






ESG INVESTMENT STRATEGIES AND THE FINANCIAL PERFORMANCE OF EUROPEAN AGRICULTURAL COMPANIES: A NEW MODELLING APPROACH

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Abstract. This paper aims to appraise the impact of ESG credentials on the financial performance of agricultural companies with main headquarters in Europe by examining the strategic ESG investment behaviour of firms in twelve specific sectors. The methodology consists of a two-fold approach: first, cross-sectional FGLS regression with generalised least squares; second, overall interlinkages between considered variables through Bayesian network analysis. The research questions focus on the implications of each ESG pillar – environmental, social, and governance – on the performance of agricultural companies. Key findings entail that the environmental dimension strongly relates to agricultural companies' outcomes, such as toxic chemicals reduction strategies, waste recycled to the total waste contribution, biodiversity impact reduction, and eco-design products. As regards the social pillar of ESG, salaries and wages positively relate only to shareholders' earnings, while governance factors like CEO compensation, board structure type, and board's gender diversity favourably influence the financial performance of agricultural companies. ESG implications for agricultural companies are beneficial when they implement sustainable strategies. These strategies include establishing targets for water efficiency policies, increasing employee turnover, maintaining a steadfast water efficiency policy, enhancing the use of environmentally-friendly products, and reevaluating board structures from unitary to two-tier or mixed types.

Keywords: agriculture, ESG, profitability, shareholders' earnings, sustainable investment, Europe, econometric modelling.

JEL Classification: O13, L25, F21, N50.

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1. Introduction

The agricultural sector is one of the most vulnerable economic sectors due to its heavy dependence on natural resources and frequent exposure to climatic shocks, negatively impacting agricultural production (Turrall et al., 2011). Beyond the challenges of climate change, the agricultural sector also faces several regulatory pressures (tax regulations, environmental regulations on pesticide use, nitrogen emission reduction, food safety, price caps, etc.) that can make their financial position vulnerable through increased operational costs and reduced productivity (Vanslebrouck et al., 2002). Over-regulation of the agricultural sector mainly affects small and medium-sized agricultural companies with limited available resources, which restrict their activities and even go as far as exiting the market (Kovalchuk et al., 2021). As far as large-scale agricultural companies are concerned, environmental regulations can be quite incentivising, increasing competitive advantages in the market by attracting responsible investments and access to new markets (Aimurzina et al., 2019). However, regardless of their size, companies in the agricultural sector face several specific risks (e.g. market risks generated by the volatility of agricultural commodity prices, climate risks generated by exposure to climate change, operational risks generated by the seasonality of agricultural production, dangers of over-regulation, etc.) which, in the absence of coherent strategies, can affect their financial performance (Jankelova et al., 2017). Against this backdrop, companies in the agricultural sector need to show increased resilience by adopting sustainable practices that both conserve soil and water resources and optimise production while maintaining long-term financial stability. The increasing social and environmental pressures of the last decades thus require a different financial approach to integrating ESG criteria into financial decisions to maintain their high market competitiveness.

The ESG (Environmental, Social, Governance) dimensions can influence the financial performance of agricultural companies in various ways, and their proper handling can bring significant benefits in terms of operational efficiency, market access, and reputation.

Integrating ESG aspects into the business strategy can contribute to agricultural companies' long-term sustainability and success. Understanding the influence of each ESG coordinate on agricultural companies' financial outcomes (ROE – Return on Equity, ROA – Return on Assets, and EPS – Earnings Per Share) is essential for assessing their sustainability and financial performance (Pirtea et al., 2021).

When discussing the *environmental dimension*, it is essential to mention that environmental protection actions can significantly impact agricultural companies' expenses (Sneeringer, 2009; Adelman & Barton, 2022). Adopting a sustainable approach to natural resources, proper waste management, and emissions reduction can significantly contribute to these companies' operational efficiency and cost reduction (DeBoe, 2020). Moreover, in the context of increasing awareness of climate change and consumer demand for more sustainable products, agricultural companies that embrace positive environmental practices can have advantages in market access and building a positive reputation (Boakye et al., 2021).

Regarding the *social dimension*, it is worth highlighting how agricultural companies manage relationships with employees and ensure adequate working conditions can significantly impact productivity and workforce morale (Malanski et al., 2019). This, in turn, can directly influence financial indicators such as ROE and ROA. Agricultural companies that invest in engaging with local communities can gain their support and avoid potential conflicts or social issues. This approach can contribute to the long-term stability and profitability growth of companies in this sector (Conca et al., 2021; Chen et al., 2023).

When discussing the *governance dimension*, it is evident that proper governance involves critical aspects such as transparency in financial reporting, adherence to ethical principles in business activities, and establishing an efficient leadership structure (Gerber et al., 2024). It is important to emphasise that poor governance can generate instability and risks for investors. A well-managed leadership team and a competent board of directors can significantly contribute to effective decision-making and developing and implementing strategies that maximise shareholder value (Cristea et al., 2022).

The complexity of the relationship between ESG factors and the financial performance of companies from agricultural field can also be highlighted through the lens of institutional theory, institutional logic, stakeholder and legitimacy theories. According to the institutional theory of Meyer and Rowan (1977), in the literature (Garcia & Orsato, 2020; Huang, 2022), the idea is advanced that the ESG performance of companies is affected by institutional differences in the quality of rules, policies and regulations, much more than the economic and financial context in which they operate. According to the concept of “institutional logics” introduced in the literature by Friedland and Alford (1991), the performance of companies operating in the same institutional setting is quite variable, with companies responding differently to sustainability challenges (Annesi et al., 2024). In recent years, stakeholder theory has become increasingly linked with the framework of ESG criteria that are used to evaluate how companies operate in ways that are sustainable and ethical, aligning with stakeholder interests (Kim et al., 2021; Talan et al., 2024). In accordance with ESG frameworks, legitimacy theory (Del Gesso & Lodhi, 2024) emphasizes how companies align their activities with societal expectations and norms to maintain legitimacy, accountability, and social approval. We thus assess that agricultural companies can achieve variable financial performance even if they operate in the same institutional setting and integrate different ESG practices.

The general objective of this research is to appraise the impact of the constituents of ESG coordinates – environmental, social, and governance – on the performance, expressed by profitability and shareholders’ earnings, of agricultural companies with primary headquarters in Europe. A notable focus is placed on the strategic ESG investment behaviour of agricultural firms operating in twelve specific sectors and their potential to hinder or heighten companies’ financial outcomes. Different from other studies, the methodological rationale implemented in the current study is innovative and consists of a two-fold approach: first, direct implications of ESG credentials on agricultural companies’ profitability are assessed by applying cross-sectional regression using Feasible General Least Squares (FGLS) (Pooled OLS); second, overall interlinkages between considered variables, namely ESG credentials and agricultural companies’ outcomes are assessed through Bayesian network analysis, based on two models, Gaussian Graphical Models (GGMs) and Gaussian Copula Graphical Models (GCGMs).

Related to the research objective and the methodology proposed, we assess the following *research hypotheses*:

- *H1: There are direct and significant influences of the ESG components on the outcomes of agricultural companies;*
- *H2: There are overall solid interlinkages between the ESG components and the outcomes of agricultural companies.*

The proposed hypotheses will guide the empirical analysis and contribute to the ongoing dialogue on sustainable financial practices in the agricultural sector.

Despite the complexities of this subject, however, much of the existing research has focused on the influence of the main pillars of ESG – environmental, social, and governance – rather

than on the specific indicators included in their structure. There is still much work to be done to fully understand the complex relationship between ESG and financial performance and identify the practices and indicators that are most effective in driving positive economic outcomes.

Our research enhances the scientific literature on this topical subject with a new modelling approach and comprehensive framework of analysis that embeds strategic coordinates of ESG fundamentals and investments into strategies driving the economic and financial performance of companies operating in agricultural fields.

The remainder of the paper follows: Section 2 puts forward the literature review and main theoretical fundamentals of the relationship between ESG and corporate financial performance, Section 3 provides the data/indicators and methodology, Section 4 entails the main findings and discussion, and Section 5 concludes with policy and managerial recommendations.

2. Literature review

The relationship between ESG and corporate financial performance has been a widely debated research topic in academic and economic circles. ESG factors refer to a company's environmental impact, social responsibility, and governance practices, which are believed to impact its financial performance significantly. If, in the past, the prevailing theory argued that a company's primary objective was maximising shareholders' profit (Friedman, 2007), This argument suggested that ESG actions could incur additional costs and could be manipulated by managers to boost ESG ratings without delivering significant benefits to shareholders. However, in recent years, the perspective has shifted towards a broader view, emphasising the importance of meeting the needs of internal and external stakeholders. This suggests that ESG actions can significantly benefit corporate performance (Xie et al., 2019; Alsayegh et al., 2020; Qureshi et al., 2021). Companies with superior ESG performance tend to exhibit better governance and more efficient management, contributing to improved economic performance (Nirino et al., 2021). Additionally, ESG performance can attract talented employees, investor support, and public favour, enhancing the company's reputation and competitiveness (Wang & Sarkis, 2017).

Firstly, a bibliometric analysis was conducted on articles indexed in the Web of Science Core Collection to further assess the existing literature on the relationship between agriculture and corporate social responsibility. The analysis focused on the co-occurrence of the keywords "agriculture and corporate social responsibility" in the articles, with a total of 234 articles being identified. The resulting information was processed in VOSviewer, and the tool generated 6 clusters of keywords, which are depicted in Figure 1. The clusters are representative of the main subjects being debated in the literature. The first cluster includes keywords such as corporate social responsibility, sustainability, and stakeholder engagement; the second cluster includes performance, measurement, and indicators; the third cluster includes keywords such as agriculture, farming, and food systems; the fourth cluster includes sustainable development, innovation, and entrepreneurship; the fifth cluster includes biodiversity, ecosystem services, and conservation; and the sixth cluster includes keywords such as governance, accountability, and transparency.

The identified clusters provide an insight into the main themes and areas of interest that have emerged in the literature. This information is extremely valuable for researchers and practitioners interested in this field and can guide future research and policy development.

(2023) highlight that the ESG approach can significantly contribute to the sustainability and long-term success of agricultural companies. However, it is essential to note that ongoing research and adaptation of practices are needed to maximise the benefits of ESG indicators in agricultural company operations, depending on market specifics and regional contexts.

In regions with strict and well-defined regulations, such as the European Union, companies are often required to adopt sustainable practices and provide detailed reporting on their ESG performance. For instance, the EU Non-Financial Reporting Directive (2014/95/EU) mandates large companies to disclose information about managing social and environmental issues. These regulations support transparency and encourage companies to improve their ESG performances (Mittelbach-Hörmanseder et al., 2021; Ioannou & Serafeim, 2023).

A region's corporate culture and prevailing social values can also influence the adoption of ESG practices. In Nordic countries, for example, there is a strong tradition of corporate social and environmental responsibility, leading to higher levels of commitment to sustainability (Halme & Laurila, 2009; Midttun et al., 2015; Latapi et al., 2021). Companies in these countries may have more advanced ESG initiatives due to social expectations and cultural norms.

Using data collected from 1,426 observations across 31 emerging economy countries over ten years (2008–2017), Buallay (2022) focuses on how sustainability reporting in the food industry can enhance companies' financial performance. The author argues that transparent reporting on sustainability can benefit companies in emerging states' food industry by reducing costs, strengthening brand image, and attracting investors oriented towards ESG criteria. The author emphasises the importance of sustainability in the food industry and suggests that adopting a proactive approach can bring significant economic advantages.

Several studies suggest a positive relationship between ESG indicators and company financial performance regarding the main components (Branco & Rodrigues, 2006; Ferrero-Ferrero et al., 2016). Companies that have adopted sustainable practices in the environmental, social, and governance areas tend to achieve better financial results in terms of ROE (Return on Equity), ROA (Return on Assets), and EPS (Earnings per Share) (Friede et al., 2015).

The bibliometric analysis (Figure 1) identified *environmental performance* as the most frequently studied dimension of ESG in agriculture, especially in terms of its impact on the financial outcomes of these companies. In the literature underpinnings, several vital studies provide a deeper understanding of this relationship, such as Chouaibi et al. (2021), which focus on researching the relationship between environmental disclosure in ESG companies and financial performance. Based on data collected from a sample of 523 companies listed on stock exchanges in North America and Western Europe, the authors analyse whether social and ethical practices have a moderating impact on this relationship. The main findings indicate that environmental disclosure positively correlates with financial performance in ESG companies. However, the role of social and ethical practices is identified as a moderating factor in this relationship, suggesting that these practices can influence how environmental disclosure affects financial performance in these companies.

Furthermore, different cultural and legislative environments can influence the effectiveness of ESG practices in achieving sustainability and enhancing financial performance.

Based on these key findings in the literature and related to the general research hypotheses proposed in the Introduction part and the methodology proposed, we introduce here the following hypothesis to assess:

H1a: Environmental sustainability component directly and positively influences agricultural companies' financial performance.

Regarding the ESG subdimensions, *social performance (S)* and *governance (G)* have a more favourable impact on corporate performance (Álvarez et al., 1998; Peasnell et al., 2005; Darko et al., 2016; Goel & Sharma, 2017) than environmental performance (E). Referring to the concerns in the literature, Porter and Kramer (2011) introduced the concept of “Creating shared value”, according to which companies can improve their financial performance by integrating and addressing social issues (safety and well-being of employees and the community) as part of corporate strategy. The authors have shown that this new approach contributes not only to enhancing the reputation of companies but also to achieving sustainability goals while ensuring financial stability. Similar concerns are also found in Zeng and Jiang (2023), who suggest that the social and governance dimensions of ESG have a much more substantial impact on the corporate performance of agricultural companies than the environmental dimension.

However, the bibliometric analysis (Figure 1) highlights a lack of studies focused on the social aspects of ESG in agriculture, suggesting an important research gap.

Based on these findings in the literature, we introduce here the following hypothesis to assess:

H1b: Social sustainability component directly and positively influences the financial performance of agricultural companies.

As visualised in the co-occurrence of the keywords used in the articles indexed in the Web of Science Core Collection (Figure 1), *governance, corporate and sustainability* are frequently used in identified studies.

This was further elaborated in the literature, emphasising that *governance credentials* drive sustainability outcomes. For instance, Zeng and Jiang (2023) analysed the impact of ESG on corporate performance in the context of 156 agricultural and forestry companies listed in China. The study examines how ESG influences corporate performance from three perspectives: governance, market, and company. The results obtained by the authors suggest that ESG performance and corporate performance are positively and significantly correlated, indicating that higher ESG ratings are associated with improved corporate performance.

Several studies (Cheng et al., 2014; Friede et al., 2015; Conca et al., 2021; Zeng & Jiang, 2023) show that in locations where there is a tight alignment between government regulations, stakeholder expectations, and corporate strategies, companies tend to report a more substantial impact of ESG initiatives on their performance.

Other authors obtained similar results (Qureshi et al., 2021; Chen et al., 2023), presenting evidence of a positive correlation between ESG performance and the financial outcomes of companies, proving that ESG can bring financial benefits, including increased stock value and attraction of investors interested in sustainability and governance aspects. Conca et al. (2021) investigated the impact of direct reporting on ESG aspects on listed agri-food companies in Europe. The authors analysed financial data and ESG reporting information from several agri-food companies listed on European markets. They examined how the quality of direct ESG reporting is associated with their financial performance, including indicators such as ROE and ROA. The results suggest that direct and transparent reporting of ESG aspects can benefit European agri-food companies by improving financial performance and market valuation.

In the specialised literature, several authors are concerned with researching gender diversity on corporate boards (Liu et al., 2014; Terjesen et al., 2016). At the European level, there is a trend of encouraging women's participation in corporate decision-making (Hawarden & Greenwood, 2021), with countries like Norway introducing a quota system for women's participation on the boards of agricultural companies (Brandth & Bjørkhaug, 2015). However,

the relationship between gender diversity and the financial performance of companies is not very conclusive, as empirical studies in the literature identify both a positive relationship (Lückerath-Rovers, 2013; Terjesen et al., 2016; Tleubayev et al., 2020) and a negative one (Adams & Ferreira, 2009; Ahern & Dittmar, 2012). In a study conducted on 261 agri-food companies in Russia, Tleubayev et al. (2020) showed a positive link between gender diversity and the financial performance of the companies in the sample. In contrast, the results obtained by Pavlović et al. (2018), following their analysis of 40 agricultural companies listed on the Serbian Stock Exchange, show a weak connection between financial performance (ROA) and the number of women on the board.

Based on these findings, we introduce here the following hypothesis to assess:

H1c: Governance sustainability component directly and positively influences the financial performance of agricultural companies.

ESG indicators are becoming increasingly important for companies across various sectors as they seek to balance sustainability and profitability. The specialised literature provides empirical evidence suggesting that companies with higher ESG ratings have better financial performance. This positive correlation between ESG and financial performance is well-documented in several studies.

However, there is still an ongoing debate on the relationship between ESG and financial performance, as it is unclear if ESG is the direct cause of better financial outcomes or if other factors are responsible for both. While some studies suggest that ESG practices are the primary factor behind better financial results, it is still uncertain whether ESG practices are the sole reason for these outcomes. It is possible that other factors, such as market conditions, regulatory frameworks, and company-specific factors, could also influence the financial performance of companies. The impact of ESG on the financial performance of firms from agriculture may not be immediate and could take a long-term approach. As a result, it is challenging to assess the short-term effects of ESG on the financial performance of such companies. The long-term impact of ESG practices on agricultural companies may become more evident over time, making it essential to consider both short-term and long-term effects.

While the literature provides evidence of a positive correlation between ESG and financial performance, it is still unclear whether ESG practices are the sole reason for better financial outcomes. As the bibliometric analysis revealed, companies need to consider both the short-term and long-term impacts of ESG practices to ensure that they align with their sustainability goals and financial objectives.

Based on the literature synthesis and the identified gaps, we propose the following research hypothesis:

H2: There are overall solid interlinkages between the ESG components and the outcomes of agricultural companies.

In a nutshell, the relationship between ESG and financial performance is a complex and multifaceted topic that has generated considerable interest among researchers in recent years. While there is growing evidence that companies adopting ESG practices can experience improved financial performance, many questions and disagreements still require further research to arrive at more precise and universally applicable conclusions.

In particular, research into the relationship between ESG and financial performance in the agricultural sector has shown that the impact of ESG practices on financial performance is contingent on a range of factors, such as the specific ESG practices adopted, the context

in which they are implemented, and the specific indicators used to measure financial performance.

Finally, the lack of uniformity and standardisation in ESG evaluation methodologies makes comparing results across different studies and industries difficult. Additionally, there is an issue with the quality and availability of data, as well as variations over time and between sectors, which can influence the outcomes of the authors' ESG analysis (Friede et al., 2015). These issues can affect the validity and reliability of conclusions drawn from the literature on the impact of ESG on the financial outcomes for businesses from agriculture.

Overall, the analysis reveals that the literature on agriculture and corporate social responsibility is diverse and covers a range of topics. Numerous studies have been conducted to explore this relationship. While some have found a positive correlation between strong ESG practices and better financial performance, others have found no clear link or even a negative correlation.

The differences in findings can be attributed to the varied contexts, methodologies, industry sectors (Figure 1), and countries analysed in these studies (Figure 2). Despite the diverse results, investors, regulators, and consumers alike are increasingly recognising the importance of ESG factors. Companies that prioritise ESG practices are likely to benefit from improved reputation, reduced risk, and enhanced financial performance in the long run.

3. Data and methodology

3.1. Data/indicators employed in the empirical analysis

Data were extracted from the London Stock Exchange Group of Companies [LSEG] Eikon Database (the former Refinitiv Eikon) according to the last available year (2023), including 147 companies operating in agriculture fields with headquarters in Europe, as presented in Table 1.

Table 1. Sample description – companies operating in agricultural fields with headquarters in Europe (source: LSEG, 2023)

Items	Descriptions
1. Fields/ sectors	Brewers, Consumer Goods Conglomerates, Distillers and Wineries, Fishing and Farming, Food Processing, Food Retail and Distribution, Household Products, Non-Alcoholic Beverages, Personal Products, Personal Services, Tobacco
2. Country of Headquarter	Austria (1), Belgium (4), Cyprus (1), Denmark (5), Faroe Islands (1), Finland (5), France (15), Germany (12), Greece (2), Hungary (1), Iceland (2), Ireland (6), Italy (6), Luxembourg (3), Malta (1), the Netherlands (6), Norway (9), Poland (2), Portugal (2), Russia (2), Spain (2), Sweden (9), Switzerland (9), Ukraine (2), the United Kingdom (39)

Variables comprised the following three groups of indicators (LSEG, 2023):

- *environmental indicators*: Policy Water Efficiency (PW_Ef) (TRUE – 1, FALSE – 0), Targets Water Efficiency (TW_Ef) (TRUE – 1, FALSE – 0), Toxic Chemicals Reduction (TCh_R) (TRUE – 1, FALSE – 0), Biodiversity Impact Reduction (BI_r) (TRUE – 1, FALSE – 0), Waste Recycled to Total Waste (WT_TW) (coefficient, 0–1), Total Waste to Revenues (TW_Rev) (million USD), Eco-Design Products (EcD_P) (TRUE – 1, FALSE – 0), Environmental Products (Env_P) (TRUE – 1, FALSE – 0);

- *social indicators*: Salaries and Wages from CSR reporting (SW) (USD), Turnover of Employees (TRN_Empl) (USD), Flexible Working Hours (FWH) (TRUE – 1, FALSE – 0);
- *governance indicators*: CEO Compensation Link to Total shareholder return – TSR (CEO_Comp) (TRUE – 1, FALSE – 0), Board Structure Type (BS_T) (Unitary – 2, Two-tier – 3, Mixed – 4), Board Gender Diversity (BG_Div) (%);
- *outcomes indicators*: "Return On Equity – Actual" (ROE) (%); "Return On Total Assets" (ROA) (%); "Earnings Per Share – Mean" (EPS) (USD).

Descriptive statistics of all indicators employed in the empirical analysis are presented in Table 2.

Table 2. Descriptive statistics of variables (source: LSEG, 2023)

Variables	N	Mean	Standard deviation (Sd)	Minimum	Maximum
PW_Ef	147	0.802	0.399	0	1
TW_Ef	147	0.428	0.496	0	1
TCh_R	147	0.224	0.418	0	1
Bl_r	147	0.503	0.501	0	1
WT_TW	77	0.769	0.214	0.1	1
TW_Rev	85	58.92	283.9	0.06	2613
EcD_P	147	0.129	0.336	0	1
Env_P	147	0.448	0.499	0	1
SW	36	2.23e+09	4.73e+09	24309.97	2.33e+10
SW_log	36	8.615	1.056	4.385	10.36
TRN_Empl	78	19.08	10.653	2.91	59.18
FWR	147	0.517	0.501	0	1
CEO_Comp	147	0.612	0.488	0	1
BS_T	147	2.306	0.518	2	4
BG_Div	147	31.21	15.043	0	75
ROA	143	0.050	0.075	-0.501	0.397
ROE	120	0.237	1.121	-0.857	12.32
EPS	130	21.56	217.29	-13.64	2478

Summary statistics highlighted notable differentials in terms of the financial performance of companies in the analysed sample, particularly as regards the earnings per share (EPS), but also concerning the specific ESG credentials, such as total waste to revenues (TW_Rev) salaries and wages from CSR reporting (SW), turnover of employees (TRN_Empl) or board gender diversity (BG_Div). These issues require tailored sustainable investment strategies to foster the economic benefits of companies operating in specific agricultural fields (such as food processing, consumer goods conglomerates, fishing and farming, food retail, and distribution).

3.2. Methodology

The methodological rationale relied on two advanced econometric procedures, namely cross-sectional FGLS regression models and Bayesian network analysis based on Gaussian Graphical Models (GGMs) and Gaussian Copula Graphical Models (GCGMs).

In the first stage, due to the variation of scale (the variance for each of the panels/units/companies differs) and because we assumed that the error terms of panels are correlated, we designed and estimated three linear regression models using FGLS. This method provides robust estimates even in the presence of AR(1) autocorrelation within panels, cross-sectional correlation, and heteroskedasticity across panels, common sources of endogeneity. Moreover, considering we have a relatively small sample, we used FGLS also because of its advantage in small sample settings, namely its ability to handle heteroscedasticity and autocorrelation. These issues, if uncorrected, can severely bias the results of OLS, especially in small datasets (Wooldridge, 2010). Even when the number of observations is relatively small, FGLS takes advantage of this, providing more robust estimates than classical regression techniques (Baltagi, 2008). Moreover, FGLS relies on asymptotic properties, but Monte Carlo studies show it can still perform well with small panels (Baltagi & Li, 1995). It adjusts the model to correct inefficiencies caused by small sample sizes through weighting matrices and iterative procedures. At the same time, another advantage of FGLS lies in its capacity to incorporate structural assumptions about the error covariance matrix, which mitigates bias arising from endogenous variables. By modelling the variance-covariance structure of the errors, FGLS reduces the inefficiency that results from correlated errors, a common issue when working with cross-sectional data (Wooldridge, 2010).

To configure the models in accordance with the primary objective of our research, we used three different proxies for company financial performance, namely ROA, ROE, and EPS, as alternative dependent variables. The explanatory variables were represented by numerous indicators capturing the environmental, social, and governance dimensions.

Secondly, to encompass a comprehensive outlook of the interlinkages and connections between all the indicators considered in this study, we performed a Bayesian network analysis, which had relied on designing and processing two types of models, namely Gaussian Graphical Models (GGMs) and Gaussian Copula Graphical Models (GCGMs).

Bayesian networks, particularly when combined through GGMs and GCGMs, provide a probabilistic framework that can effectively handle small sample sizes by incorporating prior information and constraints to infer the underlying structure of relationships among variables. Moreover, GGMs and GCGMs are well-suited to handling the complexities of endogeneity through their ability to model conditional dependencies among variables (Koller & Friedman, 2009). GGM allows for the modeling of conditional independence relationships among variables, which can be estimated even with small sample sizes if the graph is sparse (Meinshausen & Bühlmann, 2006). This sparsity assumption often holds in practical datasets, making Bayesian networks particularly useful when observations are limited.

Looking into the structure/methodological configuration, a graph G with p nodes determines the Gaussian graphical model for a random vector $X = (X_1, \dots, X_p)$. The model includes any multivariate normal distributions whose inverse correlation matrix fulfils that when no edge exists in G (Foygel & Drton, 2010). The undirected graph contains both vertex and edge sets (Williams, 2021).

Gaussian graphical models (GGMs) are designed to avoid spurious correlations and accurately depict conditional relationships in a network. They use an undirected network of partial correlation coefficients, which can be positive or negative. These coefficients are represented graphically through the width and saturation of the edges between nodes, giving a clear picture of the strengths of the relationships.

With their roots in path analysis, Gaussian graphical models imply a variance-covariance matrix that attempts to determine the relationship between variables, i.e., the direct and

indirect effects of one variable on another. In a Gaussian graphical model (also called a partial correlation network), positive partial correlations are usually represented by blue or green edges, and negative partial correlations are represented by red edges (Epskamp, 2016). The width and saturation of an edge indicate the absolute strength of a partial correlation. No edge is drawn between two nodes when there is no partial correlation between them. When two variables are independent after conditioning on every other variable in the data set, there is no edge, and the GGM can be understood as a network model of conditional relationships. Instead of modelling marginal connections, this enables us to model conditional associations, which we would expect to be zero (Meehl, 1990).

Summarizing, in a comparative approach and in line with the main purpose of our research endeavour, both cross-sectional FGLS regression and Bayesian network analysis through GGMs and GCGMs offered distinct advantages in handling small sample sizes and providing robust estimates. Hence, by using these two methods in combination, this study addressed endogeneity in both structural and probabilistic contexts. FGLS is particularly strong when the data contains autocorrelation or heteroscedasticity, and its ability to utilize information makes it a robust choice for small sample sizes. Bayesian networks, particularly through GGM, are efficient in settings where prior knowledge can be incorporated, and regularization methods are needed to avoid overfitting.

4. Results and discussion

4.1. Cross-sectional FGLS regression

To appraise the 1st hypothesis, *H1: There are direct and significant influences of the ESG components on the outcomes of agricultural companies*, we have first applied the FGLS regression models. More specific, we assessed the detailed hypothesis outlined in the literature review section, namely:

H1a: Environmental sustainability component directly and positively influences the financial performance in agricultural companies;

H1b: Social sustainability component directly and positively influences the financial performance in agricultural companies;

H1c: Governance sustainability component directly and positively influences the financial performance in agricultural companies.

Table 3 below detailed the results obtained after processing the FGLS regression models for each dependent variable, respectively, ROA – model (1), ROE – model (2), and EPS – model (3), for which probability > chi2 is 0.

Upon closer examination of the empirical evidence generated from our models, we observed that in the case of the *environmental indicators group*, estimations demonstrated that agricultural companies from Europe could positively and significantly impact their return on assets (ROA) (model 1) by adopting waste recycling (WT_TW) and eco-design products (EcD_P), as part of their CSR activities. Waste recycling actions may improve the financial outcomes of these companies by cost savings of waste disposal, converting waste into valuable secondary products or by improving resource efficiency by promoting the circular use of resources in the agricultural process. Conversely, including policy water efficiency (PW_Ef) and environmental products (Env_P) could have an unfavourable impact on their ROA. These

coordinates, water efficiency policies and the development of environmental products, while beneficial for sustainability, can have unfavourable impacts on the profitability of agricultural companies by investments (such as drip irrigation systems, water recycling equipment or advanced agricultural technologies) that can strain the financial resources of agricultural companies, especially smaller ones, leading to higher operational costs.

Table 3. Results for Cross-sectional FGLS regression, dependent variables ROA, ROE, and EPS (source: authors' contribution in Stata 18)

Variables	(1)	(2)	(3)
	ROA	ROE	EPS
PW_Ef	-0.0491** (0.0162)	-0.228*** (0.0538)	2.726 (1.752)
TW_Ef	-0.00421 (0.00910)	0.0177 (0.0267)	-2.009* (0.868)
TCh_R	-0.0180 (0.0106)	-0.0243 (0.0350)	1.001 (1.140)
BI_r	-0.00392 (0.0125)	0.0306 (0.0430)	-0.905 (1.399)
WT_TW	0.138*** (0.0226)	0.255** (0.0775)	10.07*** (2.524)
TW_Rev	0.0000374 (0.0000132)	0.000109** (0.0000393)	-0.00334** (0.00128)
EcD_P	0.0220* (0.00903)	-0.0495 (0.0287)	4.046*** (0.935)
Env_P	-0.0337*** (0.00920)	-0.00527 (0.0302)	-3.503*** (0.983)
SW_log	0.000497 (0.00414)	-0.00653 (0.0137)	0.776 (0.445)
TRN_Empl	-0.00134*** (0.000310)	-0.00125 (0.00106)	-0.127*** (0.0346)
FWR	0.0250* (0.0122)	0.134*** (0.0364)	-2.322 (1.187)
CEO_Comp	-0.0179 (0.0155)	0.0178 (0.0502)	-5.547*** (1.634)
BS_T	-0.0293* (0.0127)	-0.0265 (0.0250)	-3.037*** (0.814)
BG_Div	0.00110** (0.000377)	0.00614*** (0.00119)	0.0332 (0.0389)
_cons	0.0624 (0.0475)	-0.0550 (0.128)	3.101 (4.156)
Wald chi2(14)	141.94	140.53	108.57
Prob > chi2	0.0000	0.0000	0.0000

Note: Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

The results can be explained in the context of institutional theory and institutional logics. Thus, Garcia and Orsato (2020) suggest that companies' ESG performance is influenced both by the economic and financial environment and by companies' size, differences in local/

regional regulations, rules and policies. Annesi et al. (2024) suggest that companies may respond differently to sustainability pressures, even if they are subject to the same rules and regulations.

Model 2 showed that ROE was positively influenced by the inclusion of waste recycled to total waste (WT_TW) and total waste to revenues (TW_Rev). At the same time, it was unfavourably affected by water efficiency policy considerations (PW_Ef). Model 3 suggested that EPS was favourably influenced by applying waste recycled (WT_TW) and eco-design products (EcD_P), but unfavourably affected by targets water efficiency (TW_Ef), total waste to revenues (TW_Rev) and environmental products (Env_P). The explanations of these results can be justified by the fact that eco-design products often involve higher prices in the market. Customers, especially environmentally conscious consumers, may be willing to pay a premium for such products, thus increasing revenues for the agricultural sector. As regards targets water efficiency, these may imply high capital expenditures, such as advanced irrigation systems, which may reduce short-term profitability, negatively affecting EPS. Regarding producing environmental products, such as organic or sustainably grown products, usually involves higher production costs, such as the use of organic fertilizers and pest control measures. These higher costs can reduce profit margins, leading to lower net income and negatively impacting EPS.

Our results are consistent with institutional theory (Garcia & Orsato, 2020), which demonstrates that differences in institutional rules and regulations (e.g., water efficiency policies) can sometimes have a negative impact on profitability.

The results obtained suggested that sustainability practices, such as waste recycling and the use of green products, can have a significant positive impact on the financial performance of firms from agriculture sector, consistent with previous studies indicating that environmental initiatives can improve operational efficiency and reduce costs (Ferrero-Ferrero et al., 2016; Friede et al., 2015).

Observations that water efficiency policies have a negative impact on ROA can be analysed in the context of the time lags, company size or costs associated with implementing these policies. Although the results contrasted with the general assumption that resource efficiency always leads to improved financial performance (Kaplan & Norton, 2007; Porter & Kramer, 2018), it can be explained by the fact that implementing water efficiency policies often requires substantial initial investments. If these initial costs are significant, they can negatively affect the ROA, at least in the short term, because the increase in assets without an immediate increase in revenue reduces the profitability of these assets. Moreover, the payback period for the initial investments through savings generated by increased efficiency can be lengthy.

The hypothesis *H1a: Environmental sustainability component directly and positively influences the financial performance in agricultural companies* was partially fulfilled.

Regarding the *social group of indicators*, the estimated coefficient associated with flexible working hours (FWH) was positive and statistically significant, reflecting a favourable influence only on profitability expressed by ROA (model 1) and ROE (model 2), as other authors also proved (Conca et al., 2021; Ioannou & Serafeim, 2023). The explanation of this result is given by the fact that flexible working hours, or flexible work arrangements, offer employees more control over when they work, offering balance on their personal and professional responsibilities more effectively, which can positively impact productivity and ultimately profitability in agricultural companies. Instead, employee turnover (TRN_Empl) negatively influenced both profitability related to assets (ROA, model 1) and earnings of shareholders (EPS, model 3).

Based on these results, the hypothesis *H2a: Social sustainability component directly and positively influences the financial performance in agricultural companies* was, also, partially fulfilled.

Considering the *governance pillar of ESG*, board gender diversity (BG_Div) favourable influenced profitability, respectively, ROA (model 1) and ROE (model 2), while board structure type (BS_T) unfavourable influenced ROA (model 1) and EPS (model 3), and CEO compensation link to TSR (CEO_Comp) induced unfavourable results for EPS (model 3).

Gender diversity on the board can bring a variety of perspectives, experiences, and approaches, which may improve decision-making and innovation. The results obtained were in line with previous studies (Peasnell et al., 2005; Wang & Sarkis, 2017; Goel & Sharma, 2017) that suggested diversity can contribute to a better understanding of the market and customer needs, leading to more effective strategic decisions and improved financial performance.

The type of board structure can have an unfavourable impact on ROA and EPS if the structure impedes efficient dynamics or reduces the accountability of members. For example, a board with an inefficient structure or overlapping roles can lead to delays in decision-making or internal conflicts, thus affecting profitability (Darko et al., 2016). Additionally, a compensation relationship that focuses too much on TSR may encourage the CEO to pursue short-term increases in stock value, at the expense of long-term strategies. This can lead to decisions that sacrifice sustainable profits for quick gains, negatively affecting EPS, as other authors also proved (Goel & Sharma, 2017).

The hypothesis *H1c: Governance sustainability component directly and positively influences the financial performance in agricultural companies* was, as well, partially fulfilled.

To put in a nutshell, the 1st hypothesis, *H1: There are direct and significant influences of the ESG components on the outcomes of agricultural companies*, was partially fulfilled, since there were some ESG dimensions for which there was no established correlation with the outcomes of the agricultural companies.

4.2. Bayesian Network Analysis

For overall interlinkages, to assess the 2nd hypothesis, *H2: There are strong overall interlinkages between the ESG components and the outcomes of agricultural companies*, we have applied the Bayesian network analysis, based on the two models, *Gaussian Graphical Models (GGMs)*, respectively, *Gaussian Copula Graphical Models (GCGMs)*.

The results for *Bayesian network analysis, based on Gaussian Graphical Models (GGMs)*, represented in Figure 3 (and Figure A1 and Table A1 from Appendix), revealed low influences as regards ESG components with outcomes indicators, respectively, ROA, ROE, and EPS. Profitability expressed by ROA was favourably connected only with waste recycled to total waste contribution (WT_TW) and CEO compensation linked to TSR (CEO_Comp), as regards environmental, respectively, governance pillars. The explanation is that CEOs compensation tied to TSR are likely to emphasize efficiency, as higher profitability improves TSR. In agriculture, this could involve improving supply chain management, reducing waste, implementing precision agriculture technologies, or better resource management (e.g., water and energy). These improvements reduce operational costs and increase profit margins, leading to higher shareholder returns.

Related to equity, profitability expressed by ROE was positively associated with several environmental factors. These factors included the amount of waste recycled compared to total waste produced (WT_TW), the reduction of the company's biodiversity impact (BI_r),

and the company's efforts to improve water efficiency (TW_Ef). EPS was strongly linked to the reduction of toxic chemicals (TCh_R), as an environmental variable, and the compensation given to the CEO (CEO_Comp), albeit with less intensity in terms of the latter, which relates to the governance component.

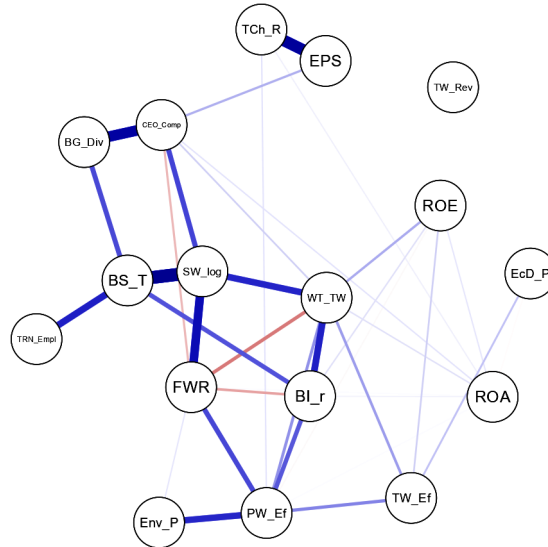


Figure 3. Bayesian Network Analysis results by applying GGMs (source: authors' contribution in JASP)

We noted that salaries and wages from CSR reporting (SW) were highly and positively associated with flexible working hours (FWH), waste recycled to total waste contribution (WT_TW), board structure type (BS_T) – which is, on average, of unitary type (the mean is 2.306122 in Table 2) – and CEO compensation (CEO_Comp) policy (the mean value in Table 2 is 0.6122449, respectively most companies apply this component of CSR). Also, the turnover of employees was highly and positively associated with agricultural companies' board structure type (BS_T).

The results for *Bayesian network analysis, based on Gaussian Copula Graphical Models (GCGMs)*, represented in Figure 4 (and Figure A2 and Table A2 from Appendix), revealed strong interlinkages between considered variables, namely ESG components and outcome indicators of agricultural companies. More precisely, profitability, expressed by ROA, was highly interconnected only with the environmental pillar of ESG, namely positive association with targets water efficiency (TW_Ef) and negative one with policy water efficiency (PW_Ef).

As measured by ROE, profitability was strongly correlated with the environmental group of indicators. Specifically, it was positively associated with the percentage of waste that is recycled (WT_TW) and the production of environmental products (Env_P), while it was negatively associated with policies related to water efficiency (PW_Ef). Regarding the social aspect of ESG, ROE was only positively linked to salaries and wages (SW). Regarding corporate governance, ROE was positively correlated with the inclusion of CEO compensation (CEO_Comp) in CSR policies, while it was negatively associated with the board structure type (BS_T).

Finally, the results reflected the complex nature of ESG, as discussed in the specialist literature by Nirino et al. (2021) and Zeng and Jiang (2023), who noted that not all ESG practices are uniformly beneficial and that their impact can vary considerably depending on company-specific and industry-specific factors.

The results showed the complexity of the relationship between ESG factors and the financial performance of agricultural companies. Moreover, these results were explained by institutional theory (Garcia & Orsato, 2020) which emphasizes the importance of the institutional framework in which companies operate under different sustainability rules and regulations. Equally, the results were also explained by institutional logic (Annesi et al., 2024), which confirms that companies can achieve different financial performance even within the same institutional framework, depending on the practices adopted.

The 2nd hypothesis, *H2: There are strong overall interlinkages between the ESG components and the outcomes of agricultural companies*, was also partially fulfilled since not all ESG credentials were interconnected with the outcomes of the agricultural companies.

5. Conclusions

This paper aimed to appraise the impact of the constituents of ESG – environmental, social, and governance – on the financial performance, expressed by profitability and shareholders' earnings, of agricultural companies with primary headquarters in Europe. The methodological rationale consisted of a two-fold approach: first, direct implications of ESG credentials on agricultural companies' outcomes were assessed by applying cross-sectional FGLS regression with generalized least squares (pooled OLS); second, overall interlinkages between considered variables, namely ESG credentials and agricultural companies' outcomes were evaluated through Bayesian network analysis, based on two models, Gaussian Graphical Models (GGMs) and Gaussian Copula Graphical Models (GCGMs).

The main results of the 1st hypothesis, *H1*, have entailed that the performance of agricultural companies *strongly and directly related* to environmental dimensions, as reflected by the positive connections between waste recycled to total waste contribution and eco-design products. As regards the social pillar of ESG, the financial outcomes of agricultural companies positively and directly related only to flexible working hours. At the same time, the governance group of variables favourably influenced these coordinates through the board's gender diversity.

Due to negative and direct connections of outcomes of agricultural companies with policy and targets water efficiency and environmental products – on environmental dimensions – turnover of employees – for social pillar – and board structure type and CEO compensation – as governance constituents – specific strategies on these directions have to be included by the agricultural companies, as follows: (i) although policy water efficiency is included by the agricultural companies (the mean value of it is 0.802, as reflected in Table 1), the targets for these are not considered for the majority of these companies (the average value of it is 0.428, as reflected in Table 1); (ii) raising the turnover of employees by further providing of flexible working hours and by applying technological innovations; and (iii) changing the board structures from unitary (the mean value of it is 2.306, associated with unitary structure, as reflected in Table 1) to two-tier or mixed types.

Overall, the interconnections of agricultural companies' performance with the main constituents of the ESG components, disclosed by the 2nd hypothesis, H2, evidenced significant and positive links between the environmental pillar and factors, such as waste recycled to total

waste contribution, biodiversity impact reduction, targets water efficiency, toxic chemicals reduction, and eco-design products. The social components of agricultural outcomes were only strongly associated with salaries and wages. As for the governance pillar, the only strong association was with CEO compensation, which can be explained by the factors like time lags, company size, or regional differences in regulations.

Our results attest that agricultural companies often face negative connotations concerning ESG standards, evidencing unfavourable overall associations of agricultural outcomes with ESG credentials. However, to counteract this, we design several policy/managerial directions and recommend implementing the following ESG investment strategies:

- maintain a steadfast water efficiency policy: water is a valuable resource, and agricultural companies can conserve it by implementing a water efficiency policy. This policy can include the use of precision irrigation technologies, reducing water waste, and recycling water;
- enhance the usage of environmentally-friendly products: as evidenced by Table 1, less than half of agricultural firms have implemented environmentally friendly products. However, it is essential to enhance the usage of such products as they can improve soil health, reduce environmental contamination, and promote the overall sustainability of the agriculture industry;
- reevaluate the board structure: A company's board structure can directly impact ESG outcomes. Agricultural companies should reevaluate their board structure and ensure that it includes diverse members with a strong understanding of ESG principles. Additionally, the board should establish ESG goals and regularly monitor their progress.

The relatively small number of observations could represent a limitation of the study, having potential biases in ESG reporting, and the time gap between ESG investments and the outcomes of the companies. These limitations could underestimate the true impact of ESG components on financial performance and restrict the generalizability of the results. Therefore, future research will encompass a broader coverage and granularity of data that is more prone to unveil the amplitude and complexity of the ESG fundamentals, and we will develop the ESG implications within the frameworks of the institutional theory, institutional logic, stakeholder and legitimacy theories.

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Roles/Writing – original draft; and Writing – review & editing. Raluca Mihaela Drăcea: Conceptualization; Formal analysis; Investigation; Resources; Roles/Writing – original draft; and Writing – review & editing. Andreea-Oana Iacobuță-Mihăiță: Conceptualization; Formal analysis; Investigation; Resources; Roles/Writing – original draft; and Writing – review & editing. Tomasz Dorożyński: Conceptualization; Formal analysis; Investigation; Resources; Supervision; Validation; Roles/Writing – original draft; and Writing – review & editing.

Disclosure statement

The authors declare they have no competing financial, professional, or personal interests from other parties.

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APPENDIX

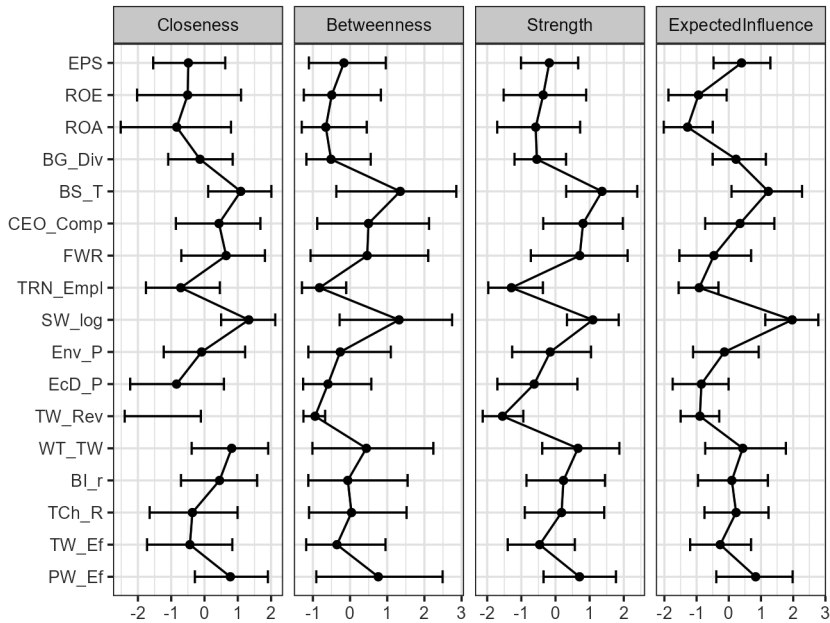


Figure A1. Centrality plot for GGM results (source: authors' research in JASP)

Table A1. Centrality measures per variable for GGM results (source: authors' research in JASP)

Variable	Network			
	Betweenness	Closeness	Strength	Expected influence
PW_Ef	0.759	0.776	0.704	0.834
TW_Ef	-0.353	-0.438	-0.463	-0.266
TCh_R	0.039	-0.363	0.178	0.227
BI_r	-0.062	0.453	0.234	0.094
WT_TW	0.438	0.817	0.658	0.434
TW_Rev	-0.942	-0.145	-1.551	-0.897
EcD_P	-0.594	-0.839	-0.624	-0.851
Env_P	-0.265	-0.086	-0.153	-0.136
SW_log	1.319	1.331	1.094	1.967
TRN_Empl	-0.822	-0.713	-1.291	-0.919
FWR	0.460	0.650	0.711	-0.462
CEO_Comp	0.496	0.435	0.807	0.350
BS_T	1.350	1.089	1.362	1.226
BG_Div	-0.513	-0.135	-0.546	0.224
ROA	-0.652	-0.833	-0.579	-1.280
ROE	-0.492	-0.506	-0.359	-0.940
EPS	-0.166	-0.485	-0.182	0.396

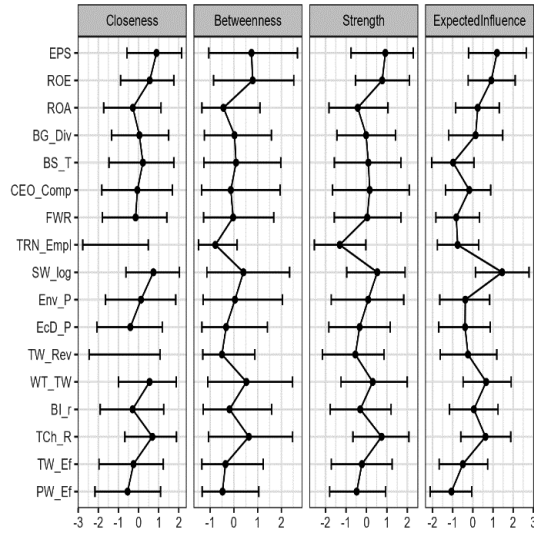


Figure A2. Centrality plot for GCGM results (source: authors’ research in JASP)

Table A2. Centrality measures per variable for GCGM results (source: authors’ research in JASP)

Variable	Network			
	Betweenness	Closeness	Strength	Expected influence
PW_Ef	-0.481	-0.543	-0.478	-1.061
TW_Ef	-0.357	-0.253	-0.223	-0.494
TCh_R	0.629	0.687	0.738	0.627
Bl_r	-0.185	-0.297	-0.305	0.051
WT_TW	0.526	0.549	0.305	0.662
TW_Rev	-0.505	-0.190	-0.544	-0.240
EcD_P	-0.330	-0.407	-0.334	-0.387
Env_P	0.043	0.122	0.084	-0.376
SW_log	0.401	0.739	0.528	1.454
TRN_Empl	-0.783	-0.345	-1.309	-0.755
FWR	-0.034	-0.147	0.038	-0.822
CEO_Comp	-0.131	-0.058	0.157	-0.177
BS_T	0.091	0.217	0.093	-0.977
BG_Div	0.025	0.042	-0.016	0.136
ROA	-0.443	-0.280	-0.427	0.244
ROE	0.792	0.557	0.769	0.915
EPS	0.741	0.893	0.924	1.200