmers who could provide complete data, rather than random sampling, also represent limitations (Guest et al., 2006). Thus, the results, while insightful, should be interpreted cautiously due to these methodological and sampling shortcomings. Future research is needed to validate and extend these findings across different farm contexts.

Future studies should focus on farm-specific factors such as orientation, size, plot and pasture management, livestock input handling, and CAP payment efficiency. Additionally, data on farmers' training and education is necessary, as effective use of magement tools depends on both know-how as well as availability. The possibly high costs of these tools should also be considered, as this may discourage adoption in the absence of subsidies. Evaluating farmers' understanding of how to use these tools is essential to ensure successful implementation. Lastly, constructing extensive panel datasets would enable performance analysis over time and account for unobserved individual effects.

## CRediT authorship contribution statement

**Beatriz García-Cornejo:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Investigation, Formal analysis, Conceptualization. **José A. Pérez-Méndez:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Formal analysis, Data curation, Conceptualization. **Alan Wall:** Writing – review & editing, Writing – original draft, Validation, Resources, Project administration, Methodology, Funding acquisition, Formal analysis, Conceptualization. **David Castrillo-Cachón:** Writing – review & editing, Writing – original draft, Validation, Resources, Investigation, Data curation.

## Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Beatriz García Cornejo, José Antonio Pérez Méndez and Alan Wall declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. David Castrillo Cachón declare that he works as control technician at the COPAE-Principality of Asturias, which is the competent authority for the compulsory control and certification of European organic production (according to EU Regulation, 2018/848). It is a public entity in which he has signed commitments on confidentiality, data protection and no conflict of interest with operators.

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## Appendix

Table A1 Correlation between variables.

| | Diversification | % Own land | % Industry sales | Use of ICT | Use of MAP | Female | Manager age | Organic training |
|---|---|---|---|---|---|---|---|---|
| Diversification | 1 | | | | | | | |
| % Own land | -0.054 | 1 | | | | | | |
| % Industry sales | -0.185 | 0.407 | 1 | | | | | |
| Use of ICT | 0.162 | 0.269 | 0.261 | 1 | | | | |
| Use of MAP | -0.007 | 0.045 | 0.079 | 0.255 | 1 | | | |
| Female | 0.015 | -0.139 | -0.057 | 0.122 | -0.153 | 1 | | |
| Manager age | -0.098 | -0.165 | -0.133 | -0.213 | -0.074 | 0.052 | 1 | |

(continued on next page)

(*continued*)

| | Diversification | % Own land | % Industry sales | Use of ICT | Use of MAP | Female | Manager age | Organic training |
|---|---|---|---|---|---|---|---|---|
| Organic training | 0.015 | 0.184 | -0.022 | 0.147 | -0.163 | -0.166 | -0.083 | 1 |
| % Hired labour | 0.228 | 0.403 | -0.006 | 0.263 | 0.048 | 0.004 | -0.065 | 0.206 |
| Assured continuity | -0.160 | 0.005 | 0.182 | -0.168 | 0.050 | -0.097 | 0.038 | 0.004 |
| Asturias | 0.013 | -0.269 | -0.199 | -0.094 | 0.108 | 0.298 | 0.165 | -0.154 |
| Dairy farms | -0.137 | 0.275 | 0.519 | 0.024 | -0.012 | 0.027 | 0.006 | -0.279 |
| Beef farms | -0.227 | -0.414 | -0.309 | -0.318 | -0.040 | 0.135 | 0.165 | 0.037 |
| Other livestock farms | 0.329 | 0.104 | -0.096 | 0.090 | 0.084 | -0.157 | 0.074 | 0.021 |

| | % Hired labour | Assured continuity | Asturias | Dairy farms | Beef farms | Other livestock farms |
|---|---|---|---|---|---|---|
| Diversification | | | | | | |
| % Own land | | | | | | |
| % Industry sales | | | | | | |
| Use of ICT | | | | | | |
| Use of MAP | | | | | | |
| Female | | | | | | |
| Manager age | | | | | | |
| Organic training | | | | | | |
| % Hired labour | 1 | | | | | |
| Assured continuity | -0.036 | 1 | | | | |
| Asturias | -0.138 | -0.164 | 1 | | | |
| Dairy farms | -0.166 | 0.077 | -0.190 | 1 | | |
| Beef farms | -0.367 | 0.122 | 0.194 | -0.611 | 1 | |
| Other livestock farms | 0.346 | 0.086 | -0.352 | -0.212 | -0.251 | 1 |

## Data availability

The authors do not have permission to share data.

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