Economic Research-Ekonomska Istraživanja

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rero20

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ECONOMIC RESEARCH-EKONOMSKA ISTRAŽIVANJA
2023, VOL. 36, NO. 1, 2120039
https://doi.org/10.1080/1331677X.2022.2120039

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Dynamics in the economic performance of farms: a quintipartite decomposition of the profitability change at the aggregate level

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ABSTRACT
This paper presents a framework for decomposition of changes in farm profitability with regards to structural, activity and intensity (efficiency) effects. The Index Decomposition Analysis (IDA) is adapted for isolation of the effects of profit margin, asset turnover, leverage, capital intensity and structure. The proposed approach complements the regression-based analysis as the IDA allows combining data from different levels of aggregation and taking the structural change into account. The Shapley value is applied to facilitate the decomposition. The proposed model is applied to the case of Greek farms for 2010–2017. Besides from the theoretical contribution to analysis of the farm profitability, this paper is first to evaluate the financial performance of Greek farms.

ARTICLE HISTORY
Received 5 October 2021
Accepted 25 August 2022

KEYWORDS
Profitability; index decomposition analysis; Shapley value; Greece

JEL CODES
C43; Q10; Q14

1. Introduction

The concept of sustainable development (Arianpoor & Salehi, 2020) requires that business activities ensured implementations of the social, economic and environmental objectives. In this paper, we focus on the issue of the agricultural profitability from the economic and social viewpoints thus contributing to discussion on agricultural sustainability. In general, reasonable profitability rate ensures that a certain company (e.g., farm) is able to maintain its activity in the long run. However, the measurement of profitability can be based on different assumptions and measures. The choice of the framework for profitability analysis, therefore, should adhere to theoretical requirements.

In the light of the sustainability concept, we suggest tracking the (dynamics in) the two measures: return on equity and the net farm income per family work unit (FWU). The former measure indicates the economic viability of the farm, i.e., it shows if the capital invested can be recovered throughout the business activities. As regards the latter measure, it shows whether the social viability of the farm can be maintained, i.e., whether the family members of the farmer can be reasonable remunerated.

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Greece embarks on production of olives, sheep and goat farming and field cropping. The agricultural sector of Greece has been affected by the Common Agricultural Policy (CAP) of the European Union (EU). Indeed, both farm structure and input consumption have been impacted by the support payments. Thus, it is important to evaluate the underlying trends in the Greek farm profitability.

The proposed framework is a systematic approach involving index decomposition analysis (IDA) that allows tracking the dynamics in the profitability, i.e., returns on equity on farm net income per family work unit. We further discern the 'pure' profitability change and the structural effect at the country level. Such an approach allows one to identify the key driving factors behind the profitability change and identify the relevant policy implications. The Shapley value (Aristondo & Onaindia, 2020; Gao et al., 2017; Shapley, 1953) is applied to decompose the change in profitability.

The research seeks to identify the major factors directing the change in the profitability of Greek farms. The following questions are addressed: (i) how can the aggregate profitability be decomposed at the country level; (ii) what are the structural changes in the Greek agriculture; (iii) how do those changes affect profitability of the Greek agriculture. For this exercise, we utilise the aggregate Farm Accountancy Data Network data for 2010–2017.

The paper is organised as follows: Section 2 presents a literature review on the analysis of agricultural profitability from the sustainability viewpoint. Section 3 discusses the methods for decomposition of the profitability change. Section 4 describes the data used. Section 5 presents the results.

2. Literature review

Achieving sustainability in agriculture is a growing concern in recent times. The concept of sustainability has been accommodated in the CAP 2014–2020 reform objectives to enhance the competitiveness of the agricultural sector and to improve its sustainability over the long term (European Commission, 2013). In addition, the European Commission's proposal for CAP-post 2020 provides a scope for enhanced sustainability. It supports that the sustainability assessment should be integrated more effectively into the CAP design and implementation, in a way that addresses all the three dimensions of sustainability-social, economic and environmental. The importance of assessment of sustainability has become evident from the bulk of empirical studies in the literature.

According to Latruffe et al. (2016), the farms sustainability has three functions: (i) *the production of goods and services* (*economic function*); (ii) *the management of natural resources* (*ecological function*), *and* (iii) *the contribution to rural dynamics* (*social function*). These functions are interconnected, are equally important, and their combination compose the background of sustainable agriculture. In this sub-section we discuss the literature on the measurement indicator of the economic sustainability, profitability.

Economic dimension of sustainability is generally 'viewed as economic viability defined as a farming system can survive in the long term in a changing economic context' (Grenz, 2017; Latruffe et al., 2016) and is mostly measured by financial ratios dealing with profitability, liquidity and stability. Here, we focus on the profitability assessment of Greek farms. Profitability measures the amount of profit a farm generates through its operations. It shows how well the farm uses its assets and equity to generate revenues and create a profit from it. Zorn et al. (2018) propose five financial ratios for profitability among them the return on assets (ROA), the return on equity (ROE) and the income per family working unit (FWU) to assess economic sustainability for the Swiss dairy farms. Similarly, Baležentis et al. (2019) measures profitability for Lithuanian farms using the ROE and the ROA respectively, where he applies DuPont identity to decompose changes in profitability. DuPont identity of ROE decomposes ROE into profit margin or earnings, asset turnover and leverage. Melvin et al. (2004) considers the DuPont model to assess the drivers of profitability and financial performance of farm businesses. Mishra et al. (2009, 2012) uses the DuPont expansion model to examine the drivers of agricultural profitability in the USA. Nehring et al. (2015) uses DuPont method to analyse the economic and financial performance of US broiler farms and examine the factors affecting farm profitability.

Farm structure and profitability are linked in a two-way relationship. The changes in profitability may trigger farm entry and exit. At the same time, adjustment in farm structure may occur due to demographic, political or natural reasons. In this case, the changes in profitability may occur at the sector level due to redistribution of agricultural inputs. Chavas (2001) provided a review of the effects of structural changes upon agricultural markets. Neuenfeldt et al. (2019) and Corsi et al. (2021) looked into the determinants of farm structural changes. The economic factors (from either macro or micro perspective) appeared to be among those shaping the farm structure. In particular, production prices may impact structural changes. These also render changes in profitability. The presence of successors and natural conditions also have been found to affect the farm exit decisions.

There has also been research on the determinants of farm profitability. Tey and Brindal (2015) presented a meta-analysis of the studies on agricultural profitability. The latter study showed that production capacity, efficiency, and crop prices were important in determining the levels of the profitability. Grashuis (2018) applied quantile regression to identify the drivers of farmer cooperative profitability from the viewpoint of DuPont analysis. Cost inefficiency appeared as a major driver of the changes in profitability. Skevas et al. (2021) considered spatial autocorrelation in the analysis of farm profitability. Góral and Soliwoda (2021) applied panel regression to assess the relationships among large farm profitability and selected variables. It was found that subsidies negatively impact the profitability of farms. Farm behaviour and profitability may also be impacted by the regulations imposed by the government (Saman, 2021; Tao & Wang, 2020).

This work uses the IDA (Ang et al., 2003, 2009) and Shapley value (Liang et al., 2018; Shapley, 1953) for decomposing the changes in profitability at aggregate level. Similar methodology is applied by Baležentis and Kriščiukaitienė (2015) examining the drivers of milk revenue in Lithuanian farms. Baležentis and Novickytė (2018) decompose the ROE using DuPont analysis based on IDA for Lithuanian family farms. Aristondo and Onaindia (2020) follow Shapley approach to decompose the overall poverty changes in Europe.

3. Methods

3.1. The general model for Shapley decomposition

The paper proposes an IDA-based framework for decomposing the changes in the measures of profitability at the aggregate level. In our case, we consider the country-level data with multiple farming types and covering multiple time periods. In this section, we discuss the preliminaries for the IDA and its application for farm profitability analysis.

The basic block of the IDA is the IDA identify which comprises the variables of two types: the aggregate variable and the factor variables. The aggregate variable is multiplicatively related to the factor variables. The factor variables can generally be divided into the structural, activity and intensity ones. The factor variables can be defined for multiple sectors (types of activities, regions). The structural indicators capture the changes in the aggregate variable due to shifts in the relative importance of activities. The activity indicators represent the extent of activities and can be regarded as carriers in the model. The intensity variables indicate the performance of operation. Indeed, an IDA model does not necessarily need to incorporate factors of all the three types simultaneously.

In the case there are n sectors and k factor variables, the general IDA identity takes the following form:

$$V = \sum_{i=1}^{n} \prod_{j=1}^{k} x_{ij}, \tag{1}$$

where x_{ij} is the j-th factor of the i-th sector, V is the aggregate variable, and the time index is dropped for sake of brevity. The decomposition of change in the aggregate variable, $\Delta V,$ from period t_0 to t_1 is formally described as

$$\Delta V = V^{t_1} - V^{t_0} = \sum_{j=1}^{k} \Delta V_{x_j}, \tag{2}$$

where j is the index of the factor variables in the IDA identity. The decomposition given in Eq. (2) can be carried out by applying different techniques (Ang et al., 2003, 2009). The two main approaches are the techniques linked to the Laspeyres index and those linked to the Divisia index. Among the indices belonging to the former group, the Shapley/Sun index is prominent due to the perfect decomposition and path independency properties it satisfies. The Shapley/Sun index relies on the Shapley value (Shapley, 1953). The effects outlined in Eq. (2) are quantified by calculating the marginal contribution of changes in each factor variable to the aggregate variable. The combinations of factors taking their values from the base and current time periods are considered.

The Shapley value is applied for the decomposition of changes V by considering the possible combinations of changes in the values of the factor variables from base time period t_0 to the current time period t_1. In this sense, the set of variables that stand at time priod t_1 is denoted as S. By including or excluding the variable of interest, $x_{j'}, j' \in j,$ in set $S,$ one may calculate the marginal contribution of this variable to the change in the aggregate one. Formally, this contribution is giuven as

$$\Delta V_{x_{j'}} = \sum_{i=1}^{n} \left[\sum_{s=1}^{n} \frac{(s-1)!(n-s)!}{n!} \sum_{S: x_j \in S, |S|=s} \left(V(S,i) - V\left(S \backslash x_{j'}, i\right) \right) \right], \tag{3}$$

where summation is carried over all the possible combinations of memberships in S given a certain cardinality s. The value of the aggregate variable V for a certain combination of S is defined as

$$V(S,i) = \sum_{i=1}^{n} \left(\prod_{j \in S} x_{ij}^{t_1} \prod_{j \notin S} x_{ij}^{t_0} \right). \tag{4}$$

3.2. Shapley decomposition for farming profitability

The labour-intensive farming types may be underrated in the case the family labour is used in the labour-saving farming types as the use of the unpaid labour is not taken into account when calculating the net profit. In order to account for the alternative costs associated with the unpaid (family) labour, we construct the Returns on Labour (ROL) indicator which is defined as the profit generated by a labour unit. In our case, we use the family labour to represent the recipients of the entrepreneurial income.

In the case of the farm profitability analysis, we construct the IDA identity with the net farm income per FWU as the aggregate variable. The factor variables include the components of the DuPont identity (Melvin et al., 2004; Mishra et al., 2012) along with the structural and activity variables. We assume there are n farming types indexed over $i = 1, 2, \ldots, n$. The formal expression of the underlying IDA identity for the farm profitability analysis takes the following form:

$$\begin{aligned} P_t &= \sum_{i=1}^{n} \frac{NI_{it}}{Y_{it}} \frac{Y_{it}}{A_{it}} \frac{A_{it}}{W_{it}} \frac{W_{it}}{F_{it}} \frac{f_{it}}{f_t} = \sum_{i=1}^{n} M_{it} T_{it} L_{it} C_{it} s_{it} \\ &= \sum_{i=1}^{n} ROE_{it} C_{it} s_{it} = \sum_{i=1}^{n} ROL_{it} s_{it} = \sum_{i=1}^{n} P_{it}, \end{aligned} \tag{5}$$

where P_t is the profit per FWU (Eur/FWU) during period t for the sample of farms, NI – Net Income, Y – Total Output, A – Total Assets, W – own assets, F – labour input of farmer's family (in FWU), f_{it} is the number of farms represented by type i and $\sum_{i=1}^{n} f_{it} = f_t$ is the total number of farms represented during period t; M is the profit margin, T is the asset turnover, L is leverage, C is capital intensity and s is the share of farms represented. Thus, the model in Eq. (5) nests the DuPont identify which defines the returns on assets – denoted as ROE. The contribution of farming type i to the overall profitability P_t is denoted by P_{it}.

The economic dimension of sustainability is, therefore, represented by the ROE. Indeed, by setting $C_{it} = 1, \ \forall \mathrm{i, t}$, Eq. (5) collapses to a simple DuPont identity. The inclusion of the capital intensity, C, allows one to capture the social dimension of sustainability as the farms with higher profits per family labour unit are likely to be more viable. One may refer to the net income-labour ratio as the returns on labour.

The identity provided in Eq. (5) establishes a static relationship among multiple variables. In order to analyse the dynamics in the aggregate variable, the change is decomposed:

$$\begin{aligned} \Delta P_t &= P_{t_1} - P_{t_0} \\ &= \Delta_M + \Delta_T + \Delta_L + \Delta_C + \Delta_s, \end{aligned} \tag{6}$$

where t_0 and t_1 denote the base and current periods respectively. The five terms on the second line of Eq. (6) quantify the contributions of changes in each of the factor variables towards the change in the aggregate variable, profit per FWU.

The effects in Eq. (6) can be obtained by adapting Eq. (3). The effect of the profit margin, Δ_M, is obtained through the following calculations:

$$\begin{aligned} \Delta_M = \sum_{i=1}^{n} \Bigg[& \frac{1}{5}\left(M_{it_1}T_{it_0}L_{it_0}C_{it_0}s_{it_0} - M_{it_0}T_{it_0}L_{it_0}C_{it_0}s_{it_0}\right) \\ & + \frac{1}{20}\left(M_{it_1}T_{it_1}L_{it_0}C_{it_0}s_{it_0} - M_{it_0}T_{it_1}L_{it_0}C_{it_0}s_{it_0} + M_{it_1}T_{it_0}L_{it_1}C_{it_0}s_{it_0} - M_{it_0}T_{it_0}L_{it_1}C_{it_0}s_{it_0}\right. \\ & \left. + M_{it_1}T_{it_0}L_{it_0}C_{it_1}s_{it_0} - M_{it_0}T_{it_0}L_{it_0}C_{it_1}s_{it_0} + M_{it_1}T_{it_0}L_{it_0}C_{it_0}s_{it_1} - M_{it_0}T_{it_0}L_{it_0}C_{it_0}s_{it_1}\right) \\ & + \frac{1}{30}\left(M_{it_1}T_{it_1}L_{it_1}C_{it_0}s_{it_0} - M_{it_0}T_{it_1}L_{it_1}C_{it_0}s_{it_0} + M_{it_1}T_{it_1}L_{it_0}C_{it_1}s_{it_0} - M_{it_0}T_{it_1}L_{it_0}C_{it_1}s_{it_0}\right. \\ & + M_{it_1}T_{it_1}L_{it_0}C_{it_0}s_{it_1} - M_{it_0}T_{it_1}L_{it_0}C_{it_0}s_{it_1} + M_{it_1}T_{it_0}L_{it_1}C_{it_1}s_{it_0} - M_{it_0}T_{it_0}L_{it_1}C_{it_1}s_{it_0} \\ & \left. + M_{it_1}T_{it_0}L_{it_1}C_{it_0}s_{it_1} - M_{it_0}T_{it_0}L_{it_1}C_{it_0}s_{it_1} + M_{it_1}T_{it_0}L_{it_0}C_{it_1}s_{it_1} - M_{it_0}T_{it_0}L_{it_0}C_{it_1}s_{it_1}\right) \\ & + \frac{1}{20}\left(M_{it_1}T_{it_1}L_{it_1}C_{it_1}s_{it_0} - M_{it_0}T_{it_1}L_{it_1}C_{it_1}s_{it_0} + M_{it_1}T_{it_0}L_{it_1}C_{it_1}s_{it_1} - M_{it_0}T_{it_0}L_{it_1}C_{it_1}s_{it_1}\right. \\ & \left. + M_{it_1}T_{it_1}L_{it_0}C_{it_1}s_{it_1} - M_{it_0}T_{it_1}L_{it_0}C_{it_1}s_{it_1} + M_{it_1}T_{it_1}L_{it_1}C_{it_0}s_{it_1} - M_{it_0}T_{it_1}L_{it_1}C_{it_0}s_{it_1}\right) \\ & + \frac{1}{5}\left(M_{it_1}T_{it_1}L_{it_1}C_{it_1}s_{it_1} - M_{it_0}T_{it_1}L_{it_1}C_{it_1}s_{it_1}\right) \Bigg]. \end{aligned} \tag{7}$$

The same procedure can be applied by replacing the effect of profit margin change with any other factor variable in Eq. (7).

4. Data

The research relies on the aggregate data from the Farm Accountancy Data Network (FADN). The data for Greek are applied. The research covers the period of 2010–2017. The following farming types are considered: specialist cereals, oilseed and protein (COP) crop farms, specialist other fieldcrops, specialist horticulture, specialist wine, specialist orchards-fruits, specialist olives, permanent crops combined, specialist sheep and goats, specialist cattle, mixed crops, and mixed crops and livestock.

As it was mentioned in Introduction, we seek to analyse the two types of profitability: Economic profitability which we relate to the returns on equity (ROE) and the social profitability which we define as the returns on the family labour unit. These indicators are further analysed by means of the decomposition techniques defined in Section 2.

The research relies on the absolute indicators form the FADN (European Commission, 2020) which are further translated into relative ones. The absolute indicators include:

- *NI* – Net Income (SEW420) indicator represents the profit of farming,
- *Y* – Total Output (SE131) indicator represents the production level,
- *A* – Total Assets (SE436) includes short- and long-term assets utilised in the production process,
- *W* – Net Worth (SE501) indicates the value of the assets less liabilities,
- *F* – Unpaid Labour Input (SE015) indicates the labour input of farmer's family.

In this paper, we also seek to account for the structural dynamics within the agricultural sector of Greece. The FADN system relies on the multi-level stratified sampling. Therefore, the number of farms represented by each farming type (SYS02) can be used as the weighting factor for the profitability indicators.

5. Results

The profitability change is analysed for different farming types in Greece. The weighting based on the number of farms represented is then applied to weight the results. Thus, the sector-wide measures of profitability are also established.

5.1. Structural dynamics

The structure of farms has changed during 2010–2017 in Greece. As Table 1 suggests, the total number of farms represented by the FADN system slightly increased (1.24%). Among the farming types covered in this study, the highest increase in the number of farms is observed for specialist sheep and goat farms. This case, the

Table 1. Structure of the Greek farm sample, 2010 and 2017.

	Number			Structure, %		
Farming type	2010	2017	Rate of growth, % p.a.	2010	2017	Rate of change, p.p.
Specialist COP	18840	24130	3.65	6.0	7.1	1.1
Specialist other fieldcrops	52450	54150	0.44	16.7	15.9	−0.8
Spec. horticulture	9880	9250	−1.14	3.1	2.7	−0.4
Spec wine	11120	11710	2.63	3.5	3.4	−0.1
Spec. orchards-fruits	35100	37470	1.14	11.2	11.0	−0.2
Spec. olives	69560	70970	−0.11	22.1	20.8	−1.3
Permanent crops combined	34980	33050	−1.14	11.1	9.7	−1.4
Spec. sheep and goats	29490	49690	7.70	9.4	14.6	5.2
Spec. cattle	5550	4830	−2.17	1.8	1.4	−0.4
Mixed crops	20500	22150	1.30	6.5	6.5	0
Mixed crops and livestock	26740	23730	−1.18	8.5	7.0	−1.5
Total	314210	341130	1.24	100	100	

Note: rate of growth is based on the stochastic trend.
Source: Designed by the authors.

number of farms represented by the FADN went up from 29.5 thousand up to 49.7 thousand with the average annual growth rate of 7.7%. Accordingly, the share of these farms increased from 9.4% up to 14.6%. The specialist COP farms also saw an increase in their number from 18.8 thousand up to 24.1 thousand (3.65% p.a.).

The declining farming types include specialist cattle farms. For this farming type, the number of farms shrunk from 5.6 thousand down to 4.8 thousand during 2010–2017. The decline was also observed for specialist horticulture, permanent crop and mixed crop-livestock farms. Therefore, the analysis of profitability should account for these structural changes in the Greek agriculture.

5.2. Dynamics in the absolute indicators

The absolute indicators describe the growth in the scale of farming and agricultural output across the farming types. As this research focuses on profitability, we discuss the relevant indicators: family labour input, capital assets and production output (Table 2). At the country level, the family labour input declined 3.1% per year on average during 2010–2017. The latter finding suggests the decreasing attractiveness and viability of farming activities in Greece. The own and total assets showed the average annual growth rates of 2.9% which indicates restricted use of the credit resources. The total output saw a marginal decline of 0.1% per annum, whereas the net income shrunk by 2.7% per year. Therefore, the increasing production volume did not ensure profit gains.

The highest family labour input was observed for horticulture, sheep and cattle farming. The lowest value was observed for the cereal farms (0.55 FWU on average during 2010–2017). All the farming types showed negative growth in the family labour input. The steepest decline was observed for mixed crop and livestock farms (−6.2% per annum).

The own assets employed in the agricultural production stood at 112 thousand Eur on average during 2010–2017. The total assets were just 113 thousand Eur. The two farming types showed a decline in the assets, namely specialised cattle and mixed crop farms. The highest rates of growth in the assets were observed for horticulture, olive and sheep farms. The decline in total assets was observed for cattle (−3.8% p.a.) and mixed crop (−0.5%) farms.

The average rate of growth for the total output (−0.1% per year) was below that for the asset growth. Therefore, the investments did not contribute to substantial increase in the output levels in the Greek farms. However, the farms were diverse in the directions of the output growth. For instance, cattle and mixed crop and livestock farms showed the lowest rates of growth (−5.9% and −3.2% per year respectively). The negative rates of growth were observed for cereal, wine, orchards-fruits, sheep, and mixed crops farms. Horticultural forms showed the highest rate of growth in the total output (5.3% per year) along with the highest level of the average total output (50.8 thousand Eur).

The profit growth was virtually nil at the aggregate level (0.1% per year). This indicates that even though the total output was rather stable, the profit did not catch up to the same extent. The farming types with positive growth in the net income

Table 2. Farm size indicators in Greece, 2010–2017.

	Unpaid labour input		Net worth		Total assets		Total output		Net farm income	
Farming type	Average, FWU	Rate of growth, %	Average, 10000 Eur	Rate of growth, %	Average, 10000 Eur	Rate of growth, %	Average, 10000 Eur	Rate of growth, %	Average, 10000 Eur	Rate of growth, %
Specialist COP	0.55	−2.9	9.79	0.4	9.82	0.3	1.88	−1.0	0.67	−5.3
Specialist other fieldcrops	0.84	−2.6	12.00	3.9	12.03	3.8	2.33	0.0	1.09	−4.3
Spec. horticulture	1.28	−0.5	12.94	4.8	13.00	4.6	5.08	5.3	1.69	3.2
Spec wine	0.83	−4.3	9.81	2.2	9.81	2.2	1.89	−0.4	1.00	−5.5
Spec. orchards-fruits	0.82	−3.8	12.30	2.6	12.46	2.8	2.21	−1.0	1.07	−3.2
Spec. olives	0.79	−3.8	10.57	4.0	10.59	3.9	1.15	3.6	0.72	−1.9
Permanent crops combined	0.87	−3.1	12.32	5.0	12.32	5.0	1.63	3.8	0.95	1.0
Spec. sheep and goats	1.31	−2.2	10.71	3.3	10.76	3.1	3.63	−1.7	1.99	−1.9
Spec. cattle	1.17	−3.0	13.28	−3.8	13.34	−3.9	2.85	−5.9	1.94	−0.2
Mixed crops	1.06	−4.0	12.26	−0.4	12.28	−0.5	2.34	−1.3	1.17	−6.4
Mixed crops and livestock	1.06	−6.2	9.40	1.2	9.44	1.0	2.40	−3.2	1.32	−4.4
Total	0.92	−3.1	11.23	2.9	11.27	2.9	2.23	−0.1	1.14	−2.7

Note: rates of growth are based on the log-lin trend.
Source: Designed by the authors.

included horticulture (3.2% p.a.) and permanent crop farms (1% p.a.). The net income varied from 6.7 thousand Eur for the cereal farms up to 19.9 thousand for sheep farms.

5.3. Dynamics in the relative indicators

The two profitability indicators are compared in Table 3: ROE and the ROL (i.e., the ratio of the net income to the family labour input). The Greek farms are rather similar in terms of the ROL, yet the differences are higher in the sense of ROE. In general, farming types with relatively high ROE also show better performance in terms of the ROL. As it is expected, the ROL shows lower variation than it is the case for the ROE. This can be explained by the fact that the ROL is ROE normalised by the family labour input which takes account of the differences in labour intensity existing among the farming types.

The dynamics in the profitability indicators (weighted averages) are presented in Figure 1. As one can note, the ROE followed a U-shaped trend during 2010–2017. The ROL remained stable until 2015 and slightly increased afterwards. The differences among the farming typos can be noticed in the trends for the ROL: the horticultural, permanent crop, and cattle farms showed the highest rates of growth (more than 2.8% per year). Decline in the ROE was observed for cereal, fieldcrop, wine, and mixed crop farms. The ROE declined for all farming types with exception of cattle farms.

Table 4 compares the farming types in terms of the financial ratios. The relative standard deviation (coefficient of variation) shows that asset turnover is the variable that causes the highest degree of polarisation of the farming types, whereas leverage is basically uniform across the farming types. The capital intensity and profit margin show substantial variation across the farming types.

The capital intensity shows positive trends for all farming types with exception of specialised cattle farms. This indicates that the Greek farms have experienced

Table 3. Profitability indicators for the Greek farms, 2010–2017.

	Levels		Trends	
Farming type	ROL	ROE	ROL	ROE
Specialist COP	12236	0.069	−2.4	−0.004
Specialist other fieldcrops	12873	0.093	−1.7	−0.008
Spec. horticulture	13273	0.133	3.7	−0.003
Spec wine	11990	0.105	−1.1	−0.008
Spec. orchards-fruits	13111	0.089	0.6	−0.006
Spec. olives	9113	0.070	2.0	−0.004
Permanent crops combined	11010	0.079	4.1	−0.004
Spec. sheep and goats	15213	0.189	0.3	−0.011
Spec. cattle	16691	0.150	2.8	0.005
Mixed crops	11007	0.098	−2.4	−0.007
Mixed crops and livestock	12420	0.141	1.7	−0.009
Average	12057	0.103	0.8	−0.006
Relative St. Dev.	0.17	0.37		

Note: Levels represent the average values over 2010–2017; ROL is the ratio of the farm Net Income to FWU; ROE is the ratio of the farm Net Income over own assets (Net Worth); trends are based on the log-lin trend for the ROL and linear trend for the ROE.
Source: Designed by the authors.

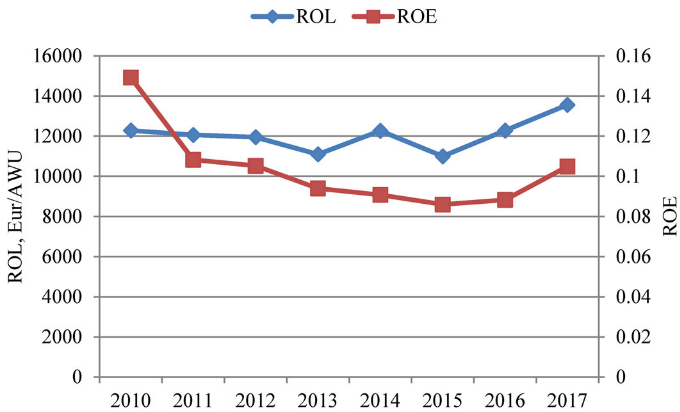

Figure 1. The average ROE and ROL in the Greek farms over 2010–2017.
Source: Designed by the authors.

Table 4. Financial ratios for Greek farms, 2010–2017.

	Capital intensity, Eur/FWU (W/F)		Leverage (A/W)		Asset turnover (Y/A)		Profit margin (NI/Y)	
Farming type	Average	Trend	Average	Trend	Average	Trend	Average	Trend
Specialist COP	180353	0.0334	1.003	−0.001	0.191	−0.003	0.356	−0.016
Specialist other fieldcrops	143609	0.0651	1.002	−0.001	0.196	−0.008	0.466	−0.021
Spec. horticulture	101678	0.0529	1.005	−0.002	0.394	0.002	0.334	−0.008
Spec wine	118805	0.0655	1.000	0.000	0.196	−0.005	0.529	−0.027
Spec. orchards-fruits	152608	0.0641	1.013	0.002	0.179	−0.007	0.484	−0.011
Spec. olives	136736	0.0783	1.002	−0.001	0.109	0.000	0.630	−0.035
Permanent crops combined	145054	0.0812	1.000	0.000	0.134	−0.002	0.581	−0.018
Spec. sheep and goats	82527	0.0558	1.005	−0.002	0.342	−0.017	0.547	−0.002
Spec. cattle	112585	−0.0078	1.005	−0.001	0.217	−0.006	0.697	0.043
Mixed crops	117192	0.0355	1.002	−0.001	0.193	−0.002	0.497	−0.027
Mixed crops and livestock	90980	0.0732	1.005	−0.002	0.255	−0.012	0.544	−0.007
Total	129323	0.0611	1.004	−0.001	0.198	−0.004	0.528	−0.019
Relative St.Dev.	0.22		0.00		0.42		0.20	

Note: trend for the capital intensity is expressed in percentage (i.e., growth rate), whereas absolute changes are used otherwise (rates of change); NI – Net Income, Y – Total Output, A – Total Assets, W – Net Worth, F – Unpaid Labour Input.
Source: Designed by the authors.

increasing investments into assets since 2010. The highest capital intensity (per family labour unit) is observed for the cereal farms. This can be explained by the lowest family labour input in these farms. The lowest capital intensity is observed for the sheep and goat farms and mixed crops and livestock farms.

Leverage is virtually the same across the farming types. Specifically, the value of 1 is observed. This suggests that Greek farms do not rely on the borrowed capital in general. All holdings rely on their own capital to face difficulties that have arisen and to be able to survive after the economic crisis. Indeed, as a result of the economic downturn, there was a reduction in liquidity and underfunding of farmers. Thus, the effect of borrowed capital on profits is zero.

Asset turnover represents the capital productivity to a certain extent. In general, a declining trend is observed with exception for horticultural and olive farms. Indeed, horticultural farms show the highest turnover ratio with sheep and goat farms ranking behind. The lowest turnover is observed for olive farms. Therefore, there exist substantial differences in capital utilisation across farming types.

Profit margin tends to decline for all the farming types with exception for the cattle farms. The latter farming type also shows the highest value of the profit margin. The lowest profit margins are observed for specialist cereal farms and horticultural farms. The differences in the profit margins are related to the price recovery possibilities which vary across farming types depending on situation in the domestic and international markets.

The discussed changes in the ROE and ROL along with their components require further analysis. Specifically, it is important to identify the factors causing a decline in the ROE and those rendering subdued growth in the ROL. The IDA will be applied to factorise the changes in these two indicators.

5.4. Decomposition

The ROL went up from 12.3 thousand Eur/FWU in 2010 to 13.6 thousand Eur/FWU in 2017. Therefore, the increase in the ROL corresponds to 10.4% or 1282 Eur/FWU. The IDA model described in Section 3.2 is then applied in order to quantify the impacts of the explanatory terms.

The five terms of the IDA model are quantified in Figure 2. As one can note, the three terms cause much of the changes in ROL, namely capital intensity, asset turnover and profit margin. The cumulative effects associated with these three terms remained stable in terms of the signs throughout the period covered.

The capital intensity effect contributed to increasing ROL during 2010–2014. Later on, the effect remained close to nil or slightly negative as the cumulative values fluctuated around the level of 2013–2014. The investments contributed to increasing capital assets in Greek farms, which allowed exploiting family labour resources in a more productive manner. However, there has been little integration in the financial markets which rendered low effects of the leverage. These findings suggest that the reasonable

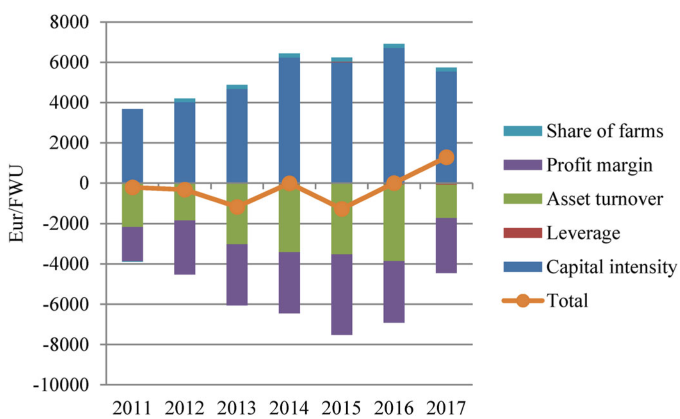

Figure 2. The cumulative decomposition of changes in Returns on Labour in Greek farms, 2010–2017 (current year for each two consecutive years is shown).
Source: Designed by the authors.

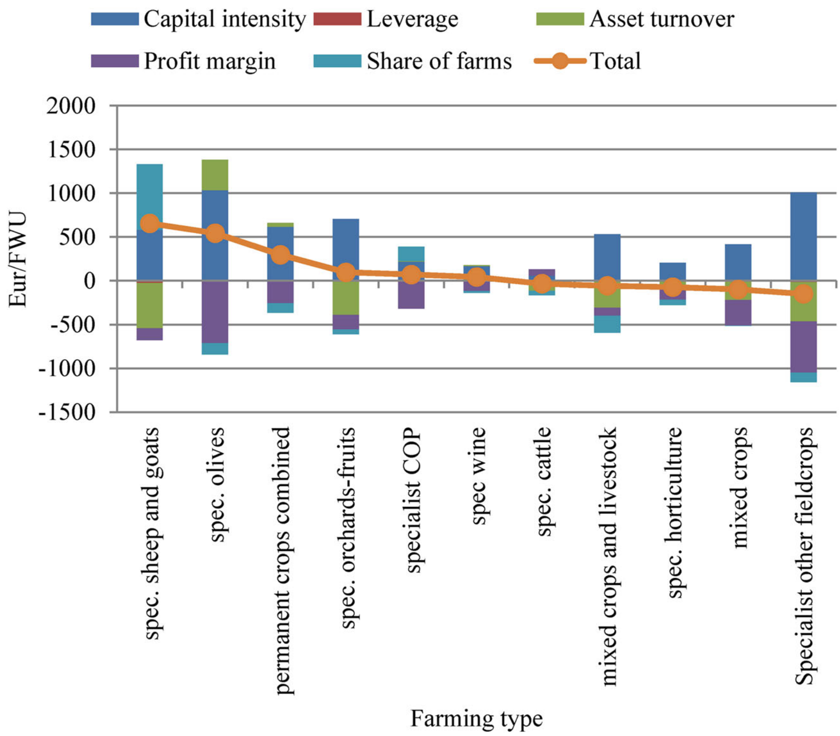

Figure 3. Decomposition of contributions to change in the ROL across farming types in Greece, 2010–2017.
Source: Designed by the authors.

investment policies may further improve the labour productivity and profitability in Greek farms.

The cumulative effect of the profit margin remained rather stable throughout 2010–2017. The declining profit margin contributed to a decrease in the ROL. However, there has been a positive trend observed since 2014 as the negative effect declined in its magnitude. Therefore, the prices of the agricultural outputs produced on the Greek farms did not allow to improve the profitability compared to the input prices.

Asset turnover had a negative effect on the ROL throughout the whole period covered. This indicates that the decline in the utilisation of the assets negatively affected the profitability. The overall change in the ROL became positive following decline in the magnitude of the profit margin and asset turnover terms. However, these two terms require further improvements in order to ensure growth in the ROL.

We further look at the differences among the farming types in terms of the contribution towards the changes in ROL. Figure 3 presents the comparison (the farming types are arranged in descending order of the contribution to the changes in the ROL). The six farming types showed a positive contribution to the change in the ROL. Notably, profit margin has a negative effect in all farming types with exception of the cattle farms.

The highest contribution towards the change in the ROL is observed for the sheep and goat farms (654 Eur/FWU). Indeed, these farms also show the positive contribution by the farm share effect (i.e., the share of this type increased in the farm structure). Along with increasing capital intensity, these farms showed a decline in the asset turnover. Therefore, the expansion of this type of farming led to decline in the asset utilisation which needs to be solved in order to ensure further profitability growth.

The specialised olive farms also show positive contribution towards growth in the ROL of 542 Eur/FWU. The major driving force is the increasing capital intensity there. The asset turnover also shows positive contribution. Thus, the increasing capital stock is being utilised in a reasonable manner in this type of farms. For this type of farms, the declining profit margin offset the positive effect of the increasing asset turnover. Thus, the price recovery should be improved by adjusting the production scope.

The permanent crop farms show the cumulative contribution to the change in the ROL of 296 Eur/FWU. In this case, the increasing capital intensity plays the most important role, whereas the decreasing profit margin and share in the farm structure contribute to a decline in the ROL. Therefore, this farming type requires adjustments in its marketing strategies in order to ensure better price recovery.

Orchard, cereal and wine farms show moderate contributions to the growth in the ROL ranging in between 94 and 42 Eur/FWU. The orchard farms faced the negative effects of declining asset turnover. All of the three farming types showed negative effects of a decline in the profit margin.

Farming types with negative contribution to the change in the ROL are more homogeneous in their cumulative contributions if compared to the case of previously discussed farming types with positive contributions. The highest cumulative contribution to the change in the ROL during 2010–2017 of −34 Eur/FWU is observed for the specialist cattle farms, whereas the lowest is observed for the for the specialised fieldcrop farms (−150 Eur/FWU). Indeed, the contribution declined with increasing capital intensity. This indicates that these farming types invested into assets and faced declining profit margins. Therefore, the decision to invest may create excessive opportunity costs if the price recovery is not satisfactory even though the leverage did not increase.

The dynamics in the changes in the ROL for the three groups of farming types is presented in Figure 4. The farming types are grouped with respect to their cumulative contribution to the change in ROL. The highest contribution is observed for sheep and got farms, olive farms and permanent crop farms (Figure 4). As one can note, the sheep and goat farms show a steady upward trend, whereas the olive farms and permanent crop farms show fluctuating contribution with steady growth during 2016–2016. Among the farming types showing subdued contribution to profitability growth, wine farms appear as those following a stable trend. Still, the contribution from this type of farms remained negative throughout much of the period covered. The orchard and cereal farms follow similar trends. The low-contributing farming types are rather homogenous in dynamics of their contributions towards the ROL. In general, the negative spikes are observed for years 2012–2013 and 2014–2015.

The results indicate that the capital intensity played an important role in promoting the ROL. We further look into the changes in the ROE, as proposed by the

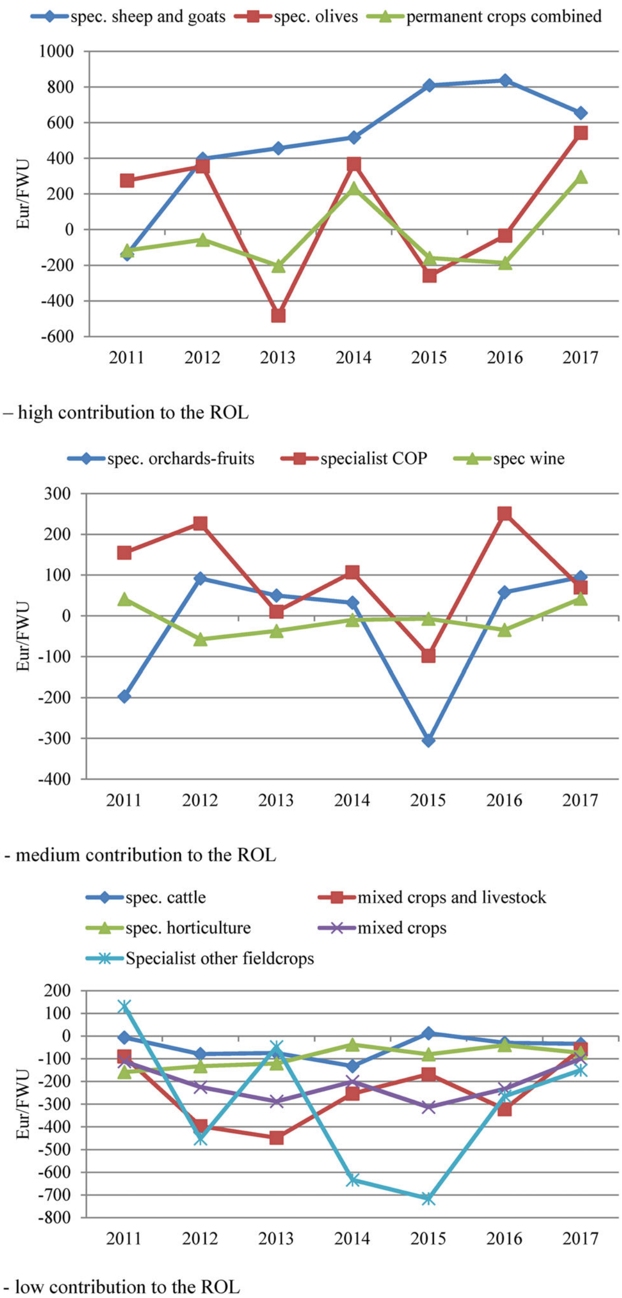

Figure 4. Dynamics in the cumulative contribution in the change in the ROL across farming types (base years are shown). (a) High contribution to the ROL. (b) Medium contribution to the ROL. (c) Low contribution to the ROL.
Source: Designed by the authors.

DuPont identity. As it was mentioned above, the IDA identity in Eq. (5) nests the DuPont identity. Therefore, we check the effects of the structural and farming type-specific changes on the ROE. During 2010–2017, the ROE declined by 4.4 p.p.

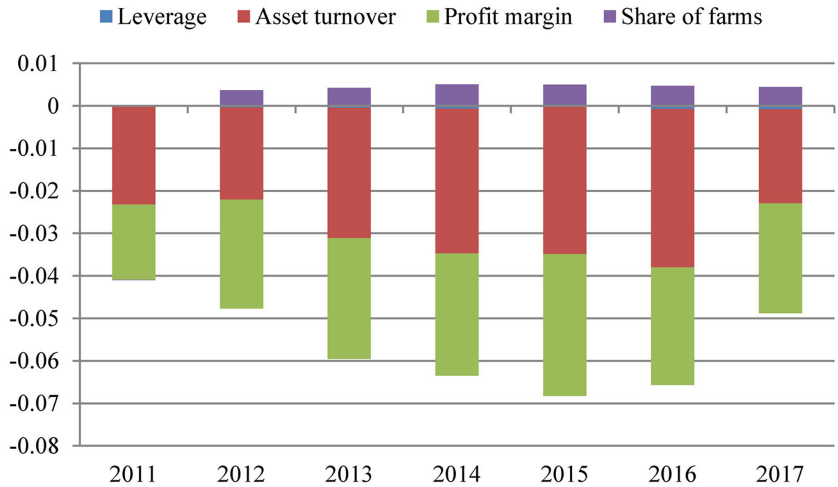

Figure 5. Cumulative decomposition of changes in the ROE in Greek farms, 2010–2017.
Source: Designed by the authors.

(Figure 1). The IDA suggests that this was mainly due to the asset turnover and profit margin effects. The cumulative effects are presented in Figure 5. The structural effect appeared as the sole one pushing the ROE up even though the effect was marginal one.

The results indicate the negative effects of the natural hazards (storms and floods in 2012–2013 and hail in 2014). As one can note, the overall ROE tends to increase once these hazards are no longer in effect. Asset turnover is mostly affected by this as it is related to production efficiency and farmers expectations.

We further discuss the most recent developments in the Greek agricultural sector by exploiting the Eurostat data as the FADN data are delayed. Particularly, the effects of the COVID-19 and the related restrictions that affected supply chains worldwide need to be assessed in the light of agricultural profitability. The COVID-19 found Greek agriculture recovering from the financial crisis of 2008–2018 and being at the point where it met the crisis in 2008. Agricultural production was little affected by COVID-19. In the period 2019–2020, Greek agriculture showed a remarkable resistance in relation to the rest of the country's economic sectors. The value of the agricultural output remained stable while mainly due to the fall of GDP, the share of agricultural value added increased from 4% in 2019 to 4.4% in 2020 (at the same rate as in 2017). At the same time the cost of inputs (intermediate consumption) showed a slight reduction of 1.3% reaching the level of 2017. The prices of the means of agricultural production decreased by 2.8%, while the prices of agricultural products decreased slightly by 1.1%. The agricultural labour decreased by 2.6% while the utilised area increased by 2.2% in contrast to the significant decrease (5%) observed in the period 2010–2017. Noteworthy, 2020 was the year in which, after 36 years, the trade balance of surplus agricultural products was restored, with agricultural exports not only absorb the shocks of the COVID-19 crisis, but also record great performance mainly in fruits and vegetables.

Finally, the evolution of the income Indicator A (real income of factors in agriculture per AWU) in the period 2010–2017 showed a decline by 1.5% while the covid-19 crisis led to a significant rise by 9.5% affecting profitability positively. From the above economic data, we could conclude that the covid-19 crisis had contributed to the improvement of the structure of Greek agriculture in relation to the period 2010–2017.

6. Conclusions

The paper proposed an index decomposition analysis framework for analysing the dynamics in the farm profitability. The Returns on Labour were used as a measure of profitability. Indeed, this measure is important in tracking farm viability. The paper focussed on the country-wide change in the Returns to Labour that was explained in four terms: profit margin, asset turnover, leverage, capital intensity and structural change. The Shapley value was applied for decomposition.

The empirical research dealt with the case of Greece. The Farm Accountancy Data Network database was utilised for the research. The results indicated that Returns to Labour slightly increased over the period of 2010–2017, yet Returns to Equity followed a U-shaped trend and did not fully recover to the initial level. Therefore, Greek agriculture requires further improvements in order to ensure profitability growth.

The decomposition analysis suggested that even though the capital intensity increased during 2010–2017, the effects of asset turnover and profit margin caused a decline in the Return to Labour. Mixed crop farms showed particularly poor results. This suggests that both production process and marketing strategies need to be improved through the access of small farmers to assets and knowledge to adopt productive and managerial changes. Research and development efforts, better education and training of farmers, availability of financial resources are factors that facilitate the adoption of new technologies for sustainable farming. Greek family farmers are very conservative with strong habits. These farmers are willing to change their managerial practices only when they are offered solutions based on scientifically, socially and environmentally justified results and not on superficial knowledge of agriculture. To ensure their future viability Greek farmers should invest in new technologies and production techniques for improving products quality and resources efficiency.

The present study relies on the aggregate data. Indeed, further research may exploit the farm-level data to identify the patterns of profitability and its determinants potentially existing within farming types. In such case, the econometric approach could be applied.

Disclosure statement

No potential conflict of interest was reported by the authors.

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References

Ang, B. W., Huang, H. C., & Mu, A. R. (2009). Properties and linkages of some index decomposition analysis methods. *Energy Policy*, *37*(11), 4624–4632. https://doi.org/10.1016/j.enpol.2009.06.017

Ang, B. W., Liu, F. L., & Chew, E. P. (2003). Perfect decomposition techniques in energy and environmental analysis. *Energy Policy*, *31*(14), 1561–1566. https://doi.org/10.1016/S0301-4215(02)00206-9

Arianpoor, A., & Salehi, M. (2020). A framework for business sustainability performance using meta-synthesis. *Management of Environmental Quality: An International Journal*, *32*(2), 175–192. https://doi.org/10.1108/MEQ-03-2020-0040

Aristondo, O., & Onaindia, E. (2020). On measuring the sources of changes in poverty using the Shapley method. An application to Europe. *Fuzzy Sets and Systems*, *383*, 80–91. https://doi.org/10.1016/j.fss.2018.12.011

Baležentis, T., Galnaitytė, A., Kriščiukaitienė, I., Namiotko, V., Novickytė, L., Streimikiene, D., & Melnikiene, R. (2019). Decomposing dynamics in the farm profitability: an application of index decomposition analysis to Lithuanian FADN sample. *Sustainability*, *11*(10), 2861. https://doi.org/10.3390/su11102861

Baležentis, T., & Kriščiukaitienė, I. (2015). The factors of milk revenue change in Lithuania: index decomposition analysis based on the Shapley value. *Management Theory and Studies for Rural Business and Infrastructure Development*, *37*(1), 8–16. https://doi.org/10.15544/mts.2015.01

Baležentis, T., & Novickytė, L. (2018). Are Lithuanian family farms profitable and financially sustainable? Evidence using DuPont model, sustainable growth paradigm and index decomposition analysis. *Transformations in Business and Economics*, *17*(1), 237–254.

Chavas, J. P. (2001). Structural change in agricultural production: economics, technology and policy. *Handbook of Agricultural Economics*, *1*, 263–285.

Corsi, A., Frontuto, V., & Novelli, S. (2021). What drives farm structural change? An analysis of economic, demographic and succession factors. *Agriculture*, *11*(5), 438. https://doi.org/10.3390/agriculture11050438

European Commission. (2013). Overview of CAP reform 2014–2020 (Agricultural Policy Perspectives Brief, No. 5). European Commission.

European Commission. (2020). *Farm accountancy data network*. https://ec.europa.eu/agriculture/rica/sitemap_en.cfm

Gao, J., Yang, X., & Liu, D. (2017). Uncertain Shapley value of coalitional game with application to supply chain alliance. *Applied Soft Computing*, *56*, 551–556. https://doi.org/10.1016/j.asoc.2016.06.018

Góral, J., & Soliwoda, M. (2021). On the profitability of Polish large agricultural holdings. *Acta Oeconomica*, *71*(1), 137–159. https://doi.org/10.1556/032.2021.00007

Grashuis, J. (2018). A quantile regression analysis of farmer cooperative performance. *Agricultural Finance Review*, *78*(1), 65–82. https://doi.org/10.1108/AFR-05-2017-0031

Grenz, J. (2017). *Response-inducing sustainability evaluation (RISE)*. Bern University of Applied Sciences.

Latruffe, L., Diazabakana, A., Bockstaller, C., Desjeux, Y., Finn, J., Kelly, E., Ryan, M., & Uthes, S. (2016). Measurement of sustainability in agriculture: A review of indicators. *Studies in Agricultural Economics*, *118*(3), 123–130. https://doi.org/10.7896/j.1624

Liang, Y., Niu, D., Zhou, W., & Fan, Y. (2018). Decomposition analysis of carbon emissions from energy consumption in Beijing-Tianjin-Hebei, China: A weighted-combination model based on logarithmic mean Divisia index and Shapley value. *Sustainability*, *10*(7), 2535. https://doi.org/10.3390/su10072535

Melvin, J., Boehlje, M., Dobbins, C., & Gray, A. (2004). The DuPont profitability analysis model: An application and evaluation of an e-learning tool. *Agricultural Finance Review*, *64*(1), 75–89. https://doi.org/10.1108/00214660480001155

Mishra, A. K., Moss, C. B., & Erickson, K. W. (2009). Regional differences in agricultural profitability, government payments, and farmland values: Implications of DuPont expansion. *Agricultural Finance Review*, *69*(1), 49–66. https://doi.org/10.1108/00021460910960462

Mishra, A. K., Harris, J. M., Erickson, K. W., Hallahan, C., & Detre, J. D. (2012). Drivers of agricultural profitability in the USA: An application of the DuPont expansion method. *Agricultural Finance Review*, *72*(3), 325–340. https://doi.org/10.1108/00021461211277213

Nehring, R., Gillespie, J., Katchova, A., Hallahan, C., Harris, J., & Erickson, K. (2015). What's driving U.S. broiler farm profitability? *International Food and Agribusiness Management Review*, *18*(Special Issue A), 59–78.

Neuenfeldt, S., Gocht, A., Heckelei, T., & Ciaian, P. (2019). Explaining farm structural change in the European agriculture: A novel analytical framework. *European Review of Agricultural Economics*, *46*(5), 713–768. https://doi.org/10.1093/erae/jby037

Saman, C. (2021). Does agricultural subsidies in the EU improved environmental outcomes? *Transformations in Business & Economics*, *20*(3C), 642–652.

Shapley, L. S. (1953). A value for *n*-person games. In H. W. Kuhn & A. W. Tucker (Eds.), *Contributions to the theory of games. Volume II. Annals of mathematical studies* (Vol. 28, pp. 307–317). Princeton University Press.

Skevas, T., Skevas, I., & Cabrera, V. E. (2021). Farm profitability as a driver of spatial spillovers: The case of somatic cell counts on Wisconsin dairies. *Agricultural and Resource Economics Review*, *50*(1), 187–200. https://doi.org/10.1017/age.2020.22

Tao, J. Y., & Wang, J. H. (2020). Farmers' willingness to accept compensation for livestock and poultry waste resource utilization and its determinants. *Chinese Journal of Population Resources and Environment*, *18*(2), 144–154. https://doi.org/10.1016/j.cjpre.2021.04.019

Tey, Y. S., & Brindal, M. (2015). Factors Influencing Farm Profitability. In E. Lichtfouse (ed.), *Sustainable Agriculture Reviews. Sustainable Agriculture Reviews*, vol 15. Cham: Springer. https://doi.org/10.1007/978-3-319-09132-7_5

Zorn, A., Esteves, M., Baur, I., & Lips, M. (2018). Financial ratios as indicators of economic sustainability: A quantitative analysis for Swiss dairy farms. *Sustainability*, *10*(8), 2942. https://doi.org/10.3390/su10082942