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Article

Levels of corporate environmental strategies in Hungary and the associated environmental management control tools

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Abstract: The research aims to map environmental protection strategies and the related control tools and to identify the links among companies with the largest number of employees and sites in Hungary. The research questions were answered using a questionnaire survey method. The authors used cluster analysis to classify the 205 company strategies into the identified strategy clusters: Leaders, Awakeners, and Laggards. Then, the examined 21 environmental management control tools in the sample were divided into four groups: strategic, administrative, methodological and economic. Economic and strategic methods were the most common in the sample. The authors used cross-tabulation analysis to examine whether there is a statistically proven relationship between belonging to environmental strategy clusters and specific control tools. The analysis showed significant but weak to moderate relationships. According to Cramer's V and the contingency coefficient, the closest relationship between the tested environmental management control tools and membership in environmental strategy clusters is shown by evaluating investments, assessing the economic viability of environmental strategies, and running an environmental training program for employees. In case of the robust lambda indicator, a significant relationship was found by examining the economics of environmental strategies and identifying environmental success factors and eco-balances. It can be concluded that the companies under examination follow a set of environmental goals, which they have incorporated into their strategic objectives. They use the available environmental management control toolbox to develop their strategies and to monitor their implementation to varying degrees.

Keywords: environmental strategy; control tools; cluster analysis; large companies

1. Introduction

Sustainability issues are having an increasing impact on how companies operate today. Focusing on sustainability and the environment means that products and services recognised by the market can be sold with increasing success. However, research conducted by Nidumolu et al. (2009) found that many companies perceive that environmental innovation reduces competitiveness. The reason is that environmental innovation is generally associated with increased costs, significant initial investment requirements, long payback periods and a lack of financial benefits (Wugan et al., 2018). Moreover, environmental regulations impose an additional administrative burden on companies, which limits their activities in the business environment (Hojnik and Ruzzier, 2016).

Although, environmental innovation brings significant societal benefits it also represents a serious risk for companies in the business environment (García-Sanchez et al., 2019). However, Nidumolu et al. (2013) conclude that managers do not have to choose between the social benefits of sustainability and the costs of implementation, as companies' costs decrease as the resource used decrease. In this context, companiesneed to link their sustainability metrics to tangible financial and operational results (Ermenc et al., 2017); for example, investments in sustainability can increase the recycling of product components, which reduces the need to purchase original materials.

The process results in better products and generates additional revenue through new business opportunities. The initial aim of the shift towards sustainability is to improve corporate image, but most companies are able to reduce costs and gain new business opportunities through greener, more sustainable products. Sustainability issues affect companies' day-to-day operations, impacting their assets, finances and revenues, as well as their willingness to take risks, which is highly dependent on the organisation's ability to innovate. All these factors lead to the development of corporate strategy. The drive for sustainability is transforming competition, forcing companies to rethink their products, technologies, processes and business models.

Sustainability is not only about environmental benefits but also about economic opportunities for companies. Investing in sustainable practices often yields long-term returns that improve companies' image and help them to be more competitive in the market. By striving for sustainability, companies can reduce their operating costs, for example by optimising the use of energy and raw materials or recycling waste.

In addition to adopting environmentally friendly technologies, improving companies' environmental performance is closely linked to customer expectations. Consumers are increasingly aware of the need to seek products and services that come from sustainable sources and are produced using environmentally sound manufacturing processes. Therefore, it is essential for companies to integrate sustainability considerations into their product development and marketing strategies to gain a competitive advantage in the market.

A commitment to sustainability affects not only internal processes but also external relationships. Environmental innovation can be fostered through cooperation and partnerships between companies. For example, collaboration between public services, government agencies and NGOs can create new opportunities for the development of green technologies and the widespread adoption of sustainable practices.

Based on these aspects, the research aims to map environmental strategies and related control tools and to identify the linkages between companies with the largest number of employees and sites in Hungary. Research should also bear in mind that sustainability is a major challenge and opportunity for large companies and small and medium-sized enterprises (SMEs). SMEs are often more responsive to sustainability trends and able to adapt quickly to market needs. Involving these companies in the research can provide a more comprehensive picture of how sustainability goals can be achieved in different industries and companies of different sizes.

Overall, sustainability and environmental innovation are increasingly becoming a strategic focus for companies as they seek to comply with legal requirements and actively contribute to solving social and environmental problems. The aim of this research is to explore these dynamics and shed light on the environmental strategies and control tools of the largest Hungarian companies, contributing to the achievement of global sustainable development goals.

2. Literature review

The literature of the present study can be divided into two parts. The first major focuses on sustainability levels and corporate strategies, while the second part presents environmental management control. Notably, the work of several authors, such as Landrum (2017) and Nidumolu et al. (2009, 2013), provides the basis for this theme. In Landrum's (2017) model, levels of corporate sustainability are defined by integrating the developmental stages of 22 micro- and macro-level models of corporate sustainability, social responsibility, environmental management and sustainable development in the literature. The model distinguishes five levels: adequacy, business-oriented sustainability, systemic sustainability, regenerative sustainability (taking into account the capacity of nature) and coevolutionary sustainability (based on the symbiosis of consumption and resources). In contrast, the present research is based on the model of Nidumolu et al. (2009, 2013), which suggests that becoming sustainable is a five-step process whereby firms must develop new capabilities at each step.

Step 1. Green Compliance as an option. The first steps companies must take on the long road to sustainability are usually the result of laws and regulations (Hamburg, 2020). The authors argue that, given that environmental regulations vary from state to state and region to region, it is worth choosing the most stringent of the regulations that apply to units located in different geographical areas of the company, as the further introduction of these regulations is becoming more and more common nowadays. In the first stage of the development process, the most important management tasks are driving environmental innovation by exceeding mandatory standards, creating transparency on resource use and emissions, assessing environmental opportunities and risks, and developing incentives embedded in day-to-day operations (Isensee and Michel, 2011). In order to move to the next stages of development, it is essential to develop the right organisational culture to address environmental and social problems appropriately (Geradts and Bocken, 2018).

Step 2. Make value chains sustainable. Sustainable business models have a network effect, transforming value chains (Young and Reeves, 2020). With Green Compliance, companies become more proactive, which helps reduce non-renewable energy use. The next step in becoming more efficient is extending it to the whole value chain, where suppliers and retailers are now developing environmentally friendly materials and components and reducing waste. Today, large companies are building platforms and digital ecosystems that break down traditional boundaries between companies, often containing globally connected data and crossing industry boundaries (e.g. in the automotive industry). Management tasks at this scale include creating transparency on direct and indirect environmental impacts and creating incentives and obligations for partners in the value chain (Isensee and Michel, 2011) to become sustainable themselves.

Step 3. Designing sustainable products and services. Radical innovation to replace current harmful products and services is a very costly process with a high degree of uncertainty and risk, so it is important to consider the details of the product innovation process and the impact of how it fits into the context of corporate strategy (Kennedy et al., 2017). Evaluation is one of the most important activities in the early stages of product and service design. These early stages are where many of the costs are determined (e.g., production costs, maintenance and servicing costs, end-of-life costs), as well as the environmental and social impacts of innovation (von Geibler et al., 2019).

Prioritise product development, businesses need the competencies and tools essential for the previous steps. The process starts by identifying the most environmentally destructive products and services. Requirements for company management include developing genuinely environmentally friendly offers, avoiding greenwashing, and evaluating product alternatives. Product life cycle analysis is also essential for the development of sustainable products. Other challenges include determining consumers' willingness to pay for greener products/services and pricing products and services ecologically (Hamburg, 2020; Isensee and Michel, 2011; Nidumolu et al., 2013). Developing green products and services is a challenge for businesses that can be turned into an opportunity. As business become more dynamic, they can drive the market with new product development, minimising the barriers that can cause consumer reluctance (Wangsa and Sin, 2024).

Step 4. Develop new business models. The fourth step is to change the competitive environment by developing new ways of creating and preserving value (Isensee and Michel, 2011) and new business models. In a business model system, business activity transforms inputs into outputs and outcomes while focusing on meeting strategic objectives and creating value in the short, medium and long term (Baldarelli et al., 2017). Changing business models is now a fundamental approach to innovation for sustainability (Evans et al., 2017). Sustainable business models transform ecosystems (Young and Reeves, 2020), make suppliers in their supply chains more accountable to customer stakeholders and promote sustainable consumption. The industry and the nature of the business are very determinant for the sustainable business models that firms can adopt (Nostrabadi et al., 2019). In these steps, management is responsible for supporting the development of green business models, evaluating them, and preparing business plans based on the green business model. The experience of the fourth step leads to the fifth step, where products and processes extend beyond the boundaries of individual markets (Nidumolu et al., 2013).

Step 5. Creating Next-Practice Platforms. The fifth step of evolution focuses on challenging today's dominant business logic, questioning and changing existing paradigms and assumptions, our conventional wisdom, and the status quo. Step five places several demands on management, such as knowledge of the impact of renewable and non-renewable resources on the business ecosystem and the industry, and last but not least, the synthesis of business models, technologies and regulations across industries. Management tasks in the fifth step are creating new markets, systemic market analysis from an environmental perspective, developing green market leadership, and market influence (Isensee and Michel, 2011).

In the fourth and fifth steps, the authors mention the possibility of using AI for cleaner production. Several authors, including Jebbor et al. (2024), discuss the environmental, economic and societal benefits of AI and note that the integration of AI demonstrates huge environmental benefits, including improvements such as significant reductions in energy and material use and improved ways of managing the waste generated. At the same time, legislators are encouraged to create a favourable legal environment that supports the ethical use of AI.

The model developed by Nidumolu et al. (2009, 2013) defined the process of becoming sustainable in five steps, enabling companies to achieve sustainability with new and newer capabilities. These are necessary for the success of the process to be uncertain without a concrete. The five steps lay the foundations for companies' commitment to developing sustainability levels and corporate strategies.

Environmental Management Control (EMC)

The authors examine environmental management control (EMC) in the second part of the literature review. They use the term environmental management control in their research because it best fit the international literature. Furthermore, they examine the use of environmental management control tools that are associated with managerial decision-making on environmental issues. Control is a management tool that helps leadership adapt to dynamic environmental changes. It is a planning, accountability, information, control, and stewardship system built on the responsibility principle. The control system is a key subsystem of the management system of an organisation, which undertakes strategic and operational planning, supervises the implementation of plans, monitors and compares plan and actual data, and analyses variances. Environmental management control applies controlling approaches in corporate sustainability management (Schäffer and Jais, 2005) as the Carbon Accounting Map is a novel solution of EMC developed to support the integrated strategic control of company GHG emissions (Bognár and Böcskei, 2022). It is important to achieve a balanced relationship between the goals of the three dimensions of sustainability (economic, social, and ecological) (Horváth, 2015; Isensee and Michel, 2012).

Deb et al. (2023) concluded that environmental management accounting is an effective tool to help companies manage environmental problems and their financial consequences, significantly and positively related to environmental performance and financial performance. Companies that perform well from an environmental perspective improve their financial performance. Khan and Gupta (2023) investigated the relationship between environmental management control and corporate performance by examining a sample spanning 25 years. They found a positive relationship between corporate green accounting and corporate performance. However, problems arise because the measures needed to improve sustainability performance are not always aligned with corporate strategies or financial targets (Juusola, 2023).

In contrast, the role of sustainability control is to provide extensive support to sustainability management (Bedenik et al., 2019) in formulating sustainability goals and developing corporate policies covering all three dimensions (Păunică and Mocanu, 2017). Environmental management control focuses primarily on ecological aspects but does not ignore other dimensions (Gould, 2011; Tschandl, 2012). Environmental management control can be understood as a management function alongside other functional control tasks. It must not be designed as a separate, isolated solution but as an integral part of the corporate information and communication system. The importance of this is also reflected in the fact that environmental aspects can influence the economic success of companies, which is why it is recommended to integrate environmental factors into companies' management and planning systems (Günther et al., 2018).

Matukova et al. (2021) confirm the effectiveness of introducing eco-management control as a set of tasks related to environmental planning, accounting, monitoring, analysis and auditing of industrial enterprises' activities. The tools that can be applied can be grouped according to the application level (strategic or operational) and the application areas. The twenty-one environmental management control tools analysed by the authors will be briefly presented in the literature in the research results section for ease of reference.

Overall, the literature review has shown that sustainable development, including environmental elements, plays a very significant role in the life of companies. One of the expressions of this is the extent to which companies operating in the European Union, particularly in Hungary, have successfully integrated environmental protection and environmental management control tools into their everyday operations. Of course, these can be implemented in various ways, either as models or as a natural process. It became clear that the authors based their research on the work of Nidumolu et al. (2009, 2013) and, in this context, examined the method they developed for companies.

3. Material and methods

The authors conducted an empirical research using a questionnaire survey to answer the research questions. The research focused primarily on larger companies, based on the assumption that these companies are likely to be at the forefront of integrating environmental objectives into their operations and strategies, as they have greater resources and are subject to stricter regulatory oversight. The sample was selected from a database of the 5000 largest companies operating in Hungary, based on number of employees (headquarters or subsidiaries). The selection was based on statistics from the Hungarian Central Statistical Office (HCSO). The online questionnaire was sent to 4606 addresses, of which 205 valid responses were received, giving an approximate response rate of 4.39%.

The questions in the questionnaire covered areas such as corporate environmental strategies, the implementation of environmental management systems, the use of environmental monitoring tools and perceptions of sustainability challenges. In order to ensure the reliability and validity of the responses, the questionnaire was pre-tested on a small sample of companies before being sent out in full. The data collected was subjected to statistical analysis, including descriptive statistics, cluster analysis and correlation tests to identify patterns and correlations between the level of integration of environmental strategies and environmental management tools. In addition, measures such as Cramer's V and contingency coefficients were used to assess the strength of relationships between variables.

Based on the literature review's findings and the available data, the authors sought to answer the following research questions. Firstly, based on the level of development of environmental strategies, what clusters can be formed in the surveyed group of companies? Secondly, is there a statistically significant relationship between belonging to strategic clusters and the use of environmental management control tools? In connection with the research questions, the authors formulated three hypotheses.

H1. The surveyed companies can be classified into different clusters according to the level of development of their environmental protection strategies.

H2. There is a relationship between the level of development of environmental strategies and the used environmental management control tools.

H3. Companies with a more developed environmental strategy have a more extensive use of environmental management control tools.

The sectoral breakdown based on the HCSO of the surveyed companies is shown in **Table 1**. According to these results, the three largest completion rates of the 205 questionnaires are typically from the manufacturing sector (38%), the water supply, sewerage, waste management and remediation sector (11%) and the agriculture, forestry and fishing sector (9%). The lowest completion rate (only one) comes from the public administration, defence and compulsory social security sector. There is a wide variation in annual net sales among the sampled companies. The largest company having a net sales of 342 billion HUF (approximately 853 million Euro) and the smallest has a net sales of 48 million HUF (approximately 119,740 Euro). It shows that the sample used for the analysis covers a wide range of types and sizes of companies.

Table 1. Distribution of companies by industry.

Industry	Frequency	Percent
A = Agriculture, forestry, fishing	18	8.78%
B = Mining, quarrying	2	0.98%
C = Manufacturing	78	38.05%
D = Electricity, gas, heating, air conditioning	7	3.41%
E = Water supply, waste water collection, treatment, waste management, decontamination	22	10.73%
F = Construction	9	4.39%
G = Trade, motor vehicle repair	14	6.83%
H = Transport, storage	14	6.83%
I = Accommodation and food service activities	3	1.46%
J = Information, communication	5	2.44%
K = Financial, insurance activities	3	1.46%
L = Real estate	2	0.98%
M = Professional, scientific and technical activities	10	4.88%
N = Administrative and service support activities	12	5.85%
O = Public administration, defence, compulsory social security	1	0.49%
Q = Human health, social care	2	0.98%
R = Arts, entertainment, leisure	3	1.46%
Total	205	100%

The sample for analysis covers different types and sizes of companies. In size, nearly 70% of companies (142) have between 50 and 250 employees, and 30% (63) have more than 250 employees, but the sample needs to be considered representative.

Companies were asked to rate their attitudes to environmental sustainability strategies on a 6-point Likert scale, representing their attitudes towards the research questions. The Likert scale is a popular and widely used measurement tool in the social sciences, used to quantitatively assess respondents' attitudes and opinions. A Likert scale usually consists of a series of statements or questions to which respondents respond along a given scale. The scale allows respondents to express their agreement or disagreement, in this case in numerical format, which allows for statistical analysis of the responses. The scale is flexible in the present research because it allows a more refined understanding of complex attitudes and feelings. The advantage of the Likert scale is that it is easy to understand and use, and allows respondents to express their opinions in more detail than with simple "yes" or "no" answers. The questionnaire therefore, also asked about the prevalence of twenty-one environmental management control tools related to environmental protection, where respondents gave yes/no answers.

The authors carried out reliability and validity analyses of the measurement scale. Reliability was measured using the Cronbach's alpha coefficient, which shows how correlated the items of the scale are with each other. In the validity analysis, the authors examined the scale's content, criterion and convergent validity. The method examines all possible combinations of items in the questionnaire to produce a value between 0 and 1, which expresses the ratio between the true values and the measurement error. The closer the coefficient is to one, the more reliable the measurement of the questionnaire's internal consistency and the measurement scale's reliability (Amirrudin et al., 2021). In many analyses and publications, a threshold value of 0.7 is considered acceptable (Kárász et al., 2022), a value above 0.8 is considered good, and a value above 0.9 is considered excellent (**Table 2**).

Table 2. The reliability of the questionnaire.

	Reliability Statistics		
	Cronbach's Alpha	**Cronbach's Alpha Based on Standardized Items**	***N* of Items**
Variables of the environmental strategy	0.958	0.958	12
Variables of the environemntal management control	0.862	0.861	21

When examining the Cronbach's Alpha item-by-item, the authors found that none of the environmental strategy variables or the environmental control variables should be omitted, as this would not improve the indicators value.

One of the main objectives of the analysis was to group the companies according to the level of development of their environmental strategies. The analyses were carried out using the SPSS (Statistical Package for the Social Sciences) software package (PASW Statistics 18). SPSS provided the possibility to perform various statistical tests, including cluster analysis, correlation and regression analyses, reliability and validity tests. Clustering was performed using cluster analysis (K means cluster), with a validity check in each case. The significance level of the F-statistic was used to determine the clusters' midpoints and the findings of verified differences between them (Molnár, 2015), so the analyses yielded relevant results. After clustering the companies into specific strategy clusters, the authors examined the sample's prevalence of environmental management control tools. In addition, they used cross-tabulation analysis to analyse whether there is a significant relationship between belonging to strategy clusters and the use of specific environmental management control tools.

As with all analyses, there are limitations. Limitations of the study include the fact that the sample focused only on the largest companies in Hungary, which may limit the generalisability of the results to smaller firms or companies operating in other countries. Furthermore, the nature of the questionnaire survey meant that respondents provided self-reported data, which may bias the results due to subjective opinions of respondents or social pressure to respond. In addition, the Likert scale used in the questionnaire and the 'yes/no' response options may limit the detail of respondents' opinions.

Based on the previously formulated research questions and hypotheses, the authors of the present study were curious to discover how and to what extent large companies operating in Hungary have integrated environmental elements into their everyday operations.

4. Results and discussion

The model of Nidumolu et al. (2013) was used as the basis for the analysis of environmental strategies. It is well-developed and quantifiable in an empirical research framework. It allows for classifying environmental strategies regardless of the time, space, and size of the firms under study. The variables examined in the research are listed in **Table 3**.

Table 3. Variables for the assessment of environmental strategies.

Steps	Variables
Step 1. Green compliance as an option	Promoting environmental innovation by going beyond mandatory standards
	Creating transparency on resource use and emissions
	Assessing environmental opportunities and risks
	Creating incentives for daily action
Step 2. Making value chains sustainable	Creating transparency on direct and indirect environmental impacts
	Creating incentives and obligations for partners in the value chain
Step 3. Designing sustainable products and services	Evaluation of environmentally friendly product alternatives
	Determining consumers' willingness to pay for greener products/services
	Organic pricing of products and services
Step 4. Developing new business models	Assessing and promoting the development of a green business model
	Preparing business plans according to the green business model
Step 5. Developing Next-Practice platforms	Creating new markets, systemic market analysis from an environmental perspective, developing green market leadership, and market influence

The cluster analysis aimed to test the hypothesis of whether the companies under examination could be classified into different clusters according to the level of development of their environmental strategies. After the analyses were carried out, three significantly different clusters were formed. The results of the cluster analysis are shown in **Table 4**.

Table 4. Final cluster centroids of the environmental strategy variables in the sample.

Final cluster centers			
	Cluster		
	1. “Leaders”	**2. “Awakeners”**	**3. “Laggards”**
Promoting environmental innovation by going beyond mandatory standards	0.7589	0.0491	−1.3919
Creating transparency on resource use and emissions	0.6941	0.1008	−1.3911
Assessing environmental opportunities and risks	0.6146	0.0250	−1.1562
Creating incentives for daily action	0.7869	−0.0943	−1.1875
Creating transparency on direct and indirect environmental impacts	0.7864	−0.0490	−1.2644
Creating incentives and obligations for partners in the value chain	0.9069	−0.2169	−1.2008
Evaluation of environmentally friendly product alternatives	0.7858	−0.1309	−1.0969
Determining consumers’ willingness to pay for greener products/services	0.8575	−0.2457	−1.0170
Organic pricing of products and services	0.9430	−0.2723	−1.1063
Assessing and promoting the development of a green business model	0.9075	−0.1760	−1.2519
Preparing business plans according to the green business model	0.9485	−0.2234	−1.2026
Creating new markets, system-wide market analysis from an environmental perspective, developing green market leadership, market influence	0.9657	−0.3251	−1.0608

The clusters are generated with standardised variables. The expected value of the standardised variables is zero so that the relative differences can characterise the clusters. The companies in the first cluster, as seen from **Table 4**. deviate positively and significantly from zero for all clustering variables, and this cluster is called the “Leaders”. 39% of the sample elements are in this group. These companies are also engaged in the highest stages of becoming sustainable and are the best performers in green compliance compared to the other clusters. They also demand and promote environmental awareness in the supply chain and develop environmentally friendly product alternatives that create new market opportunities for them. Developing green business models and a conscious market influence on environmental protection also characterise this group.

The companies in the second cluster are called “Awakeners”. This cluster comprised ordinary enterprises (39% of the sample). The cluster midpoints show that all variables are around the expected value, slightly above it for the first-level variables and slightly below it for the higher steps of sustainability. Finally, the companies in the third cluster (22% of the sample) performed well below the expected value for all variables, as shown by the negative values in **Table 4**. They thus form the group of “Laggards”.

4.1. Using environmental management control tools in the area of environmental protection

The authors analysed respondents’ use of twenty-one environmental management control tools. The methods were grouped into four main categories: strategic, administrative, methodological and economic.

Table 5. Categorisation of environmental management control tools.

Control tools	Number of employing companies, pcs	Percentage of employing companies, %
I. Strategic issues		
Development and integration of environmental objectives into the strategy (DIEOS)	112	75%
Written environmental policy (WEP)	98	66%
Environmental Training Programme for Employees (ETPE)	67	45%
II. Administrative issues		
Internal environmental audits (IEA)	114	77%
External environmental audits (EEA)	81	54%
Public Environmental Report (PER)	42	28%
III. Methodological issues		
Developing and using environmental indicators (DUEI)	79	53%
SWOT analysis (SWOT)	72	48%
Identifying environmental success factors (KPIs, key performance indicators) (KPI)	60	40%
Benchmarking environmental performance (BENCH)	31	21%
Scenario techniques (SCEN)	26	17%
Eco-balances (ECO)	24	16%
Sustainability Balanced ScoreCard (SBSC)	14	9%
IV. Economic issues		
Evaluation of investments (integrating economic and environmental evaluation) (EI)	90	60%
Planning, recording and evaluation of environmental costs (PREEC)	89	60%
Planning, recording and evaluation of revenues from environmental protection (PRERFEP)	86	58%
Assessing the economics of environmental strategies (AEES)	83	56%
Integrating environmental costs into the pricing of products/services (IECPPS)	82	55%
Evaluation of environmentally friendly product alternatives (EEFPA)	66	44%
Assessing the life-cycle costs of products (from innovation to disposal) (ALCCP)	46	31%
Environmental criteria used in the assessment and/or reward of employees (ECARE)	30	20%

Table 5 shows the number and percentage of respondents in each category of environmental management control tools, the number of companies using them and the percentage of respondents using them in increasing order of use within each category. The results show that one factor in each of the strategic and administrative issues is the most widely used environmental management control tool. The companies surveyed are most likely to use internal environmental audits (77%) and the development and integration of environmental objectives into strategy (75%).

After strategic and administrative issues, the factors listed under economic issues are the most commonly used environmental management control tools in the surveyed companies. Of these, the evaluation of investments, which integrates economic and environmental evaluation, and the planning, recording and evaluation of environmental costs are included with 60%. Environmental costs can include, for example, the costs of preventing and reducing environmental damage, the costs of disposing of waste, the costs of monitoring waste generated, and the costs of remediation of damage caused (Jasch, 2003).

The planning, recording, and evaluation of revenues from environmental protection are among the environmental management control tools used in the sample, accounting for a similar proportion of 58% of costs. Environmental revenues can come from subsidies received or waste sold, for example. Their magnitude depends on the industry, but they are a fraction of the costs.

Accounting for environmental costs can identify opportunities for cost reduction and allow for more specific pricing (Ván, 2014). A related factor in this research is the inclusion of environmental costs in the pricing of products and services, with 55% of the sample used. Another cost-related factor under examination is the assessment of the life-cycle costs of products, which looks not only at the cost implications of the phase of the life-cycle during which the product is on the market but also at the phase before (e.g., innovation, development, market introduction) and after (e.g. restoration of the natural environment, servicing, take-back obligations). This can be done through cross-period life-cycle costing, which overcomes the shortcomings of traditional costing systems, which contrast revenues and costs over a period (usually one year), typically only related to the market phase. Thus, they include only production costs and allocable overheads, and the problem of allocating upstream (pre-market) and downstream (post-market) costs to products still needs to be solved. The assessment of life cycle costs is typical for 31% of the sample studied.

Among the methodological factors, the development and use of environmental indicators is the most widespread among the companies surveyed (53%). The literature contains many recommendations for environmental indicators, including some with an economic focus, such as the EPA model, the Schaltegger and Burritt model, the UNDSD model, and the IFAC model (Szauter and Madarasiné, 2018).

SWOT analysis, one of the best-known tools in strategic analysis, is 48% for the environment in the sample surveyed. The ultimate purpose of a SWOT analysis is not simply to list (and in some cases weight) the internal strengths, weaknesses, opportunities and threats of the external environment but to provide a starting point for strategy development. SWOT analysis is a widely used tool in sustainability and the environment. Tumuyu and Marthalia (2023) applied it for strategic analysis of the transition to a circular economy, while Uhunamure and Shale (2021) employed it for analysis of the sustainable transition to renewable energy. Several authors (Das et al., 2022; Sadan and Armuda, 2023) have integrated it as a decision-making method for evaluating and developing effective and adaptable strategies in the agricultural economy.

The results of Gebhardt et al. (2023) highlight that the introduction of ESG KPIs in the Internal Management System is a practical approach to manage sustainability and improve ESG performance. The use of environmental KPIs (key performance indicators) is 40% in the sample. Environmental KPIs show how an activity can be successful and how a business can be greener. So, they are measurable indicators created to measure the achievement of strategic objectives. They must describe a complete system to help manage, align and communicate the link between sustainability and financial performance, emphasising compression and transparency. ISO standards (e.g., the ISO 14,000 series of standards) can also help develop environmental KPIs. Environmental KPIs include CO_2 emissions, gas and electricity consumption levels, waste and recycled waste rates, plastics and biodegradable materials rates, company fleet mileage, reusable products as a percentage of total products, and targets and commitments related to environmental standards (Bagó, 2019). Rackow et al. (2013) identify energy consumption as the most important KPI. The main task of green control is to create transparency by visualising the energy flow of the company along the production processes, which includes energy consumption as the fourth main target dimension in corporate control, alongside time, cost and quality. Environmental performance benchmarking is used by 21% of the companies surveyed. Benchmarking often focuses on an element of company performance, comparing it within or between companies.

Scenario techniques are used by 17% of respondents, which could be a lot higher. Scenarios are possible future states, and scenario analysis is an analytical tool used before developing strategies. Because of the expected social and economic impacts, organisations are advised to monitor existing and environmental scenarios from various institutions and consultants for global and national climate change, which often include risk models and economic projections. These include the situation assessment reports and scenarios regularly published by the UN Intergovernmental Panel on Climate Change (IPCC, 2021). Organisations must adapt to the changes affecting their work and Community and national commitments. Adaptation requires organisations to assess the most relevant climate risks they face, which can be categorised as physical and adaptation risks (NGFS, 2019).

The prevalence of eco-balances is also quite low, at 16% of respondents. The eco-balance sheet is a management accounting tool that helps organisations demonstrate the potential environmental and financial consequences of their material and energy use practices, thus providing an opportunity to improve the environmental and financial consequences by changing existing practices. It collects information on physical and monetary assets and energy flow accounting to reflect the short-term impacts on the environment of products, sites, departments and companies. Its disadvantage is its focus on short-term, historical, routine information collection (Burritt and Schaltegger, 2021). An eco-balance is often an input-output balance, contrasting a company’s material and energy inputs with its material and energy outputs, which can be products and material and energy emissions.

The ecological balance sheet can take into account not only the operational impacts in the narrower sense but also the further fate of the products produced, i.e. the extent of further transport and environmental damage caused by other producers and household consumption (Várkonyiné et al., 2023). The authors conclude that, in this case, the assessment tool described above should be linked to the life-cycle costs (LCC) of products.

The use of the Sustainability Balanced ScoreCard (SBSC) is the lowest in the surveyed companies at 9%. BSC (Balanced Scorecard) is effectively a set of strategically important targets and indicators, expectations of the values of the indicators, and actions to be taken to achieve the targets. All this is integrated into systems built around the learning development, operational processes, and customer and financial perspectives, with the cause-and-effect relationships between indicators culminating in financial performance. From a methodological point of view, the main question is how to integrate sustainability aspects into the traditional BSC. Based on the literature, there are several ways to do this. For example: integrating environmental (and social) aspects into the four perspectives; expanding the BSC to include additional viewpoints on sustainability issues and developing a separate environmental scorecard: a specific EBSC (Environmental Balanced ScoreCard) (Abdelrazek, 2019; Al-Zwyalif, 2017; Hansen and Schaltegger, 2016; Szóka, 2022). Several industry-specific practical applications of SBSC can be found in the literature, e.g. in tourism (Heebkhoksung et al., 2023), in the natural gas industry (Wang et al., 2022) and in manufacturing (Sahu and Garg, 2023). At the same time, its importance is reflected in the fact that it is also addressed in several systematic literature reviews (Jassem et al., 2022; Mio and Panfilo, 2022).

4.2. The relationship between environmental strategy clusters and the use of environmental management control tools

In the following, the authors have examined whether and to what extent a relationship exists between belonging to an environmental strategy cluster and the environmental management control tools implemented. Before presenting the results of the cross-tabulation analysis, the authors present the frequency of using each tool by cluster. Interpretation of the results: e.g., the development and integration of environmental objectives into the strategy is carried out by 87.5% of the companies in the "Leaders" cluster, compared to 77.2% of the "Awakener" cluster and 46.9% of the "Laggards" cluster. Variable names are abbreviated as in **Table 6**.

Table 6. Prevalence of environmental management control tools in strategy clusters.

	"Leaders"	**"Awakeners"**	**"Laggards"**
I. Strategic issues			
Development and integration of environmental objectives into the strategy (DIEOS)	87.5%	77.2%	46.9%
Written environmental policy (WEP)	83.6%	57.9%	50.0%
Environmental Training Programme for Employees (ETPE)	64.3%	42.1%	18.8%
II. Administrative issues			
Internal environmental audits (IEA)	87.5%	78.9%	50.0%
External environmental audits (EEA)	60.7%	52.6%	43.8%
Public Environmental Report (PER)	37.5%	26.3%	12.5%

Table 6. (*Continued*).

	“Leaders”	**“Awakeners”**	**“Laggards”**
III. Methodological issues			
Developing and using environmental indicators (DUEI)	67.9%	47.4%	37.5%
SWOT analysis (SWOT)	58.9%	42.1%	37.5%
Identifying environmental success factors (KPIs. key performance indicators) (KPI)	57.1%	31.6%	25.0%
Benchmarking environmental performance (BENCH)	32.1%	14.0%	12.5%
Scenario techniques (SCEN)	21.4%	12.3%	18.8%
Eco-balances (ECO)	28.6%	10.5%	6.3%
Sustainability Balanced ScoreCard (SBSC)	12.5%	3.5%	12.5%
IV. Economic issues			
Evaluation of investments (integrating economic and environmental evaluation) (EI)	80.4%	59.6%	25.0%
Planning. recording and evaluation of environmental costs (PREEC)	76.8%	56.1%	37.5%
Planning. recording and evaluation of revenues from environmental protection (PRERFEP)	67.3%	52.6%	46.9%
Assessing the economics of environmental strategies (AEES)	71.4%	57.9%	21.9%
Integrating environmental costs into the pricing of products/services (IECPPS)	62.5%	59.6%	34.4%
Evaluation of environmentally friendly product alternatives (EEFPA)	57.1%	36.8%	34.4%
Assessing the life-cycle costs of products (from innovation to disposal) (ALCCP)	44.6%	24.6%	15.6%
Environmental criteria used in the assessment and/or reward of employees (ECARE)	26.8%	21.1%	6.3%

The values in **Table 6** show that the frequency of each environmental management control tool’s use is higher in the Leaders cluster than in the Awakener and Laggard clusters in all cases, except for the Sustainability Balanced Scorecard, which was the lowest in the sample overall. The authors used several indicators to prove the statistical significance of the relationship between each strategy cluster and the use of environmental management control tools. The results are shown in **Table 7**.

Table 7. Related indicators of the relationship between environmental strategy clustering and the applied tools.

	Standardised residual			**Khi squ. sign.**	**Lambda**	**Goodman and Kruskal tau**	**Coefficient of uncertain.**	**Cramer V**	**Contingency coeff.**
	1	**2**	**3**						
I. Strategic issues									
DIEOS (Yes)	2.9		−4.1	0	ns	0.124	0.104	0.353	0.333
(No)	−2.9		4.1						
WEP (Yes)	3.5		−2.2	0.002	ns	0.09	0.074	0.3	0.287
(No)	−3.5		2.2						
ETPE (Yes)	3.6		−3.4	0	0.242	0.12	0.092	0.347	0.328
(No)	−3.6		3.4						

Table 7. (*Continued*).

	Standardised residual			**Khi squ. sign.**	**Lambda**	**Goodman and Kruskal tau**	**Coefficient of uncertain.**	**Cramer V**	**Contingency coeff.**
	1	**2**	**3**						
II. Administrative issues									
IEA (Yes)	2.6		−3.9	0	ns	0.111	0.094	0.333	0.316
(No)	−2.6		3.9						
EEA	There is no relationship								
PER (Yes)	2.1		−2.2	0.04	ns	0.044	0.04	0.211	0.206
(No)	−2.1		2.2						
III. Methodological issues									
DUEI (Yes)	2.8		−2	0.012	ns	0.061	0.045	0.246	0.239
(No)	−2.8		2						
SWOT (Yes)	2.2			ns	ns	ns	ns	ns	ns
(No)	−2.2								
KPI (Yes)	3.3		−2	0.003	0.159	0.08	0.059	0.282	0.272
(No)	−3.3		2						
BENCH (Yes)	2.7			0.026	ns	0.051	0.048	0.225	0.219
(No)	−2.7								
SCEN	There is no relationship								
ECO (Yes)	3.1			0.007	0.114	0.068	0.075	0.26	0.252
(No)	−3.1								
SBSC	There is no relationship								
IV. Economic issues									
EI (Yes)	4		−4.6	0	0.276	0.179	0.137	0.423	0.39
(No)	−4		4.6						
PREEC (Yes)	3.3	−2.2	−2.9	0.001	ns	0.094	0.072	0.307	0.294
(No)	−3.3	2.2	2.9						
PRERFEP (Yes)	2			ns	ns	ns	ns	ns	ns
(No)	−2								
AEES (Yes)	3.1		−4.3	0	0.277	0.141	0.106	0.376	0.352
(No)	−3.1		4.3						
IECPPS (Yes)			−2.7	0.026	ns	0.05	0.037	0.224	0.219
(No)			2.7						
EEFPA (Yes)	2.5			0.043	ns	0.044	0.032	0.209	0.204
(No)	−2.5								
ALCCP (Yes)	3		−2.1	0.008	ns	0.066	0.055	0.257	0.249
(No)	−3		2.1						
ECARE (Yes)			−2.2	ns	ns	ns	0.044	ns	ns
(No)			2.2						

In **Table 7**, the rows show each environmental management control tool's application (Yes) or non-application (No). Standardised residuals above 2 indicate the existence of a relationship with the strategy cluster, and −2 or below indicate that there is no relationship between the two variables (clusters are numbered 1—"Leaders", 2—"Awakeners", 3—"Laggards"). Interpreting the results: e.g. the operation of the Environmental Training Programme for Employees (ETPE) is related to the Leaders cluster (standardised residual: 3.6, well above 2) and certainly not related to the Laggards cluster (−3.4). The standardised residual for the following three environmental management control tools did not show a relationship with the strategy clusters: External environmental audits (EEA), Scenario techniques (SCEN) and Sustainability Balanced ScoreCard (SBSC).

Scenario techniques (SCEN), with 17%, and Sustainability BSC (SBSC), with 9%, are among the least frequently used tools in the sample as a whole, probably due to the lower number of items; no link with membership in strategy clusters could be detected. It should also be noted that the name of the Balanced ScoreCard is also questionable. The development and use of environmental indicators is 53% and the use of environmental KPIs 40% in the sample, which is so much more widespread. The BSC is the systematisation of these indicators and their integration into the corporate governance framework. In the authors' view, their importance suggests a stronger use of scenario techniques and sustainability BSC in corporate practice.

External environmental audits (EEA) occur in 54% of companies in the total sample. An interesting finding is that EEAs are not associated with membership in strategy clusters, which cannot explain the lower number of items. The reason is the need to comply with external regulations.

In parallel with the standardised residuals, it is also necessary to test the significance level of the Khi square, which is below 0.05, indicating the existence of significant relationships. It is not the corresponding value for the following controls: SWOT analysis (SWOT), Planning, recording and evaluation of revenues from environmental protection (PRERFEP) and Environmental criteria used in the assessment and/or reward of employees (ECARE). Therefore, even for these factors, there is no relationship with membership in strategic clusters. The application of SWOT analysis, one of the best-known elements of strategic control, in the field of environment is 48% of the sample. The use of environmental revenue is 58%; thus, the direction of the relationship cannot be explained by the low number of items.

Based on the Cramer V and the contingency coefficients, the authors can conclude that the following environmental management control tools show the strongest relationship with strategy clustering:

- Evaluation of investments (integrating economic and environmental evaluation) (EI) (0.423);
- Assessing the economics of environmental strategies (AEES) (0.376);
- Development and integration of environmental objectives into the strategy (DIEOS) (0.353);
- Environmental Training Programme for Employees (ETPE) (0.347);
- Internal environmental audits (IEA) (0.333);
- Planning, recording and evaluation of environmental costs (PREEC) (0.307);
- Written environmental policy (WEP) (0.300);
- Identifying environmental success factors (KPIs, key performance indicators) (KPI) (0.282);

- Eco-balances (ECO) (0.260);
- Assessing the life-cycle costs of products (from innovation to disposal) (ALCCP) (0.257).

Lambda, Goodman, Kruskal tau and the uncertainty coefficient indicate a decrease in the probability of estimation error. It expresses the extent to which knowledge of the use of a particular control tool improves the estimate of the strategy cluster membership. For example, knowing that a company has an environmental training programme for its employees improves the estimate of its membership in a strategy cluster by 12%. According to Goodman and Kruskal's tau and the uncertainty coefficient, the following environmental management control tools best reduce the probability of estimation error for belonging to the strategy cluster:

- Evaluation of investments (integrating economic and environmental evaluation) (EI) (0.179 and 0.137);
- Assessing the economics of environmental strategies (AEES) (0.141 and 0.106);
- Development and integration of environmental objectives into the strategy (DIEOS) (0.124 and 0.104);
- Internal environmental audits (IEA) (0.111 and 0.094).

According to Cramer V and the contingency coefficient, these control tools are also the most strongly associated with membership in strategic clusters.

The Lambda coefficient can be interpreted similarly. It gives the percentage value that shows the ability of the independent variable to predict the dependent variable (Hartwig, 1973). However, it is a very robust indicator (Sajtos and Mitrev, 2007); in this research, it is significant for much fewer variables than the Goodman and Kruskal tau and the uncertainty coefficient, but it indicates much higher values for the following variables:

- Assessing the economics of environmental strategies (AEES) (0.277);
- Evaluation of investments (integrating economic and environmental evaluation) (EI) (0.276);
- Environmental Training Programme for Employees (ETPE) (0.242);
- Identifying environmental success factors (KPIs, key performance indicators) (0.159);
- Eco-balances (ECO) (0.114).

These environmental management control tools also ranked highly in the Cramer V and contingency coefficients tests regarding the strength of the relationship with strategic cluster membership.

5. Conclusion

Based on the research results, it is clear that companies operating in Hungary are increasingly consciously integrating environmental management objectives and tools into their strategies and operations. They are placing a strong strategic focus on environmental issues, which enables them to be more effective at different stages of sustainability. Direct effects can be detected in their business strategies, as the integration of environmental management can provide a competitive advantage in the marketplace by meeting growing consumer expectations for sustainability. Management tools are applied differently at different levels of environmental strategy development, which can help improve cost-effectiveness and use resources more sustainably.

In response to the research questions, the authors found that the companies studied can be grouped into three clusters based on their environmental strategies: the Leaders, the Awakeners, and the Laggards. The Leaders cluster represents 39% of the sample and is involved in the highest stages of becoming sustainable. These companies meet green requirements and develop innovative business models that give them a long-term competitive advantage. By building sustainable value chains and developing sustainable products, they can capture new markets and increase their customer base. The Awakening cluster, which also counts for 39%, has an average track record in sustainability efforts, but has significant potential for improvement, which, if properly exploited, could strengthen its market position. The Laggards cluster (22% of the sample) scores well below the average on all the sustainability criteria, which could pose a risk from a business perspective as consumer preferences and regulations shift increasingly towards sustainability. Based on this, the authors accepted the H1 hypothesis that the investigated firms can be classified into different clusters according to the level of development of their environmental protection strategies.

After the cluster analysis, the authors examined environmental management control tools in the different clusters. The use of audit tools directly impact business performance by enabling companies to monitor and align their strategies more effectively with sustainability goals. The strategic and economic tools were the most widely used environmental management control tools examined, particularly in the Leaders cluster, where they are more closely linked to advanced environmental strategies. High-level environmental management systems can contribute to optimising costs and achieving sustainability goals, which increases competitiveness. Based on the results, the authors accepted the third hypothesis, which states that firms with a more advanced environmental strategy use environmental management control tools more extensively.

Further results of the research showed a significant relationship between the level of development of environmental strategies and the control tools used. Fifteen of the tools tested showed significant associations with environmental strategy clusters. Results suggests that companies with more developed environmental strategies are more effective in using control tools to help achieve strategic goals and the success of sustainability initiatives. Accordingly, the second hypothesis – that there is a relationship between the level of development of environmental strategies and the control tools used – is partially accepted.

Statistical methods were of particular importance in the research, as they allowed for an objective, quantified analysis and comparison of companies' environmental strategies. Cluster analysis helped to pinpoint which companies were at which levels of sustainability development. At the same time, statistical significance tests showed how the use of different monitoring tools was related to the level of development of sustainability strategies. With this approach, the research findings are based on qualitative findings and supported by robust, data-driven evidence. This methodological approach ensures that the research results can be replicated and applied more widely across different industries and company sizes.

As a thesis, the authors conclude that the companies under examination follow a set of environmental goals, which they have incorporated into their strategic objectives. They use the available control toolbox to develop their environmental strategies and to monitor their implementation to varying degrees. Based on the results of the Cramer V and the contingency coefficients, the most influential environmental management control tools for belonging to the environmental strategy clusters in the studied companies are, in order: evaluation of investments (integrating economic and environmental evaluation) (EI) (also confirmed by the lambda indicator). The result is particularly important for company managers who make strategic decisions on achieving sustainability goals, as the effective use of monitoring tools can improve the long-term sustainability and competitiveness.

Although the research provides valuable insights into the environmental management strategies of Hungarian companies and the use of related control tools, some limitations need to be taken into account. First, the research sample focused exclusively on companies in Hungary, which may limit the generalisability of the results to other regions or countries. Furthermore, while extensive, the list of tools and indicators used in the cluster analysis only covers some possible dimensions or innovations of sustainability strategies. In addition, due to the cross-sectional nature of the research, changes over time and the long-term effects of sustainability strategy development have yet to be examined.

There are several avenues for future research. One possible area would be to carry out a longitudinal study that would follow the evolution of companies' environmental strategies and the instruments used over time. Furthermore, a comparative analysis with companies in other countries would be worthwhile to explore the effects of national and cultural differences on sustainability strategies. Finally, a more detailed examination of the use of technological innovations such as artificial intelligence and digitalisation in environmental management could also be an important direction in promoting sustainability.

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