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Management of companies' green competitiveness: Coordination degree between core determinants

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Abstract

Companies' green competitive advantages result from the high coordination of economic, ecological, social and corporate subsystems. Thus, it is important to investigate the influence and coupling coordination degree (CCD) of the relevant components of green competitiveness. This paper justifies the relationship between green competitiveness and the coupling degree of its components. It hypothesizes that the increasing integrated index of companies' green competitiveness was determined by levels of coordination and communication between its components. The study applies the CCD model and correlation analysis to test the hypothesis. The objects of analysis were enterprises represented by three economic sectors: agro-industrial, mechanical engineering and food. The findings show that the highest coupling coordination degree among all components is represented by the companies with the highest green competitive index. These companies are characterized by the dominance of corporate components, which can increase the general level of green competitive advantages in various combinations with other determinants.

Keywords: *sustainable development, green competitiveness, coupling, assessment.*

JEL Classification: O1, Q5, Q56

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1 INTRODUCTION

Global environmental problems are becoming a massive barrier to sustainable development, spreading energy and economic crises, damaging the ecosystems and decreasing the competitiveness of countries and enterprises. According to the OECD report, air depletion would cost USD 3 trillion per year. In addition, air pollution could provoke 9 million premature deaths, which will lead to a huge increase in welfare spending (Ziabina et al., 2020). At the same time, multi-level economic competition (between countries, regions, industries, and companies) is becoming stronger in globalization, from the allocation of energy and raw materials, capital, and dividends to innovative and developing policies. Consequently, managing and resolving energy, resource, economic and environmental crises and developing companies' green competitiveness (GC) are becoming urgent issues facing government management, the business sector, and the academic community. On the other hand, green processes are deepening, and GC must become a new power for enterprises in solving economic and environmental problems, energy and resource utilization. Consequently, it boosts the rethinking of the companies' activities in the way of implementing sustainable projects and programs. The GC of enterprises is a complex category determined by a number of factors, among which the main are energy, economic, environmental, and social determinants. It is defined as the ability to build and use the companies' environmental advantages, the potential for implementation of sustainable projects, renewables, and green business ideas, the strengthening of investment attractiveness, formation of the green corporate culture, green image and brand (Yang et al., 2021). At the same time, it is important to study the influence of coupling coordination degree (CCD) of the relevant components of GC.

The paper has the following structure: the literature review contains the analysis of the theoretical landscape of the GC assessment's approaches and core determinants; methods and methodology describes the applied variables, methods and models to achieve the paper's aims; results explains core empirical results on the interconnection between the level of GC and the coupling of its components; conclusion – a comparison analysis of the obtained findings with the results of the previous investigations; the final section explains the core findings, defining limitations and further directions of investigations.

2 THEORETICAL BACKGROUND

2.1. The approaches for GC assessment

The approaches and strategies for implementing the sustainable and competitive innovative development have been often analysed (Zaloznova et al., 2019; Vysochyna et al., 2021; Polcyn, 2021; Kwilinski, 2018b; Kuzior, 2021; Dzwigol and Dzwigol-Barosz, 2020; Bilan et al., 2019; Saher et al., 2021). They were investigating the ways environmental and economic instruments influence social and economic development. Traditionally, the analysis of GC is provided at the macro level and includes the following assessment groups: global competitiveness of national economies; the GC of countries; the competitiveness of regions, and the sectoral GC. The methodology used in the calculations of the Global Sustainability Competitiveness Index (Solability, 2021) is the so-called three-dimensional model of sustainability, which combines the economic component, the determinants of environmental quality and society. It is used to assess and manage the sustainability and performance of economic systems. The scientific and methodological approach was proposed by Zang et al. (2020) and offers components of a system for assessing sustainable competitiveness. This system is built on five main components (green quality development, resource conservation, pollution decreasing, quality of the urban environment, green culture, and sustainable investments) and is based on science, comprehensiveness, representativeness, and efficiency. According to this approach, GC is mainly determined by the technological industrial level, production efficiency and economic growth, green investment, and consumption at the national economy level. Scientists (Zeng et al., 2014; Cheng et al., 2018; Chen et al., 2019; Charles et al., 2014) have proposed a methodology for assessing GC for individual regions and provinces, which includes seven key components of cluster development: natural potential, the quality of the natural environment, energy consumption and energy conservation, the level of renewables development, economic and social stability of the regions, the availability of relevant infrastructure, and the level of population health. At the same time, researchers (Cheng et al., 2019) have proposed making important improvements in the GC assessment. According to such an approach, this model should be based on a systematic analysis to provide new perspectives for empirical research on regional GC. The appropriate approach expands the range of research from production to the consumer side, and the spatial characteristics and dynamic indicators offer the basis for evaluating the long-term and dynamic effects of green competitive regional development. Other researchers (Kamierczak-Piwko et al., 2019; De Mendonca et al., 2019; Duffett et al., 2018) have identified two key metrics for assessing GC: 1) sustainable development, which is proposed to be assessed by the economic (countries' competitiveness, green development, social, economic, and commercial policy, etc.) and industrial development (occupational safety, staff health, environmental quality management, sustainable corporate culture, green logistics, etc.); 2) green environment (eco-management and management of toxic substances, environmental design, green labelling). Okanović et al. (2021) proposed assessing educational institutions' GC and emphasised that an appropriate system should include an analysis of the resilience of university campuses (energy use, green buildings, recycling, renewables, green transportation, waste, water, food, and processing). The researched scientific and methodological approaches to assessing GC largely pay attention only to the macroeconomic and regional aspects of assessing green competitive advantages. The existing scientific background only partially characterizes the assessment of the GC of enterprises. Thus, Wang et al. (2021) used a casual and multi-level clustering analysis to evaluate and compared GC in industrial enterprises in urban areas. Mao (2021), to emphasize the democratic determinants in decision-making processes, used the assessment approach of GC based on affiliated persons' perspectives. Hu (2018) evaluated the textile industry's GC in the province of Zhejiang through an assessment of four dimensions: environmental, resource, capability, and knowledge. At the same time, there are no systemic approaches that characterize a company's GC assessment. Thus, it is quite relevant to propose a methodology that will define the level of GC of companies.

2.2. GC: economic determinants

Previous experience suggests that the main determinants of a company's GC are connected with economic, environmental, and social factors (Bilan et al., 2020; Dagilienė et al., 2020; Dementyev & Kwilinski, 2020; Didenko et al., 2020; Kolkova, 2020; Kwilinski, 2018b, 2020; Vasylieva et al., 2021; Bai et al., 2019; Mentel et al., 2020). Fankhauser et al. (2013) identified success factors for GC at the economy sector's level. Such indicators include the speed of conversion to green production, the implementation of green innovation, and the current production output. Wang et al. (2020) investigated at the macro level and demonstrated the green economic tools' influence on economic indicators of national economies and the competitiveness of enterprises. They proved that there is a link between the set of determinants: technological, social, economic, and environmental. These basic factors of sustainable development were analysed with the help of the Kuznets concept. The results of the investigation describe the non-linear relationship between indicators of companies' activity and nature degradation. Past studies (Dzwigol, 2019; 2020) substantiated the essence and features of the influence on countries' competitiveness in the leading economic processes and indicators. Dzwigol also explored, and generalised approaches to modelling companies' strategies in the condition of “Industry 4.0,” in which all processes have to be intensified, and the efficiency and profitability of economic activity is a quite relevant indicator. Thus, authors (Vasylieva et al., 2021; Baydas et al., 2021) described the energy and resource efficiency and analysed the interconnection between competitive development, green investment, and the energy gap scale. Some approaches (Wang et al., 2022; Li et al., 2021) advised utilising modern competitive strategies to increase organisational performance and lead to sustained competitive advantages in the market environment. Liu et al. (2022) analysed the influences of investment on GC in China's industrial sector, using a panel dataset to evaluate the production sector's provincial competitiveness. Based on analysis, the following economic indicators that affected companies' GC could be identified: the output of goods and services (as a factor that determines the primary objective of a business process), companies' profit (as a component, which characterises the efficiency of companies' activity), attracted green investments (describe the level of funding green innovation), energy intensity (assess the energy consumption by manufacturing sector), resource intensity of production (as a dimension of the scale resource using (e.g., spatial, mineral, water) necessary for the production cycle, which also includes processing, disposal, and recycling.

2.3. GC: ecological determinants

Miśkiewicz (2021) emphasised that the increasing negative anthropogenic effects lead to an imbalance mostly in all sectors of the national economy. By analysing levels of environmental pollution and checking the hypothesis that competitive technology allows for reducing greenhouse gas emissions, he proved that a set of issues, connected with the different aspects of the national economy, could be decided. Agyabeng-Mensah and Tang (2021) described the role of renewables and green logistics in building GC and achieving higher economic, social, and environmental indicators. Borchers et al. (2021) investigated the preconditions of appearance and types of Lasswell’s impacts, which create a basis for an efficient communication process for implementing green technologies and developing a green competitive environment. For supporting environmental competitiveness, many scholars (Coles et al., 2015; Dey et al., 2020; El Amri et al., 2021; He, 2019; Kharazishvili et al., 2021) have analysed the modern strategies and instruments for implementation of recycling and resource-saving technologies. Findings of green eco-policy tools (Huseynov, 2021; Kozlov, 2021; Kwilinski, 2018b) indicate the feasibility of their use to increase the level of renewables and to build and strengthen the advantages, which will lead to forming a green competitive businesses sphere. Liu et al. (2022) analysed the significant factors in developing an innovative way of waste treatment, concluding that funding energy, resource-saving, and recycling are the core elements in improving production competitiveness. The experimental results obtained by Paladino and Neviani (2022) confirm the high quality of bioenergy in the sphere of companies' energy consumption and prove the GC of this sustainable process on a macro level. Hildenbrand et al. (2021) analysed the features of implementation of circular economy principles and mechanisms in Nordic countries for enhancing GC and developing a green economy. They justified the empirical relevance of resource recirculation strategies. Hence, the following ecologic indicators that affected companies' GC could be identified: the share of renewables in the national economy energy consumption (as an indicator of climate-neutral technologies implementation and sustainable green transition), the indicators of air pollution, the number of used and depleted water resources, the amount of waste (as an indicator of climate impact), the level of wastewater treatment (as an indicator of the level of removal of contaminants), and indicators of recycling processes (as an indicator that reflects reducing the harmful disruption and damage being done to the environment).

2.4. GC: social determinants

Serniak et al. (2021) concluded that neglecting the social indicators as an important factor in forming an enterprise's advantages and increasing its competitiveness is decreasing the processes of implementing sustainable projects and programs of an enterprise. They used a comprehensive set of indicators that characterised the quantitative and qualitative aspects of human resource management at enterprises, such as gender structure, employee training and development funding, social infrastructure, etc. Muisyo et al. (2022) demonstrate that environmental HR management practices enhance the firm's GC. They studied how companies can build green competitive advantages based on green leadership, message trust, peer involvement and employee potential. Wang et al. (2022) assessed a combined framework, which describes the set of relationships between social innovation strategies and GC. The empirical conclusions of the investigation emphasize that social innovation strategies have a positive influence on developing companies' GC; providing training and additional education for employees and green knowledge sharing enhance GC and the implementation of their environmental innovation strategies. Lo et al. (2021) emphasised that knowledge sharing and training for companies' staff are the most important processes in gaining competitive advantages. Barrymore et al. (2022) investigated how the gender structure of companies' staff is a driver that changes competitiveness. They found that established rewards for men and women eliminate the gender competitiveness gap. They also noted that, from this point of view, gender influences the main characteristics of companies' stakeholders as persons who can create and promote the preconditions for the companies' GC. Rožmanet et al. (2022) showed that eco-friendly working conditions lead to better well-being, enhance work engagement, and, as a result, increase sustainable benefits and competitiveness. Their analysis allows for forming a set of indicators that describes the social component of companies' GC: the number of staff (as a driving force for developing companies' GC), the gender structure of the employees (as an indicator which describes gender involvement), the level of funding for employee education, training, and development expenses (as an indicator that accelerates green companies' competitiveness), social infrastructure costs (as an indicator that helps to optimise quality of business processes and support green competitive advantages), the morbidity rate and several accidents at work (which characterise the level of production process security).

2.5. GC: corporate determinants

Asif et al. (2022) substantiated the role of transparency and trust in Industry 4.0 and corporate environmental management within sustainable development. They analysed the processes of monitoring and auditing to improve their competitiveness. Muisyo et al. (2022) used the ability motivation opportunity theory to substantiate that developing GC is impossible without green culture, motivated management, and green trust. Amini et al. (2018) concluded that a deep understanding of the core elements of environmental policy motivates companies' GC, and sustainability and such tendencies are observable in certain industries. Dey et al. (2020) investigated lean management practices and environment-targeted ownership structures to help SMEs be environment-friendly and develop green competitive advantages. Using the SmartPLS modeling, Szász et al. (2021) concluded that the efficiency of the management system, particularly, the board of directors, has a positive impact on increasing the sustainability and GC of automotive companies. Wu and You (2022) investigated the relationship between the risk of stock price crashes and corporate green technological innovation. They found that stock price crashes are not linked to the quantity of green technology innovation but are negatively correlated to the quality of green technology innovation. Finally, Alves and Alves (2015) analysed a system of companies' corporate management that integrates the approaches of lean manufacturing and greening, based on providing a green culture and environmental policy. Thus, a set of indicators was determined, which characterised the environment-oriented corporate management system that influenced companies' GC: transparency of reporting (as an indicator that allows all stakeholders to analyse the results of companies' activities, as positive and negative), ownership structures (as an indicator that can determine the ways of green corporate strategies), the efficiency of the board of directors (as an indicator that describes the board alignment around ways and issues for developing companies' GC), level of environmental culture (as a guidepost, which indicates the company's possibility to practice green responsibility every day and implement green initiatives), and availability of environmental policy (as an indicator of how companies manage and monitor their impact on the environment).

2.6. Coupling coordination degree of the GC of enterprises

A certain level of GC results from the coordination of its components: economic, environmental, social, and corporate. Existing studies in coupling coordination degrees now broadly characterise the regional and sectoral level of development. Thus, it is quite important to assess the CCD between the main determinants of GC of enterprises. Li et al. (2012) assessed the level of their coordination using the coupling technique, which is a multi-stage model for estimating the level of coupling and relationships between components of the system. According to Tang (2015), the category of coupling describes the degree of strength of the relationship of elements within the system and determines the method and degree to which the tasks performed by the complete subsystem are related. Cao (2022) found a difference in CCD when it comes to the optimisation of financial stability and the promotion of economic expansion. Tang (2022) adopted the InVEST model and linear weighted sum method to research the CCD between the urbanisation level and improving regional development, environmental quality, and sustainable cities development. Zhang et al. (2022) concluded that combining the theory of affiliated persons and CCD allowed for assessing the sustainability of the tourism sphere. Chen et al. (2022) used an improved CCD model for assessing the linking between mineral resource exploitation, economic indicators and environmental pollution. They concluded that the CCD determined conditions in Chinese provinces with an increasing trend, but that there is the potential for future improvements in Shanghai.

Considering these analyses, this paper will justify and empirically confirm the interconnection between the level of GC and the coupling of its components. In this case, the research hypothesis is as follows:

Hypothesis 1*: The coupling of economic, environmental, social, and corporate components effect a company’s GC.*

3 RESEARCH OBJECTIVE, METHODOLOGY AND DATA

The study applied two core stages to estimate the interconnection between the level of GC and the coupling of the components. The first stage was the evaluation of the companies' GC. The second was an estimation of the CCD of companies’ GC. The object of investigation was Ukrainian companies from 2001 to 2019. These companies represent the sectors that are the base of economic development and were grouped by industry: agro-industrial companies, mechanical engineering companies, and food companies. The data were generated from the following: internal analytical reports of companies, the information portal of the Agency for Infrastructure Development of the Stock Market of Ukraine, the National Industrial Portal, and the information portal of the Center for Environmental Initiatives "Ecodia". The study applied EViews 12.0 for empirical calculations.

3.1 Assessing Companies’ GC

To evaluate the integrated level of GC, the paper proposes an entropy approach that involves the assessment of companies' GC depending on the coupling degree of subsystems (economic, social, environmental, corporate) management. The entropy weight (ω) method is used in the multi-criteria decision analysis (Shi et al., 2020; Cheng et al., 2019). It aims to find the most balanced and diverse set of criteria weights by maximizing the entropy of the decision matrix. The process involves calculating the entropy for each criterion based on the values and scores in the decision matrix. By using the entropy method, decision-makers account for the diversity and balance among different criteria, avoiding biases and giving more objective consideration to each criterion's contribution (Li et al., 2022; Zou et al., 2022; An et al., 2022). The methodology of the entropy method was applied based on the studies (Yang et al., 2021) and previous investigations. In this study the entropy method is based on assessing the relationship between a significant number of objects and the system of indicators of GC, which consists of determining the level of entropy of its indicators, the degree of variation, probabilistic nature, and asymmetry of exogenous information (Fig. 1). The scale for companies' GC was 0 (low level) to 1 (high level). Figure 1 contains the algorithm for assessing a company's GC.

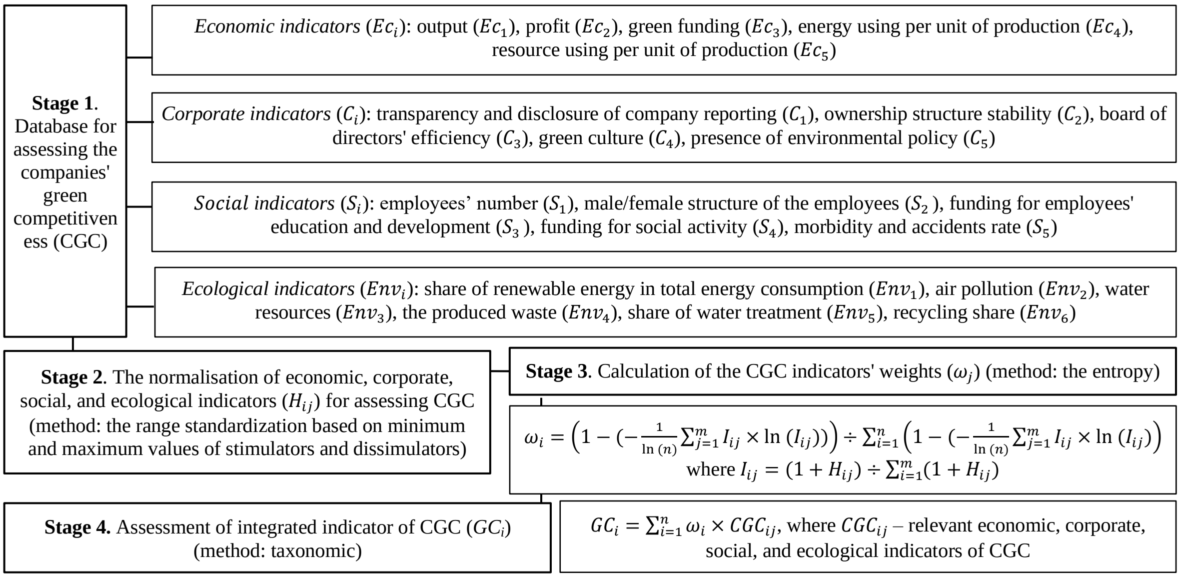


Fig. 1 – Methodology of integrated assessing the companies’ CGC
Sources: own research.

Table 1 presents the descriptive statistics of the indicator for enterprises' GC.

Tab. 1 – The descriptive statistics of the indicator of enterprises' GC

Var	Mean	St. dev	Variance	Max	Var	Mean	St. dev	Variance	Max
Economic indicators					*Social indicators*				
Ec_1	2.30×10^9	3.91×10^9	1.53×10^{19}	2.40×10^{10}	S_1	4781.05	7604.45	5.78×10^7	30200
Ec_2	4.81×10^8	1.12×10^9	1.25×10^{18}	8.92×10^9	S_2	44.27	7.43	55.32	59
Ec_3	1.82×10^7	3.75×10^9	1.41×10^{15}	2.34×10^8	S_3	1828312	3294828	1.09×10^{13}	2.18e×10^7
Ec_4	0.21	0.27	0.07	4.24	S_4	5897477	1.87×10^7	3.50×10^{14}	2.03×10^8
Ec_5	0.52	0.83	0.69	14.14	S_5	4.11	1.35	1.83	7
Corporate indicators					*Ecological indicators*				
C_1	60.98	14.63	214.00	85.00	Env_1	4.86	10.13	102.81	89
C_2	0.90	0.28	0.08	1.00	Env_2	50013.9	126715.4	1.61×10^{10}	860000
C_3	0.90	0.28	0.08	1.00	Env_3	73424.06	216774.5	4.70×10^{10}	1068382
C_4	0.90	0.29	0.08	1.00	Env_4	45659.29	63618.46	4.05×10^{09}	218148.1
C_5	0.85	0.33	0.11	1.00	Env_5	74.45	16.70	278.95	99
					Env_6	64.32	14.11	199.21	98

St. dev – Standard deviations; Var – variable.
Sources: own research.

3.2 Assessing the coupling coordination degree of the GC of enterprises

The increasing integrated index of a company's GC is due to coordination and communication between its components. To confirm this hypothesis, a three-level approach was developed based on the coordination coupling model and correlation analysis. The methodology of the assessment CCD of a company's GC is built on the scientific background proposed by Shi (2019), which includes two blocks: assessment of the CCD between economic, environmental, social and corporate components of GC; comprehensive assessment of the level of coupling between all groups of indicators of GC.

Assessment of the CCD contains two steps:

1. Estimation of the level of coordination between j-th subgroups of CGC indicators (formula 1) and level of the relationship between the components of CGC (formula 2):

$$T_{ij} = (q_i \times f_i + q_j \times f_j)^{1/2} \quad (1)$$

$$T_{ij} = \sum_{i=1}^{n} (\frac{1}{\mathrm{n}} \times f_{\mathrm{n}})^{\frac{1}{\mathrm{n}}} \quad (2)$$

2. Estimation of the level of the relationship between the j-th subgroups of CGC indicators (formula 3) and coordination between the components of CGC (formula 4):

$$C_{ij} = \left(\frac{f_i \times f_j}{[(f_i + f_j)/2]^2}\right)^{1/2} \quad (3)$$

$$C_{ij} = \left(\frac{f_1 \times f_2 \times f_3 \times f_4 \times f_5}{[(f_1 + f_2 + f_3 + f_4 + f_5)/5]^5}\right)^{1/5} \quad (4)$$

3. Assessment of the level of coupling (formula 5):

$$D_{ij} = \sqrt{C_{ij} \times T_{ij}} \quad (5)$$

The hypothesis of the interconnection between the integrated index of GC and the coupling degree of its components is checked by the Pearson coefficient (Rodgers, 1998):

$$r_{xy} = \frac{\sum_{i=1}^{m} (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{m} (x_i - \bar{x})^2 \sum_{i=1}^{m} (y_i - \bar{y})^2}} = \frac{cov(x,y)}{\sqrt{s_x^2 s_y^2}} \quad (6)$$

where $\bar{x}, \bar{y}$ – sample averages xm and ym; s_x^2, s_y^2 – selective variances, $r_{xy} \epsilon$ [-1;1].

4 RESULTS AND DISCUSSION

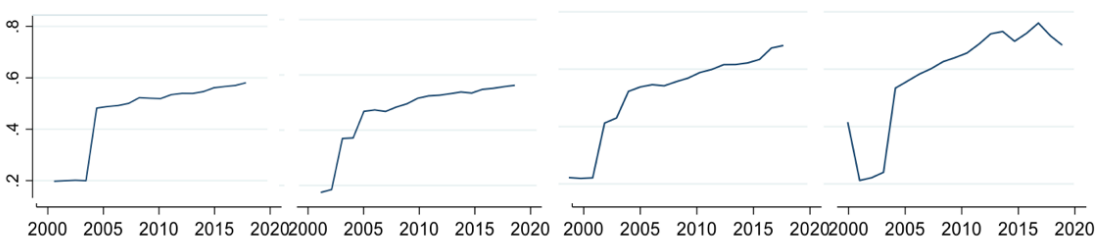
The enterprise's selected objects of analysis are powerful business entities (significant corporate associations), which have their history, closed production cycle and strong traditions of production and marketing. The practical application of the proposed methodology for evaluating the indicator of GC allowed us to obtain the following results (Table 1-4, Figure 2-4). Based on the data normalization, the entropy coefficients of each indicator of GC were calculated (Table 2).

Tab. 2 – The entropy of components of the indicator of enterprises' GC

Industry	**Economic Indicators**					
	ω_{Ec1}	ω_{Ec2}	ω_{Ec3}	ω_{Ec4}	ω_{Ec5}	
Agro-industrial companies	0.036	0.036	0.031	0.010	0.004	
Mechanical engineering companies	0.036	0.029	0.028	0.017	0.019	
Food companies	0.035	0.047	0.049	0.045	0.045	
Industry	**Social Indicators**					
	ω_{S1}	ω_{S2}	ω_{S3}	ω_{S4}	ω_{S5}	
Agro-industrial companies	0.067	0.038	0.036	0.021	0.018	
Mechanical engineering companies	0.071	0.0273	0.046	0.046	0.037	
Food companies	0.037	0.0554	0.025	0.025	0.047	
Industry	**Ecologic Indicators**					
	ω_{Env1}	ω_{Env2}	ω_{Env3}	ω_{Env4}	ω_{Env5}	ω_{Env1}
Agro-industrial companies	0.057	0.055	0.044	0.043	0.061	0.057
Mechanical engineering companies	0.065	0.072	0.061	0.095	0.031	0.065
Food companies	0.052	0.048	0.054	0.071	0.030	0.052
Industry	**Corporate Indicators**					
	ω_{C1}	ω_{C2}	ω_{C3}	ω_{C4}	ω_{C5}	
Agro-industrial companies	0.061	0.094	0.055	0.055	0.042	
Mechanical engineering companies	0.034	0.029	0.065	0.072	0.061	
Food companies	0.034	0.054	0.054	0.050	0.056	

Sources: own research.

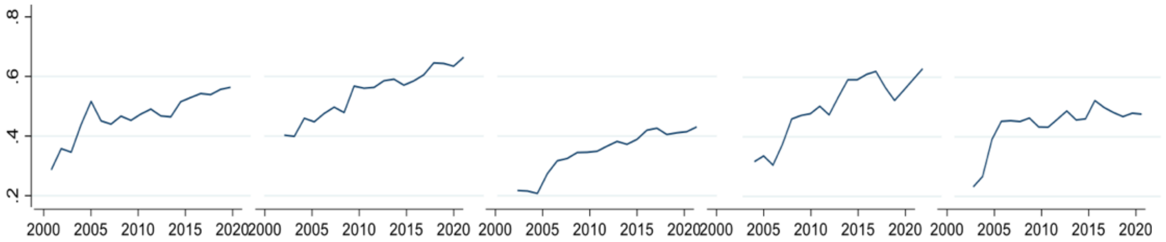
The results of practical calculations presented in Table 1 show that the share of indicators is different for different industries and determines the differentiated level of impact on the integrated indicator of GC. The highest importance for the agro-industrial complex was indicators of ownership structure (ω_j = 0.094, corporate component) and number of staff (ω_j = 0.067, social component); for mechanical engineering and the food industry – the highest importance was the amount of waste (ω_j = 0.095 and ω_j = 0.071 respectively, the environmental component). Figure 2 represents the visualization of companies' GC calculations in 2001–2019, where PrJSC "Oril-Leader" is the leader in their sector in developing green competitive advantages.



(a) (b) (c) (d)

Fig. 2 – The result of the visualization GC evaluation for agro-industrial enterprises
(a) – SPF Urozhay LLC; (b) – PrJSC APK-Invest; (c) – PrJSC Oril-Leader; (d) – PrJSC Myronivsky Hliboproduct
Sources: own research.

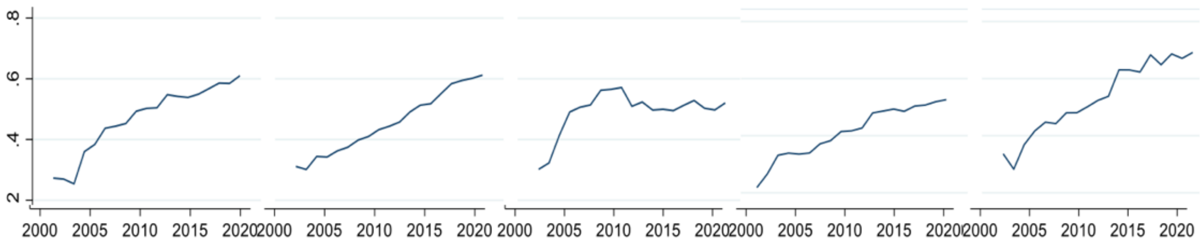
This trend is explained by the existence of an effectively functioning environmental management system, product quality control, implementation of environmental standards and norms, a high level of environmental investment (PrJSC “Oril-Leader” is a leader in biogas technology, etc.), and significant funding for the social sphere. Note that the agriculture complex has many possibilities for boosting the GC of enterprises through the implementation of renewables and recycling and green corporate standards. A graphical interpretation of the results of practical calculations for the food industry is presented in Fig. 3.



(a) (b) (c) (d) (e)

Fig. 3 – The result of the visualization GC evaluation for food enterprises
(a) – PrJSC Danon Kremez; (b) – PJSC Wimm-Bill-Dann Ukraine; (c) – PrJSC Kremenchukmyaso; (d) – PrJSC Mondelez Ukraine; (e) – PrJSC Vinnitsa Confectionery Factory
Sources: own research.

According to calculations for 2001-2019, the leading company in the food industry is the company PJSC "Wimm-Bill-Dann Ukraine" (GC = 0.66), which implemented a quality management system and improved safety of production activities based on the requirements of the international standard ISO 9001 and ISO 22000. The lowest value of the indicator of GC for the food industry at the end of 2019 is typical for PJSC "Kremenchuk Milk Plant" (GC – 0.56). The graphical visualisation of the results of the GC evaluation for 2001–2019 is represented in Fig. 4. It shows that, since 2012, the leader was PJSC Motor Sich (GC index – 0.69).



(a) (b) (c) (d) (e)

Fig. 4 – The result of the visualization GC evaluation for mechanical engineering enterprises
(a) – PrJSC SKF Ukraine; (b) – JSC Ukrainian Energy Machines; (c) – PrJSC Zaporizhia Automobile Building Plant; (d) – JSC Nasosenergomash Sumy; (e) – JSC The Motor Sich
Sources: own research.

Note that all analysed companies have a vast potential for developing GC through implementing the set of economic, ecologic, social, and corporate events and instruments. The appropriate level of GC results from the not-so-high coordination of its components: economic, environmental, social, corporate, and marketing. The results of CCD assessment between economic, environmental, social and corporate components of GC for enterprises from different industries are presented in Table 2. The findings (Table 3) show that, in general, for the analysed period (2001–2019), there was a tendency to increase the coupling coordination degree of GC for JSC "Ukrainian Energy Machines." The highest coupling level is observed between the social and corporate components (in 2019, it was 0.564). The lowest coupling level in 2019 is typical for social and environmental components – 0.427. There is a strong tendency to increase the coupling coordination degree of GC for PrJSC Oril-Leader. Note that the coupling is highest for the environment and corporate components, which in 2018 obtained the level – 0.579. It results from coordinated work of management and understanding of the importance of developing green competitive advantages.

Tab. 3 – Results of the pairwise assessment of the coupling coordination degree between economic, environmental, social and corporate components of CGC (fragment)

Variables	2001	2005	2009	2013	2015	2017	2019
	JSC "Ukrainian Energy Machines"						
Economic ↔ Social	0.446	0.395	0.432	0.431	0.461	0.466	0.459
Economic ↔ Ecological	0.462	0.412	0.456	0.480	0.514	0.515	0.503
Economic ↔ Corporate	0.458	0.415	0.455	0.473	0.503	0.501	0.491
Social ↔ Ecological	0.366	0.364	0.398	0.428	0.433	0.419	0.427
Social ↔ Corporate	0.533	0.512	0.542	0.514	0.541	0.559	0.564
Ecological ↔ Corporate	0.525	0.521	0.540	0.504	0.527	0.540	0.543
	PrJSC Oril-Leader						
Economic ↔ Social	0.367	0.371	0.372	0.383	0.408	0.420	0.436
Economic ↔ Ecological	0.190	0.202	0.206	0.217	0.244	0.251	0.262
Economic ↔ Corporate	0.259	0.118	0.092	0.105	0.140	0.148	0.169
Social ↔ Ecological	0.323	0.355	0.354	0.374	0.390	0.385	0.386
Social ↔ Corporate	0.491	0.482	0.495	0.505	0.515	0.543	0.562
Ecological ↔ Corporate	0.458	0.494	0.511	0.520	0.528	0.557	0.579
	PRJSC "Mondelez Ukraine"						
Economic ↔ Social	0.470	0.516	0.523	0.577	0.593	0.514	0.557
Economic ↔ Ecological	0.518	0.550	0.556	0.611	0.619	0.575	0.606
Economic ↔ Corporate	0.530	0.585	0.598	0.645	0.644	0.587	0.617
Social ↔ Ecological	0.346	0.349	0.402	0.423	0.408	0.401	0.450
Social ↔ Corporate	0.488	0.528	0.526	0.569	0.592	0.543	0.577
Ecological ↔ Corporate	0.496	0.556	0.556	0.591	0.611	0.551	0.586

Sources: own research.

At the same time, at the end of 2019 came a low level of the CCD between economic and social components (in 2019 is 0.169). The calculations for food enterprise PJSC "Mondelez Ukraine" (Table 3) show the slow-increasing dynamic of CCD. For all components for the analysed period, the increase is ten percent on average. For the whole research period, the highest level of coupling was for environmental and corporate (in 2019 is 0.617) components. The results of the evaluation of the level of CCD between all groups of indicators of GC are represented in Table 4. The empirical results show the miscellaneous tendencies for selected agro-industrial companies. There is no one tendency in the dynamic for each company. Such dynamic results arose from the absence of a common complex strategy for developing companies' GC, because in the different years different components of GC dominate. The highest coupling level was for the JSC The Motor Sich for the analyzed period (0.772). The lowest coupling level describes the functioning of the PrJSC Zaporizhia Automobile Building Plant (0.468). The presented visualisation of coupling assessment for the food industry also provides the opportunity to analyse the gaps between a company's level of coupling.

Tab. 4 – Results of a comprehensive assessment of coupling coordination degree of GC for different industries

Companies/Industries	2005	2009	2013	2015	2017	2019
Agro-industrial companies						
PrJSC Myronivsky Hliboproduct	0.596	0.685	0.728	0.705	0.749	0.680
PrJSC APK-Invest	0.561	0.584	0.608	0.610	0.629	0.650
SPF Urozhay LLC	0.535	0.592	0.593	0.584	0.628	0.639
PrJSC Oril-Leader	0.589	0.566	0.609	0.612	0.619	0.679
Mechanical engineering industry						
PrJSC SKF Ukraine	0.655	0.644	0.639	0.664	0.664	0.687
JSC Nasosenergomash Sumy	0.620	0.671	0.679	0.659	0.663	0.674
JSC Ukrainian Energy Machines	0.634	0.667	0.663	0.672	0.655	0.659
PrJSC Zaporizhia Automobile Building Plant	0.642	0.701	0.634	0.548	0.580	0.598
JSC The Motor Sich	0.667	0.713	0.747	0.768	0.775	0.772
The food industry						
PJSC Wimm-Bill-Dann Ukraine	0.756	0.731	0.738	0.729	0.768	0.769
PrJSC Danon Kremez	0.697	0.626	0.612	0.658	0.633	0.621
PrJSC Vinnitsa Confectionery Factory	0.692	0.700	0.725	0.714	0.706	0.709
PrJSC Mondelez Ukraine	0.644	0.684	0.715	0.686	0.716	0.732
PrJSC Kremenchukmyaso	0.651	0.688	0.679	0.697	0.664	0.645

Sources: own research.

Thus, selected companies are approximately in the same diapason of coupling level (between 0.48 and 0.67) and have the enormous potential for it to increase. The results for all sectors showed that the highest level of coupling (a measure of the strength of the interconnectedness of the GC components) was by JSC The Motor Sich (GC index – 0.772) and PJSC "Wimm-Bill-Dann Ukraine" (GC index – 0.769). These enterprises are characterized by the dominance of corporate components, which in various combinations with other determinants can positively influence the development of green competitive advantages. For the entire period of the study, on average, the highest level of coupling was for machine-building enterprises – between social and corporate (0.624) and environmental and corporate (0.602); food industry enterprises – between social and corporate (0.637) and environmental and corporate (0.598); enterprises of the agro-industrial complex – between social and corporate (0.641) and environmental and corporate components (0.531). Empirical results of the coordination assessment between the integrated index of GC and its level of coupling showed a high value of the Pearson coefficient, which confirms the hypothesis (Table 5).

Tab. 5 – Pearson's correlation coefficient calculations

Industries	2001	2005	2010	2015	2019
Agro-industrial enterprises	0.76* (0.00)	0.75* (0.00)	0.82* (0.00)	0.71* (0.00)	0.73* (0.00)
Mechanical engineering enterprises	0.76* (0.00)	0.81* (0.00)	0.79* (0.00)	0.84* (0.000)	0.85* (0.00)
Food enterprises	0.87* (0.00)	0.79* (0.00)	0.86* (0.00)	0.85* (0.00)	0.89* (0.00)

Note: * – statistical significance at 1%, in brackets – p-value.
Sources: own research.

Thus, the calculated values of Pearson's correlation coefficients for enterprises of the agro-industrial complex, machine-building, and food industry are high, indicating a high level of dependence on the integrated level of GC and the level of coupling of its components. The obtained results of coupling will serve as a basis for making management decisions to optimize the activities of enterprises, because ensuring GC is possible in the coordinated interaction of all its components (economic, environmental, social, corporate).

5 DISCUSSION

The empirical findings confirm the research hypothesis that the coupling of economic, environmental, social, and corporate components affect a company’s GC. Similar conclusions were obtained by studies (Chen et al., 2019; Hou et al., 2022; Hu, 2018). Mao (2021) focused on evaluating the GC of industrial enterprises in the context of environmental protection. The findings of this study highlight the importance of considering environmental factors in enhancing the competitiveness of enterprises. This study emphasizes the need for a coordinated interaction among economic, environmental, social, and corporate components to ensure GC. Yu et al. (2022) suggest that the coordinated interaction among various components of the industrial innovation ecosystem, including economic, environmental, social, and corporate aspects, is essential for driving green transformation. Coupling coordination serves as a basis for making management decisions to optimize the activities of enterprises towards achieving GC, which aligns with the results of this study. Despite the results of Li et al. (2022), which focused on the coupling coordination degree for urban green growth between public demand and government supply in an urban agglomeration, specifically through a case study conducted in China, this study contributes to the understanding of how coupling coordination can be used as a basis for making management decisions to optimize the activities of enterprises and ensure GC. Cao (2022) examined CCD differences between the fiscal subsystem of companies and their energy and economic determinants, concluding that a higher coupling level contributes to improved financial structure and fosters relevant financial business development. Similarly, Jiang (2022) and Hou et al. (2022) investigated the internal mechanisms and subsystems for harmonized development, considering the economy, environment, and health components. They discussed the importance of green product development in achieving a balance between economic, ecological, and health aspects. In addition, Yu et al. (2022) discovered a strong relationship between competitiveness and green innovative development. However, describing and assessing corporate indicators may be challenging for certain sectors and companies due to their qualitative nature. Therefore, it is crucial to expand the number of indicators that characterize a company's GC in order to investigate CCD across a broader range of indicators.

6 CONCLUSION

Based on the findings, enterprises should aim to improve the internal level of CCD among all management subsystems, especially economic, environmental, social, and corporate subsystems. The transparent and coordinated interconnection of these components will contribute to an increase in companies' GC. A key finding of this study is the relationship between an enterprise's integrated index of GC and the level of coupling among its components. The calculations of CCD for the three basic sectors of the national economy indicate a similar level of coupling among all enterprises, with the corporate component playing a dominant role. The corporate component serves as the foundation for environmentally friendly management decisions, environmental management systems, audit systems, and more. The findings confirm the relationship between a company's GC and the coupling of its components. Notably, JSC The Motor Sich and PJSC Wimm-Bill-Dann Ukrain exhibit the highest coupling values among all GC components. Furthermore, the pairwise assessment of the CCD between economic, environmental, social, and corporate components of GC reveals certain tendencies within specific sectors. For machine-building enterprises (JSC Ukrainian Energy Machines), the highest CCD is observed between the social and corporate components (0.564), while the lowest CCD is between the social and environmental components (0.427). In agro-industrial companies (PrJSC Oril-Leader), the highest CCD occurs between the environment and corporate components (0.579), with the lowest CCD is observed between the economic and social components (0.169). In the food industry (PJSC Mondelez Ukraine), the highest CCD is found between the environmental and corporate components (0.617). The study's findings have important implications for managers seeking to enhance their enterprise's GC. The following recommendations are derived from the results:

- Focus on improving internal coordination: Enterprises should prioritize improving the coupling coordination degree (CCD) among all management subsystems, including the economic, environmental, social, and corporate components. This involves fostering transparent and coordinated interconnections between these components. Managers should promote collaboration and integration across departments to ensure a holistic approach to sustainability.
- Strengthen the corporate component: The corporate component plays a dominant role in determining the coupling level among enterprise components. To enhance GC, companies should prioritize environmentally friendly management decisions, develop robust environmental management systems, implement effective audit systems, and foster a corporate culture that values sustainability. Managers should allocate resources and implement strategies that support green practices throughout the organization.
- Emphasize social initiatives and corporate responsibility: The pairwise assessment of CCD highlights the importance of social initiatives and corporate responsibility for machine-building enterprises. Managers should actively engage in social initiatives, such as community involvement and employee well-being programs, and prioritize corporate responsibility in their decision-making processes. This not only contributes to social development but also enhances the enterprise's GC.
- Enhance environmental consciousness: Agro-industrial companies should focus on strengthening the coupling coordination between the environment and corporate components. Managers should prioritize environmentally conscious practices, such as sustainable farming methods, waste reduction, and resource efficiency. Implementing environmental management systems and fostering a culture of environmental responsibility will contribute to higher levels of GC.
- Foster collaboration between economic and social aspects: The lowest CCD observed between the economic and social components indicates potential areas for improvement in social-economic coordination. Managers should seek to align economic development goals with social initiatives. This could involve promoting fair labor practices, providing employee training and development opportunities, and contributing to local economic growth. By fostering collaboration between economic and social aspects, companies can enhance their GC while simultaneously addressing societal needs.
- Emphasize environmental-friendly corporate practices: In the food industry, the highest CCD is observed between the environmental and corporate components. Managers should prioritize and promote environmentally friendly corporate practices such as sustainable sourcing, and reducing carbon emissions and packaging waste. By adopting green supply chain practices and implementing environmentally conscious production methods, companies can enhance their reputation and competitiveness in the market.

While this study provides valuable findings, it is important to acknowledge its limitations. Future research should consider factors such as governance efficiency, including aspects like control of corruption, rule of law, and transparency, and explore the role of green companies in achieving sustainable development goals. By addressing these aspects, further insights can be gained to advance our understanding of CCD and its implications for companies' GC.

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