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Evaluation of Data-Driven Sustainability Potential at SMEs Using an Altered Ecocanvas Model

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Abstract: Incorporating sustainability into business operations is likely to become one of the most significant priorities and challenges for companies in the near future. SMEs operating within conventional frameworks often experience constraints when adjusting to evolving circumstances. They frequently lack resources, qualified experts, skills, and capabilities to enable the efficient implementation of DT within the organization. In this paper, Eurostat datasets were analyzed to uncover trends in SME digitalization and sustainability, focusing on patterns in data utilization, employee training, and environmental considerations. These insights were integrated into an altered Ecocanvas sustainability modeling tool to develop a framework supporting their strategic planning and decision-making. It has proven to be a useful tool for this purpose by mapping business processes against sustainability and strategic goals while indicating where digital or alternative solutions can be introduced. SMEs analyze data and consider environmental impacts at different levels based on their size categories. To determine whether these differences are statistically significant, we have performed one-way ANOVA tests. This paper aims to provide a data-driven situational analysis and tool, which outlines the benefits of data analytics from several aspects while offering practical recommendations for company leaders to consider and implement.

Keywords: sustainability; Ecocanvas; ESG; reporting; barriers; SMEs; data-driven

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1. Introduction and Theoretical Background

Sustainability has become a critical issue for SMEs (small- and medium sized enterprises) besides DT (digital transformation) (Wang & Zhang, 2025). The consequences of global warming and the depletion of resources have become increasingly visible (Chatterjee et al., 2022), and the pressure on businesses to reduce their environmental impact and to operate with greater environmental awareness is getting challenging (Okolo et al., 2023). Companies that prioritize and integrate sustainability and digital solutions into their business strategy and daily operations (Ahmadi et al., 2020) tend to attract more customers, investors, and talent, leading to improved financial performance and long-term success (Pacolli, 2022). Customers and stakeholders are increasingly demanding that companies should operate sustainably and more efficiently (Appiah-Kubi, 2024), and governments are introducing regulations to incentivize and enforce sustainability practices for them (Martins et al., 2022).

The effects of these initiatives (Fang et al., 2023) in supporting the implementation and management of digital tools (Siddiqui et al., 2023) to enhance corporate efficiency

(Gallastegui & Forradellas, 2024) and competitiveness (Wang & Esperança, 2023) for SMEs can also be acknowledged. By successfully embracing twin transitions, SMEs can become resilient, remain competitive, and meet the changing market and environmental needs (Gouveia & Mamede, 2022).

The EU's (European Union) Digital Compass for the Digital Decade sets ambitious 2030 goals, aiming to enhance advanced digital skills, drive DT across industries, and encourage companies to adopt digital tools that enable and support sustainability (Chatzistamoulou, 2023). This strategic vision aims to establish Europe as a global frontrunner in a digitally empowered society while fostering innovation and corporate resilience.

The European Green Deal promotes a sustainable economy by encouraging companies to adopt green ICT (information communication technology) solutions and use DT and DA (data analytics) to develop environmentally friendly business practices (Hyldmo et al., 2024). EU Taxonomy and CSRD (corporate social responsibility directive) will make the vast majority of SMEs obligated to perform non-financial reporting endeavors shortly (Cronin & Doyle-Kent, 2022). The transition to non-financial performance reporting is happening within the EU (European Union), and SMEs need to be prepared for it (Jaeyoung & Misuk, 2023).

As Industry 4.0 technologies and digital tools (Contini et al., 2023), like data analysis and artificial intelligence (Zhao et al., 2025), enable better evaluation of company-collected data, simplifying environmental and sustainability reporting activities. Digitalization and DT have emerged as key drivers for organizational growth and success (Robertsone & Lapiņa, 2023). DA has emerged as a key resource for businesses, enabling the extraction of meaningful insights from vast datasets (Hidayat-ur-Rehman & Majed Alsolamy, 2023) that support decision-making (Watson, 2018). Leveraging advanced digital technologies and data analysis allows economic systems to evaluate and manage their impact on enterprise ESG performance precisely, driving the creation of more sustainable, responsible, and efficient development models that align with evolving environmental and social expectations (Li et al., 2024a). For example, IoT sensors can be deployed to monitor operations, capturing data on power usage and greenhouse gas release during production (Tamym et al., 2023a) to measure ESG indicators, which are then analyzed to optimize performance, reduce environmental impact, and ensure greater sustainability across production (Zhou & Liu, 2023).

SMEs often face challenges navigating the intricate regulatory environment (Faiz et al., 2024), highlighting the need for clear guidance and support from policymakers and academia to help businesses interpret and comply with environmental regulations while promoting adherence and sustainable practices (Lam et al., 2024).

When regulations and policies require the re-design of the daily operational frameworks, SMEs need to innovate by creating new business models that align with these values (Lee et al., 2024). This requires pinpointing opportunities for enhancing business functions, utilizing digital solutions to bridge gaps, and embedding sustainability deeply into both operations and strategic planning (de Andrade et al., 2024).

Digitalization can enable SMEs to take advantage of emerging paradigms to re-create more sustainable business models (Pedone et al., 2021). Using an analytics-driven approach and implementing the necessary technologies, SMEs can uncover operational insights and fine-tune performance and resource usage while reducing waste (Rodríguez-Espíndola et al., 2022), ultimately leading to a more sustainable, circular economy principle-focused business structure (Mancuso et al., 2023). AI (artificial intelligence) acts as a revolutionary tool in ESG reporting, advancing the precision and efficiency of the process by automating data analysis (Huang et al., 2024) and simplifying the evaluation of ESG measures. With the ability to handle extensive datasets, recognize trends, and generate practical insights (Liu et al., 2024), AI minimizes risks of manual errors while enhancing overall performance

by expediting data-driven decisions and improving the dependability of sustainability reporting frameworks (Dudek & Kulej-Dudek, 2024).

Research findings from China (Guo & Pang, 2025; Cai et al., 2023) concluded that DT significantly enhances companies' ESG ratings while simultaneously encouraging higher levels of investment in digital technologies. To harness data as a valuable analytical resource, SMEs must develop robust capabilities in data analysis, interpretation, and exploitation (Li et al., 2024b). Better alignment between environmental indicators and DT is required to ensure SMEs' environmental footprint is accurately measured and improved in the future (Fortier et al., 2024).

Even though the social aspect of sustainability is often overlooked in transformation processes, SMEs acknowledge that achieving sustainability is a multi-faceted challenge that demands a well-defined strategic approach and focused management efforts (Jakobs et al., 2024). SMEs and their employees will face added administrative burden (Chen et al., 2022) under new reporting standards, potentially requiring new hires or training investments for existing staff (Lan & Zhou, 2024), posing fiscal and organizational challenges.

Cheng et al. (2021) highlights that DA capabilities of the companies are vital for developing competitive and sustainable corporate supply chains as well. Mastering DA can be a foundation of smart and sustainable manufacturing standards (Chinnathai & Alkan, 2023). Conventional decision-making methods may not effectively harness the full potential of technological tools (Nouinou et al., 2023), so companies are advised to use assets like BI (business intelligence) tools or even AI-supported platforms.

The integration of data analytical practices into business workflows set challenges to SMEs, which may be hesitant to invest in novel technologies due to concerns about costs, expertise, and data privacy (Wang & Wang, 2020). DT and the use of DA as a component of digital innovation drive cost reduction, productivity enhancement, and a shift from short-term management practices to long-term strategic growth (Ding et al., 2024). By embracing new principles and perspectives with re-imagined business models, SMEs can meet external expectations, reduce their environmental impact, and create new revenue streams for themselves (Kersan-Skabic, 2021). Kamble et al. (2021) mentions that analyzing data is an excellent way to address sustainability concerns, but more practical research is needed that directly showcases general industry sustainable business practices.

The main goal of this paper is to provide a comprehensive framework through business functions and other ESG-relevant aspects for practitioners and decision-makers by illustrating how digital solutions and DA can assist in re-designing business models for enterprises and help them identify and integrate not only environmentally sustainable practices but also digital tools into them. The paper's objective is to resolve the knowledge gap of company leaders regarding the potential benefits of using data analytics and promoting its utilization to define and reach impactful sustainable strategic development goals to enforce resilience. Lack of knowledge on digital tools is still a longstanding issue heavily analyzed in professional literature, and our approach offers a practical solution to effectively address and overcome this challenge for SMEs.

According to many literature claims, the authors would like to test if there is a significant difference in the current DA and sustainability practices of SMEs in different size categories.

Two hypotheses are defined in the following:

1. SMEs do not differ in data analysis practices when purchasing ICT services or equipment based on size categories.
2. SMEs also show no significant differences in their consideration of environmental sustainability in these purchasing decisions.

The following research question was defined for this study by the authors:

- How do SMEs of different size categories differ in their data analysis practices and environmental sustainability considerations when purchasing ICT services or equipment?

2. Methodology

This study employs a structured methodology, beginning with the analysis of secondary data sourced from Eurostat to examine how SMEs across the EU engage with DA and sustainability practices. In general, Eurostat provides reliable, standardized, and comprehensive statistics across European countries, ensuring comparability and accuracy in the current utilization analysis. The datasets capture key dimensions, including SMEs' initiatives to enhance employee ICT skills, adoption of AI and business intelligence (BI) tools, barriers to AI, big data analytics implementation, environmental considerations of ICT devices, and the electronic exchange of supply chain information between 2020 and 2023. The collected data was consolidated into a unified working database, enabling the use of descriptive statistical analysis and visualization-driven techniques to identify trends and support the findings of the literature review. For the analysis and visualizations, SPSS software and Tableau were used, respectively. To test the two hypotheses defined previously, one-way ANOVA difference tests were performed on variables 1 and 2, per SME size categories (small/medium/large enterprises). This statistical method is used to determine if there are significant differences between the means of three or more independent groups (countries or size categories); it is effective, easy to perform, and applicable to test hypotheses (Karadag, 2017). The size category was selected as a factor for the tests because it has been proven that companies have different digital maturity levels per size class in general (Brodny & Tutak, 2022). Missing values in specific size categories were noted within the dataset and were summarized in Table 1, besides the used variables. The working database is available upon request.

Table 1. Variables used in secondary research collected from Eurostat.

Description [With Variable Name Retrieved from EUROSTAT]	Missing Values	Year
1. Enterprises perform data analytics from different sources . . . [E_DASCRM, E_DASERP, E_DASGOV, E_DASLOC, E_DASSAT, E_DASSDS, E_DASSM, E_DASWEB],		2023
2. The enterprises considered the environmental impact of ICT services, or ICT equipment, before selecting them and applying some measures, affecting the paper or energy consumption of the ICT equipment [E_ENVPECEI],	PR[M]	2022
3. Enterprise provided training to their personnel to develop their ICT skills [E_ITT2],	PR[M]	2023
4. Enterprises buy cloud computing services used over the internet and perform data analytics [E_CC_DA],	PR[M]	2023
5. Enterprises use ML for data analysis [E_AI_TML],	PL, RO [S]	2023
6. DA for the enterprise is performed by firm's own employees/by an external provider [E_DA],		2023
7. Enterprises using BI software [E_ITBI],	PR[M]	2023
8. Enterprises share supply chain management information electronically with suppliers or customers [E_SISC],	HU, PR[M]	2023
9. One reason not to perform big data analysis, but considered, is . . . [E_BDAXCST, E_BDAXICT, E_BDAXPRI, E_BDAXPRV, E_BDAXQLT, E_BDAXSKL, E_BDAXSRC, E_BDAXUSF],	BE, CZ, DE, ET, IR, EE, IT, LA, RO, SW	2020
10. Enterprises using CRM software [E_CRM1],	PR[M]	2023

Table 1. *Cont.*

Description [With Variable Name Retrieved from EUROSTAT]	Missing Values	Year
11. Enterprises who have ERP software package to share information between different functional areas [E_ERP1],	PR[M]	2022
12. Involve customers in development or innovation of goods or services [E_SM_PCUDEV], 13. Exchange views, opinions, or knowledge within the enterprise [E_SM_PEXCHVOK], 14. Collaborate with business partners (e.g. suppliers, etc.) or other organizations (e.g. public authorities, non-governmental organizations, etc.) [E_SM_PBPCOLL],	BE, DK, ET, IR, IT, LA	2023
15. Enterprises considered, but do not use AI technologies, because . . .[E_AI_BCDP, E_AI_BCST, E_AI_BDDT, E_AI_BEC, E_AI_BINC, E_AI_BLE, E_AI_BLEG, E_AI_BNU]	CZ, DK, DE, IR, FR, LX, RO, BU	2023

All data was retrieved from Eurostat (2024) per SME size categories for all activity sectors which cover 2023, except indicator 2 (2020) and 11 (2022), where the latest available data was obtained. The data is available on Eurostat's portal.

Building on this foundation, the original Ecocanvas model was altered to assess how DA can support SMEs in enhancing sustainability practices and preparing for future ESG reporting activities. Each of the model's 12 sections was enriched with insights from the literature (backed up with secondary data), providing a comprehensive overview of the advantages and opportunities that DT and DA can offer to SMEs. This approach serves as a practical framework for SMEs to rethink their business models and digital strategies, embedding sustainability at their core. Figure 1 shows the used Ecocanvas base template as a framework for this paper.

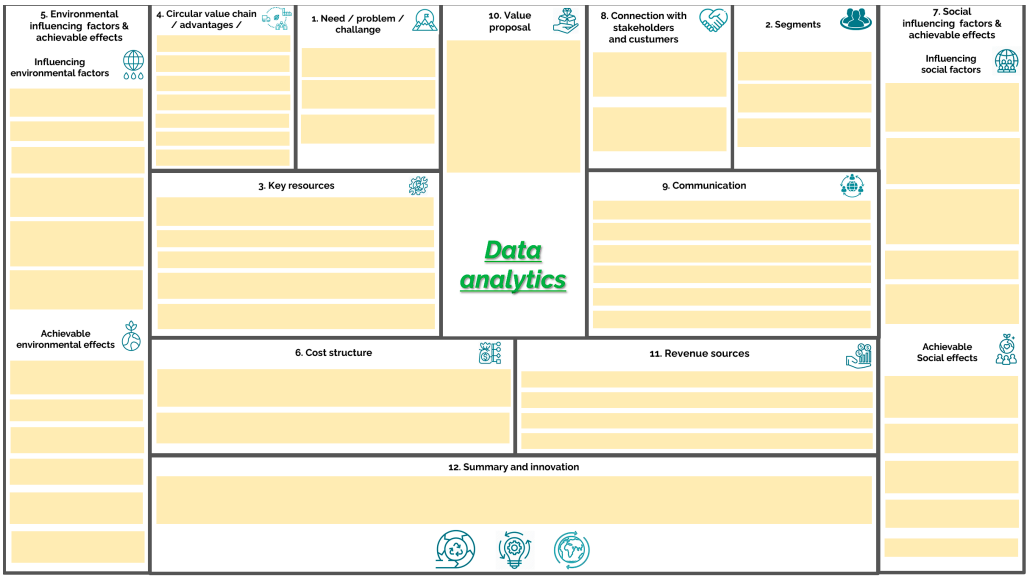

Figure 1. Empty business canvas model based on Daou et al. (2020).

As circular economy principles started to get more appreciation from stakeholders, policymakers, industry practitioners, and researchers, the demand for fresh, innovative, and sustainable frameworks was rising (Geissdoerfer et al., 2020), highlighting the importance of achievable environmental and positive social effects of business operations.

The Ecocanvas model in itself is a structured and visual approach to assess and improve a company's overall sustainability performance using circular economy principles (İncekara, 2022). According to the work of the original canvas developers, it is a helpful tool

for anyone to use it for business model mapping, as it considers several areas of company functions, such as products, processes, and services, and helps to identify opportunities for improvement with potential benefits (Daou et al., 2020). It also considers the environmental and social impact of a company's business operations, which is critical in today's world, where sustainability is a major concern.

We believe that ESG requirements will start getting more and more highlighted and become standard in supply chain management; the need to analyze data will be a necessity to prepare environmental reports from valid, real-time sources to prove sustainable readiness in the upcoming years to gain partner trust.

In the context of data analytics implementation, Ecocanvas modeling helps SMEs identify potential opportunities and risks while using a structured approach to address key aspects such as data privacy, security, and expertise, enabling them to determine the best course of action (Sumarsono et al., 2023). The canvas tool also helps SMEs identify any potential influencing impacts that DA may have on the environment or society, which is essential in ensuring that the technology is implemented sustainably. For circular economy value data, insights serve as a feedback mechanism, enabling necessary adjustments when deviations in KPIs occur or significant variations are identified.

Business process mapping (Rosado et al., 2024) has several key benefits such as improved inventory management, better customer targeting, and increased productivity (C. Li et al., 2022), which allow SMEs to view DA as an opportunity rather than a cost. Modeling helps SMEs identify potential cost savings and efficiency gains that can be achieved (Djatna & Luthfiyanti, 2015) with free or low-cost alternatives.

For instance, segments such as "Key Activities" and "Key Resources" were redefined to emphasize the adoption of DA, BI, and AI tools for improving operational efficiency and environmental performance. The "Customer Segments" section was tailored to highlight the increasing demand for environmentally conscious products and transparent ESG reporting, encouraging SMEs to leverage DA to meet these expectations. Similarly, the "Cost Structure" and "Revenue Streams" sections were adapted to account for investments in DT and the potential financial benefits of optimized processes and enhanced sustainability credentials.

Moreover, the "Value Propositions" section was enriched with insights from our literature review, showcasing how SMEs can differentiate themselves by integrating DA and ESG considerations into their core offerings. Other sections, such as "Channels" and "Customer Relationships", were adapted to reflect the importance of data-sharing mechanisms and CRM (customer relationship management) and ERP (enterprise resource planning) systems in fostering trust and collaboration within supply chains.

By tailoring the Ecocanvas model in this way, our research aims to provide SMEs with a practical overview for embedding sustainability into their business models while leveraging the advantages of DA. This customized framework can help position SMEs to innovate and thrive in an increasingly sustainability-focused market landscape.

To test the research hypotheses, one-way ANOVA tests were performed. Like all statistical tests, its application also has pre-conditions to meet. First, we checked for outliers in our datasets and checked the twice of the error or the mean + group means between size categories for both variables (Figure 2). No relatively big variances were found. The collected Eurostat datasets were scale-typed data as well. Thus, the authors concluded that the tests could be performed.

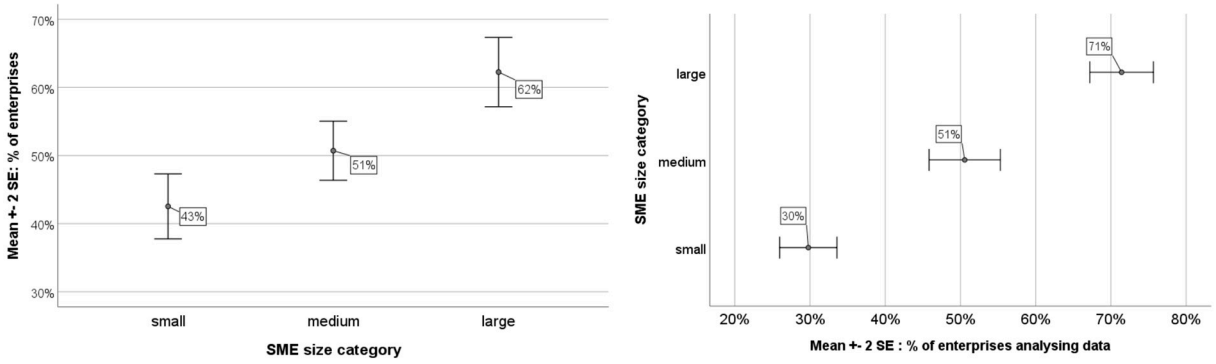

Figure 2. Pre-condition checks: (**a**) enterprises considering environment variables; (**b**) enterprises analyzing data internally or externally in 2023.

The next step was to test the normality of the variables with Levene's tests with 95% confidence intervals. As they were not significant, the ANOVA tests could be performed in SPSS. The evaluation of the results will be discussed in the following section. For post hoc tests, LSD (lease significant difference) tests were performed.

3. Results and Discussion

The findings from our analysis offer a comprehensive understanding of how SMEs engage with DA and sustainability practices in the EU, founded on the integration of Eurostat data and an adapted Ecocanvas model. By employing visualization-driven techniques, the study examines the adoption of digital tools, the challenges SMEs face, and their alignment with sustainability and ESG objectives.

To test the research hypotheses, the one-way ANOVA test results can be seen in Figures 3 and 4.

Multiple Comparisons

Dependent Variable: E_DA

LSD

(I) size cat	(J) size cat	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
small	medium	−20.78667*	3.02284	0.000	−26.8047	−14.7687
	large	−41.64111*	3.02284	0.000	−47.6591	−35.6231
medium	small	20.78667*	3.02284	0.000	14.7687	26.8047
	large	−20.85444*	3.02284	0.000	−26.8725	−14.8364
large	small	41.64111*	3.02284	0.000	35.6231	47.6591
	medium	20.85444*	3.02284	0.000	14.8364	26.8725

*. The mean difference is significant at the 0.05 level.

(**c**)

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
E_DA	Based on Mean	1.340	2	78	0.268
	Based on Median	1.058	2	78	0.352
	Based on Median and with adjusted df	1.058	2	76.691	0.352
	Based on trimmed mean	1.310	2	78	0.276

(**a**)

ANOVA

E_DA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	23408.779	2	11704.390	94.882	0.000
Within Groups	9621.851	78	123.357		
Total	33030.631	80			

(**b**)

Figure 3. One-way ANOVA results 1. Tables from SPSS as: (**a**) Levene's test results for variable E_DA (% of enterprises analyzing data); (**b**) one-way ANOVA results; (**c**) LSD post-hoc test results.

Multiple Comparisons

Dependent Variable: consider_env

LSD

(I) size cat	(J) size cat	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
small	medium	−8.17407*	3.35053	0.017	−14.8445	−1.5037
	large	−19.72111*	3.35053	0.000	−26.3915	−13.0507
medium	small	8.17407*	3.35053	0.017	1.5037	14.8445
	large	−11.54704*	3.35053	0.001	−18.2174	−4.8766
large	small	19.72111*	3.35053	0.000	13.0507	26.3915
	medium	11.54704*	3.35053	0.001	4.8766	18.2174

*. The mean difference is significant at the 0.05 level.

(**c**)

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
consider_env	Based on Mean	0.214	2	78	0.807
	Based on Median	0.257	2	78	0.774
	Based on Median and with adjusted df	0.257	2	73.534	0.774
	Based on trimmed mean	0.222	2	78	0.801

(**a**)

ANOVA

consider_env

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5301.646	2	2650.823	17.491	0.000
Within Groups	11821.058	78	151.552		
Total	17122.704	80			

(**b**)

Figure 4. One-way ANOVA results 1. Tables from SPSS as: (**a**) Levene's test results for variable consider_env (% of enterprises considering environmental effects before buying/renting ICT services or equipment); (**b**) one-way ANOVA results; (**c**) LSD post hoc test results.

In both cases, the Levene tests remained insignificant; thus, we assumed equal variances. As per the ANOVA results, both of them became significant, so significant differences were found between the size classes. To further check which size classes, differ from each other, LSD post-hoc tests were performed. They showed significance in both cases.

Based on the test results, our initiative research hypotheses were rejected, as there are significant differences in the utilization of how well enterprises perform DA and consider environmental effects.

Regarding our research question, the altered framework offers a structured lens through which the potential of DA to enhance business models and foster sustainable development is explored, laying the groundwork for practical recommendations and insights. As the model has twelve points, each section was adapted to align with the study's focus and objectives.

3.1. Impact/Need/Challenge

This section is the starting point of the model. SMEs often face several obstacles hindering their DT efforts, including limited financing (Cho, 2022), challenges in developing custom business processes that align with their unique business model, and the burden of not having enough expertise within the company. Eurostat data supports this aim. In 2020, big data analytics-related statistical results show that the top reason why DA was not used in SMEs is that many business leaders are unaware of the value of data analysis and often fail to recognize its potential. They perceive the costs of implementation as disproportionate to the possible benefits. Numerous respondents pointed out the lack of essential resources, such as sufficient ICT infrastructure, skilled personnel, and reliable data sources. Others identified challenges related to poor data quality or struggles with adhering to data protection laws and regulations. These are still common issues nowadays to tackle.

This also explains the current level of DA statistics in 2023 (Figure 5), and it is likely that the data for 2024 will follow a similar trend, as these hindering factors are expected to remain relevant in 2024 as well (Basit et al., 2024). Similar reasons can be observed regarding AI implementation blocking factors according to the collected statistics.

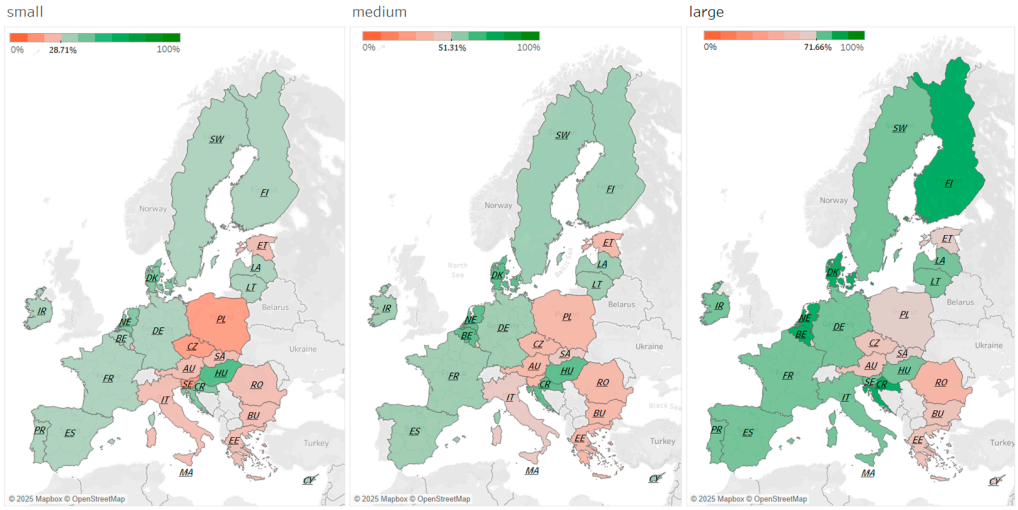

Figure 5. % of enterprises performing data analysis in 2023 per SME size based on Eurostat (2024).

The trends in DA adoption among SMEs across EU countries vary significantly by enterprise size. The green highlighting means performing over the EU-27 average, and the red coloring means underperforming. Small enterprises show a lower engagement rate, with the EU-27 average at 28.71%. Notably, countries like Hungary (51.11%), Croatia (47.67%), and Denmark (44.09%) exceed this average, indicating a stronger focus on DA among smaller firms in these regions. In contrast, countries such as Slovenia (14.14%) and Poland (14.36%) demonstrate minimal uptake, reflecting potential constraints like resource limitations or lack of digital infrastructure.

Medium-sized enterprises perform considerably better, with the EU-27 average at 51.31%. Denmark (69.28%), Croatia (69.84%), and the Netherlands (68.90%) lead in this category, suggesting these regions have favorable conditions for mid-sized businesses to adopt data-driven practices. However, Romania (30.99%) and Slovenia (34.82%) fall significantly below the average, highlighting disparities in adoption rates that might stem from economic or technological gaps.

Large enterprises exhibit the highest levels of DA utilization, with an EU-27 average of 71.66%. Denmark (88.34%), Croatia (83.91%), and the Netherlands (84.82%) are frontrunners, reflecting well-established data strategies in larger organizations. On the other hand, Romania (48.36%) and Austria (55.79%) lag, indicating room for improvement even among larger firms.

The adoption of ML (machine learning) for DA in the EU in 2023 shows a clear trend based on enterprise size, with large enterprises leading significantly at an EU average of 14.62%, compared to 4.81% for medium enterprises and just 1.78% for small enterprises. This disparity highlights the greater capacity of larger firms to integrate advanced technologies, likely due to more resources and expertise. Denmark, Finland, and Belgium demonstrate notably high adoption rates among medium and large enterprises, showcasing regional leaders in innovation. However, many countries, especially in Eastern Europe, exhibit lower adoption rates across all enterprise sizes, indicating potential barriers to implementation, such as resource constraints or limited expertise. This trend underscores the need for targeted strategies to support SMEs in leveraging machine learning for DA. By integrating digital solutions into strategies, SMEs can automate reporting, streamline data collection, and establish feedback loops for continuous improvement (Ritala et al., 2021). This approach increases competitiveness and enables transparent, accurate ESG reporting aligned with sustainability goals (Jones et al., 2021).

Data collection involves gathering information and feedback retrieved from online platforms, sensors, or any source that the company has direct access to. Big data analyt-

ics processes large datasets to uncover patterns and trends, providing businesses with insights into customer behavior, market trends, and operations for better decision-making (Dominguez et al., 2023).

DA has a key role in ESG reporting by identifying the required data, indicators, and stakeholders and mapping out processes. It supports the transformation and implementation of automated data reporting workflows, establishes clear responsibilities, and creates structured feedback loops. Additionally, it facilitates systematic data collection, document management, and continuous performance measurement, ensuring a robust and efficient ESG reporting framework, so it is crucial for companies to perform DA so they can meet the evolving requirements of the future.

3.2. Segments

SMEs can recognize several critical stakeholders that influence and contribute to their sustainability efforts.

Customers are a key segment, as they increasingly demand transparency and accountability in ESG practices. Digitalization assists organizations to streamline operations, boost efficiency, and deliver value to customers (Georgescu et al., 2022). By leveraging DA, SMEs can track customer preferences, monitor their satisfaction with sustainable products, and optimize their offerings to better align with environmentally conscious demand (Tseng, 2023). This data-driven approach enables SMEs to stay competitive and responsive to the unfolding expectations of their partner base.

Suppliers are crucial partners in an SME's path toward sustainability. Through DA, SMEs can gain insights into value chains, optimizing resource usage and monitoring emissions while ensuring the responsible sourcing of materials (Xu et al., 2023). Electronic data sharing within the supply chain fosters greater collaboration with suppliers (Kunkel et al., 2022), ensuring that environmental and social goals are met at every stage of production.

Employees, as another critical segment, are integral to the successful adoption of digital tools and sustainability practices. Moreover, to effectively perform big data analysis, organizations need a skilled workforce equipped with relevant ICT knowledge and capabilities (Straub et al., 2023).

A key part of the digital transformation process is becoming familiar with and identifying potential data sources within the company for analysis. The Eurostat listing provides only a few main categories, but there are many other possible sources and subcategories to explore. Figure 6 highlights significant differences in the utilization of different data sources for analytics across small, medium, and large enterprises in the EU-27. Large enterprises consistently lead in adopting data sources, with the highest usage seen for transaction data (79%), customer CRM data (63%), and web data (52%), while small enterprises lag behind in all categories. Medium enterprises show moderate adoption levels, often closer to the EU-27 average. Less commonly used sources, such as government open data, location data, and satellite data, see particularly low adoption rates among small and medium enterprises. SMEs are often unaware of the many data sources they can utilize.

Regulatory bodies shape the standards and requirements for ESG reporting. DA helps SMEs stay compliant by providing accurate, real-time insights into their sustainability performance, ensuring they meet regulatory expectations while building trust with stakeholders (Khalifa & Marzouk, 2025).

Investors and banks are crucial stakeholders in an SME's sustainability journey, as they are placing greater emphasis on ESG performance when choosing investments. Data-driven insights enable SMEs to reveal their dedication regarding sustainability, showcasing clear environmental and social metrics that attract responsible investment and strengthen relationships with financial partners (Udeagha & Ngepah, 2023).

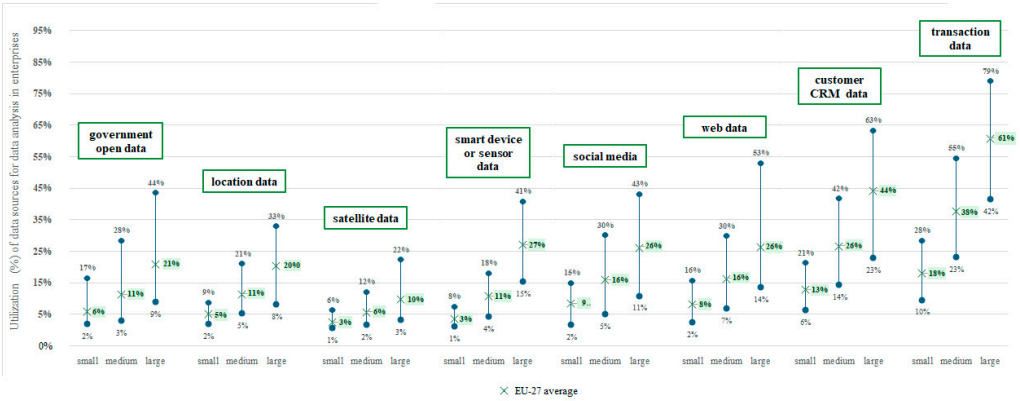

Figure 6. Data source utilization by SME size categories in 2023 (%) based on Eurostat data (2024).

Enterprise leaders and individuals should prioritize managing data analytical processes, including identifying data sources and converting them into valuable insights, rather than limiting their focus to the financial and investment aspects (Mikalef et al., 2020). Company leaders need to define their main business goals and sub-goals with standard data management processes (Chirumalla, 2021).

3.3. Key Resources

Technological infrastructure is essential for implementing DA in ESG reporting and cloud computing for scalability, secure data storage systems (Dabbous et al., 2023), and advanced analytical and visualization tools to transform raw data into actionable insights.

Instead of relying on traditional ICT infrastructure, on-demand access to computing resources, data storage, and other services with analytical capabilities can be rented and provided through cloud services for SMEs. The need for significant upfront investments in hardware and infrastructure is eliminated by this flexibility, enabling resources to be scaled according to business needs, while these cloud services also offer enhanced data security, data redundancy, and collaboration opportunities (Tawalbeh & Saldamli, 2021), making them an attractive choice for organizations embracing DA.

Per Eurostat data regarding cloud services, small enterprises show limited uptake, averaging 16.53%, with Denmark (35.55%) and Hungary (26.49%) leading, while Bulgaria (6.88%) and Slovenia (8.42%) lag. Medium-sized enterprises have significantly higher adoption rates, averaging 36.19%, with notable leaders like Denmark (58.41%) and the Netherlands (56.83%). Large enterprises exhibit the highest adoption rates, averaging 60.66%, with Denmark (84.00%) and Finland (85.33%) standing out. The data indicates that cloud services for analytics are more prevalent in larger organizations, with substantial disparities among countries (Eurostat, 2024).

Investing in open-source tools, such as Apache Hadoop and Spark, provide cost-effective solutions for storing, processing, and analyzing vast amounts of data while offering flexibility, scalability, and customization options, empowering businesses to derive actionable insights from their data assets (Aslam et al., 2022).

By providing training opportunities regarding ICT skills, privacy laws, ESG reporting requirements, and sustainability principles, SMEs can empower their workforce to actively contribute to sustainability objectives (Alshuaibi et al., 2024). Company staff often do not possess the necessary skills or knowledge or capabilities (Várallyai et al., 2023) to simply introduce or know how to integrate DA utilization into their business models, but they would consider doing that. Training and support should be provided to employees to ensure effective use of big data and know-how on sustainability principles even with the help of gamification (Khun & Lucke, 2021).

According to Eurostat (2024) datasets, small enterprises report an EU average of 17.69% providing ICT training, with notable leaders like Finland (34.05%) and Sweden (29.47%), while countries like Bulgaria (6.65%) and Romania (6.74%) lag significantly. Medium-sized businesses display a higher EU average of 40.02%, with Denmark (54.79%) and Finland (61.72%) at the forefront. Large enterprises lead the trend, with an EU average of 69.52%, demonstrating robust investment in ICT training, particularly in Belgium (87.09%) and Finland (87.21%). This pattern underscores that smaller businesses face more constraints in fostering ICT skill development.

ICT skill training is essential for DT, empowering organizations to adopt technologies that drive innovation, enhance operations, and adapt to changing market dynamics (Samper et al., 2022).

Collaboration enhances analytical capabilities, as partnerships with technology providers and shared supply chain data foster transparency (Biemans, 2023), provide valuable benchmarks, and enable better ESG tracking, creating a comprehensive approach to sustainability.

Reliable data resources and strong governance processes are vital (SMEs must define their data sources, whether internal or external, and ensure proper structuring, collection, and analysis) (Hardy & Maurushat, 2017). Governance frameworks safeguard data integrity and ensure analytics align with ESG objectives. Strong managerial support is essential to drive the integration of DA and DT within an organization, ensuring alignment of strategic objectives, allocation of resources, and fostering an innovative work culture (Pauwels & Aksehirli, 2025).

BI dashboards centralize ESG metrics, allowing SMEs to monitor indicators like emissions and resource use in real-time (Brennan et al., 2019). These tools help identify trends, set targets, and measure progress, driving informed, sustainable decision-making.

3.4. Value Chain Advantages

This section identifies how SMEs can leverage DA and digital tools to enhance operational efficiency, foster sustainability-driven innovation, and optimize collaboration across the supply chain. Industry 4.0, DT, and DA offer efficient solutions to supply chain challenges, enhancing visibility, agility, and resilience (Popolo et al., 2022). DA could help to optimize inventory management, reduce stockouts, minimize excess inventory (Kayikci et al., 2022), and promote customer engagement, allowing businesses to take initiative-taking measures (Krisnawijaya et al., 2022).

DA empowers businesses to optimize marketing and pricing strategies by analyzing customer behavior, segmentation, and preferences so SMEs could tailor marketing campaigns and efficiently reach targeted customer segments (Tyrväinen et al., 2020).

According to Eurostat (2024), CRM system utilization in the EU demonstrates a clear upward trend with enterprise size, reflecting increasing customer engagement complexity as businesses scale. Among small enterprises, the average adoption rate is 22.18%, with Finland (44.95%) and the Netherlands (44.42%) leading, likely benefiting from advanced digital ecosystems and targeted support for small business digitalization. In medium enterprises, where CRM adoption averages 39.50%, top performers like Finland (65.98%) and Denmark (56.44%) likely indicate robust investment in customer-focused technologies. For large enterprises, adoption peaks at 60.47%, with Finland (83.41%) and Poland (76.86%) showing strong CRM integration, driven by larger resources and a focus on data-driven customer strategies.

Collaboration with other SMEs and industry actors can foster learning and resource sharing (Melo et al., 2023), which could emphasize how DA can improve customer experience while encouraging SME leaders to embrace this or any other digital technology.

The trends in electronically sharing supply chain information within the EU highlight a clear correlation between enterprise size and adoption rates. Large enterprises show the highest engagement, with an EU-27 average of 59.11%, showcasing advanced integration in countries like Czechia, Denmark, and Germany, where rates surpass 69%. Medium-sized enterprises average 36.82%, with notable adoption in Czechia and Denmark exceeding 50%. Small enterprises lag behind at an EU-27 average of 21.25%, with higher engagement in Czechia and Slovenia but significantly lower rates in countries like Romania and Greece. This trend indicates that larger organizations have better networking activities.

Using an ERP software package to share information between different functional areas fosters seamless communication, enhances operational efficiency, and ensures data consistency, enabling more informed decision-making and streamlined business processes. ERP utilization across EU enterprises increases notably with organizational size, reflecting the growing need for integrated systems as operations become more complex. Among small enterprises, with an average adoption rate of 37.91%, leading countries like Denmark (62.77%) and Sweden (54.31%) likely benefit from more accessible digital infrastructure and supportive policies. In medium enterprises, where adoption averages 65.96%, the prominence of Denmark (84.10%) and Spain (77.89%) suggests advanced digital maturity and greater capacity to invest in ERP systems. For large enterprises, adoption peaks at 86.34%, with Denmark (97.19%) and Finland (94.59%) leading, likely due to their robust economies and emphasis on technological integration.

3.5. Environmental Advantages and Impacts

A key focus point of this paper is to identify the environmental factors pressuring SMEs to introduce DA and, furthermore, to uncover achievable environmental effects.

Environmental Influencing Factors and Achievable Effects

DA allows companies to gather and assess large volumes of data concerning power usage, GHG level, and carbon footprint so they can identify emission hotspots and trends while detecting inefficiencies (Wessels & Jakonya, 2022). Based on those, SMEs can implement targeted strategies to reduce greenhouse gas emissions to optimize operations and use energy-saving opportunities to be less vulnerable to the unpredictably changing energy prices and demands to make energy procurement strategies more efficient (J. Li et al., 2023).

By analyzing data on resource consumption, waste, and value chains, companies can uncover ways to optimize resources, minimize waste, and enhance recycling efforts. This supports the development of circular economy practices (Ebner & Iacovidou, 2021).

DA could facilitate accurate and efficient environmental compliance and sustainability reporting to ensure compliance with future regulatory standards, keep track of environmental performance indicators, and implement measures to meet and exceed regulatory requirements (Murdayanti & Khan, 2021).

In today's competitive landscape, businesses face increasing pressure from industry peers and investors to adopt sustainable practices. By monitoring industry trends and identifying best practices, organizations can implement innovative sustainability measures and stay resilient (Ali et al., 2020).

Businesses can enhance product designs to align with sustainable principles based on specific customer needs so the energy and material usage is optimized, as data-driven product designs allow organizations to create more eco-friendly, durable, and recyclable products (Bradley et al., 2017).

Figure 7 shows a statistic on the percentage of enterprises that considered the environmental impact of ICT services, or ICT equipment, before selecting them and applying some measures, affecting the paper or energy consumption of the ICT equipment in 2022. The

green highlighting means performing over the EU-27 average, and the red coloring means underperforming.

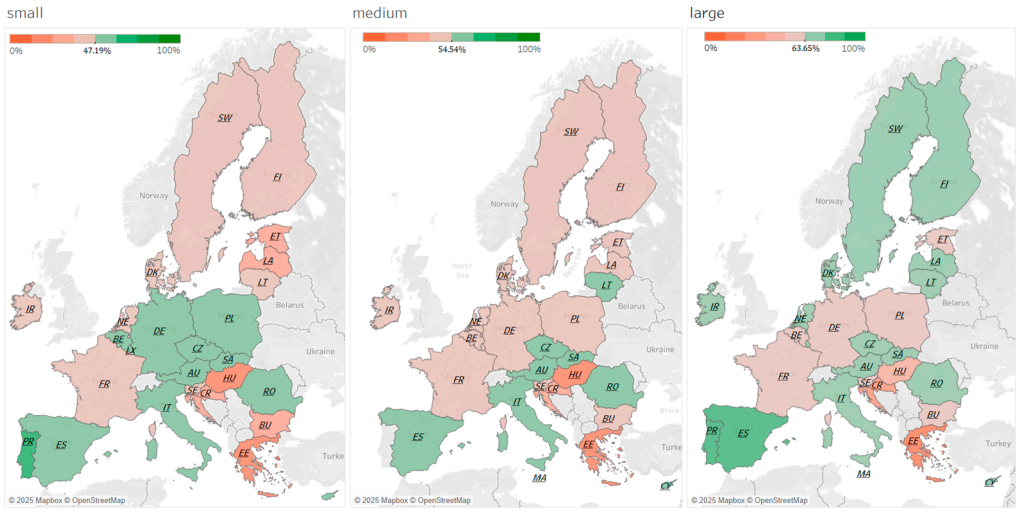

Figure 7. % of enterprises that considered the environmental impact of ICT services, or ICT equipment, before selecting them and applying some measures, affecting the paper or energy consumption of the ICT equipment in 2022 per SME size based on Eurostat (2024).

Among small enterprises, the average adoption rate is 47.19%, with Portugal (62.83%) and Italy (59.03%) demonstrating strong environmental awareness, likely driven by national sustainability initiatives and market pressures. Medium enterprises, with an average adoption rate of 54.54%, see top performers like Cyprus (66.69%) and Slovakia (60.69%), suggesting enhanced capacity for integrating green practices. For large enterprises, where adoption peaks at 63.65%, countries like Spain (81.29%) and Cyprus (74.78%) lead, reflecting the advantages of larger resources and possibly stricter environmental regulations for larger firms.

3.6. Cost Structure

One of the misbeliefs regarding DA is that costs usually seem higher for SME leaders compared to potential benefits. It is crucial to understand the costs associated with implementation from both the capital expenditure (CAPEX) and operational expenditure (OPEX) perspectives.

Starting with small projects or proof-of-concepts can help build trust and understanding of the technology. Demonstrating a clear return on investment is crucial to gaining SME leaders' support, highlighting potential cost savings and revenue growth (Dehbi et al., 2022).

CAPEX and OPEX Costs

If we look at the implementation costs as operational (OPEX) and capital (CAPEX) expenditures, we can conclude that most of the investment costs are OPEX-related.

For capital expenditures, digital services require hiring data scientists, data engineers, and other specialized personnel who possess the necessary expertise in data analysis, programming, and data management (Sekli & Vega, 2021). This also includes training costs on how to utilize data analytic techniques, data visualization tools, and data management best practices.

Many organizations opt for cloud computing as an infrastructure layer for big data solutions to avoid the upfront costs of infrastructure acquisition. Cloud services may incur ongoing operational expenses, including subscription fees, data transfer costs, extra storage fees, and scalability charges based on resource utilization, but they still prove to be less

expensive than purchasing their own equipment or costly software for internal analytics (Saglam et al., 2022).

For example, open-source software solutions such as Hadoop and Spark and Phyton can provide similar capabilities to expensive proprietary software. SMEs can also consider cloud-based solutions that offer a more cost-effective approach to storing and managing data (Blazquez & Domenech, 2018). By identifying these alternatives, SMEs can minimize the costs associated with DA implementation.

There are many cost-effective alternatives to implementing digital technologies. Open source softwares, like Apache Hadoop, Spark, Cassandra, Python, KNIME, and Raspberry Pi (such as Microsoft Power BI) can grant SMEs access to the technology at low or no cost, as they are easily accessible (Neto et al., 2022), just as the tremendous amount of training and learning material connected to them. Cloud computing can also help SMEs save on infrastructure costs by supplying scalable and flexible services (Rai et al., 2015) this way the companies do not need to purchase ICT equipment to analyze data.

3.7. Social Impacts

DA processes in organizations have a significant connection to the social environment, driven by several factors.

Social Influencing Factors and Achievable Effects

Consumers, stakeholders, and investors started to heavily seek sustainable, personalized, online-accessible, and environmentally responsible options, prompting businesses to gain insights retrieved from collected customer data to enhance their decision-making processes and to satisfy customer needs better (Tamym et al., 2023b).

Policymakers started to impose stricter environmental regulations for companies to monitor and measure their environmental and social performance. Analyzing data can help organizations with this obligation while ensuring compliance and identifying areas for improvement and providing a competitive advantage for them over their industrial peers (Kim et al., 2023).

DA also attracts skilled employees, particularly younger generations, who prioritize social and environmental responsibility. It highlights a commitment to innovation and sustainability, fostering a positive work culture and talent retention (Kim et al., 2023).

Organizations can leverage DA to capture and interpret customer information, allowing them to offer personalized experiences, tailored recommendations, and customized products, which enhances customer experience, satisfaction, and loyalty, and contributes to sustainable consumption practices (Anshari et al., 2019).

Through DA, organizations can improve accountability and transparency by sharing information about their supply chains, environmental impact, and social responsibility initiatives. These characteristics can empower consumers to make more informed choices, hold businesses accountable, and build trust among stakeholders, and foster sustainable practices (Kempeneer, 2021).

According to Eurostat statistics, for small enterprises, the EU average is 15.24%, with Malta (27.91%) and Finland (34.99%) at the forefront. These figures suggest that some smaller enterprises have developed strong collaborative frameworks, likely supported by local or sector-specific ecosystems. Medium enterprises have a higher average of 22.08%, with Malta (47.98%) and Finland (46.05%) again leading, indicating that as enterprises scale, they are better equipped to engage with external partnerships. Large enterprises demonstrate the highest collaboration rates, with an EU average of 29.61%, and Finland (63.02%) and Malta (54.22%) setting benchmarks, likely driven by greater resources and the complexity of their operations necessitating more collaboration.

Through data analysis, organizations can identify patterns and trends related to safety incidents, product quality, and consumer health. This enables initiative-taking measures to enhance safety standards, prevent accidents, and ensure the well-being of customers and employees (Qiao & Chen, 2022).

3.8. Connection with Stakeholders and Customers

One way to enhance and tailor customer communication is through the implementation of a Customer Management System, which allows businesses to centralize collected customer data, needs, and preferences while continuously tracking interactions and managing relationships more efficiently, fostering stronger customer relationships and loyalty (Perez-Vega et al., 2022).

In addition to a CMS, introducing a Stakeholder Management System (SMS) can further improve communication with stakeholders, such as investors, suppliers, partners, and regulatory bodies. It enables businesses to organize stakeholder data, monitor engagement, streamline communication efforts, identify key concerns, track sentiment, and proactively address stakeholder needs (Koot et al., 2021).

According to Eurostat data, knowledge sharing within an enterprise is crucial for fostering innovation, improving efficiency, and ensuring that valuable expertise is accessible across teams, driving overall organizational success. The collected statistics reveal distinct trends in knowledge exchange across different enterprise sizes in the EU. Small enterprises have the lowest average knowledge-sharing rates (12.93%), with countries like Malta (28.83%) and Finland (23.52%) showing the highest levels, while Hungary (5.94%) and Bulgaria (7.55%) report much lower rates. Medium-sized enterprises exhibit a higher average (20.22%), with Malta (45.39%) and Finland (35.76%) again leading, while Hungary (6.47%) shows notably low engagement. Large enterprises, with the highest average knowledge exchange rate (31.93%), see Finland (57.83%), Malta (49.40%), and Spain (45.73%) as top performers, while Hungary (8.61%) and Bulgaria (18.77%) trail behind. These trends suggest that larger enterprises are more likely to engage in knowledge exchange, though regional differences within the EU also play a significant role.

3.9. How to Enhance Data Analytics Trends

SMEs prefer incentives and tax-free solutions as they help reduce operational costs, encourage innovation, and enhance competitiveness, allowing them to invest more in growth and knowledge-sharing initiatives without the burden of high taxation (Imran et al., 2024). Applying to EU tenders can help them lay down the foundation of sustainable practices.

SME leaders should develop a digital mindset as well, which refers to the attitudes, beliefs, and behaviors that drive a culture of innovation and adaptability within a firm (Mantravadi & Srai, 2023). It involves embracing technological advancements, promoting collaboration and knowledge sharing, and embracing change as an opportunity for growth. Cultivating a digital mindset is essential for organizations to leverage DA effectively and stay competitive (Zahoor et al., 2023).

To be able to define sustainability goals as well that would support business strategies, management needs to take seriously the environmental challenges and make efforts to resolve them (Gorokhova & Mamatova, 2020).

The authors attempted to collect a couple of specific methods in Table 2 from academic sites which could contribute to making DA more popular to SME leaders, consultants, or individuals working in the ICT sector to raise their awareness.

Table 2. Methods to help introduce data analytical processes.

Method	Description
webinars and online courses	1. Educational sessions introducing the benefits of DA, which could be delivered by faculty members, industry experts, or guest speakers, and can cover diverse topics related to data visualization and predictive analytics.
workshops	2. Workshops could be designed to provide hands-on experience with big data software and tools, allowing SME leaders to gain practical experience in working with data.
data resources and tools	3. Universities could provide easily accessible big data resources, including e-books, white papers, and case studies. These resources could help SME leaders understand and identify insights and opportunities that they may have missed using traditional methods.
consulting services	4. Free consulting services could be delivered by faculty members or students. They could include advice on how to collect, analyze, and interpret data effectively.
online communities, networking	5. Establish where SME leaders could connect with other business owners and industry experts to discuss the benefits of big data to share knowledge, ask questions, and seek advice from others who have experience with big data.
promoting data visualization tools	6. Promoting free data visualization tools that could help them to understand their data better is also a satisfactory solution, as they could help SME leaders visualize data.

Based on Mendoza-Chan and Pee (2024), Yu and Wang (2024), and Barbosa et al. (2022).

Introducing BI systems is beneficial as they enable enterprises to create data-supported decisions, identify market trends better and become market leaders by leveraging insights for strategic planning and performance optimization.

For small enterprises, the average BI usage in the EU is relatively low at 10.99%, with Denmark (32.66%) and Finland (31.62%) leading the way, while countries like Bulgaria (2.32%) and Romania (5.53%) show much lower adoption rates. For medium-sized enterprises, the EU average jumps significantly to 30.91%, with countries like Denmark (68.52%), Finland (66.08%), and Belgium (53.30%) standing out for their high BI usage, while Bulgaria (9.86%) and Romania (12.14%) remain at the lower end. Large enterprises see the highest average BI usage at 62.64%, with Finland (93.96%), Denmark (92.60%), and Sweden (82.10%) showing remarkable adoption rates. On the other hand, Bulgaria (30.89%) and Romania (33.05%) still lag behind in large enterprises. Overall, BI usage increases with enterprise size, and there are significant regional differences, with Northern European countries generally leading in BI adoption, while Eastern and Southern European nations exhibit lower engagement, especially among smaller and medium-sized enterprises.

3.10. Value of Implementation

This panel of the Ecocanvas model usually summarizes why implementing innovative changes in a business model can be considered sustainable, and it gives out the main offering.

The value proposition in the altered canvas model emphasizes how SMEs can harness DA to enhance ESG performance by reducing energy consumption, minimizing waste, and optimizing resource use, thereby achieving tangible environmental benefits. Socially, it enables better stakeholder engagement, promotes transparency in supply chains, and

supports equitable workforce development, fostering a comprehensive and sustainable business strategy that aligns with long-term environmental and societal goals.

3.11. Revenue Sources

By harnessing DA, SMEs can reveal crucial insights into customer choices and trends, leading to improved revenue generation in several ways.

One revenue source could be data monetization. SMEs can capitalize on gathering data with new revenue streams by selling or licensing anonymized and aggregated data to external parties, generating additional revenue (Rabhi et al., 2019).

Furthermore, DA empowers SMEs to enhance customer experience through targeted and personalized advertisements, as they can identify demand patterns of different online segments (Krafft et al., 2021).

This leads to higher conversion rates and, ultimately, improved revenue generation. Data could supply SMEs with relevant information to enter new markets (Lindemann et al., 2020). This knowledge supports them in redesigning their production/service procedures, enhancing their competitive advantage and revenue potential.

Through DA, businesses can optimize their operations and identify bottlenecks and unnecessary processes, which usually results in cost savings, reduced waste, and improved resource allocation, ultimately contributing to higher revenue margins (Kastouni & Lahcen, 2022).

3.12. Innovation

The last section of the canvas model focuses on innovation. This panel is dedicated to capturing ideas and initiatives for continuous improvement and innovation.

The purpose of the 12th innovation panel is to encourage organizations to think creatively and push the boundaries of their current practices. It serves as a space to generate innovative ideas (usually the most important elements of the new business framework, highlighting benefits).

Circular economy systems generate an extensive amount of data, which can be accessed and analyzed only by using DA tools enabled by digitalization. These kinds of analyses can support business decision-making while visualizing different distribution channels through digital platforms like online marketplaces and digital products, which can reduce the carbon footprint of companies and promote circular business models for them (Antikainen et al., 2018).

Figure 8 shows the completed, altered canvas model, which can serve as a one-pager quick overview for SME leaders.

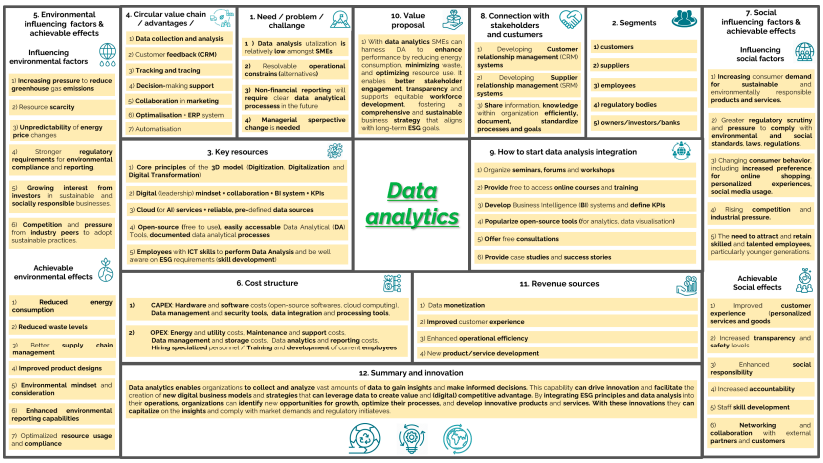

Figure 8. Final result of this paper, the filled out Ecocanvas model based on Daou et al. (2020).

4. Conclusions

The results from the one-way ANOVA tests on SME DA practices and environmental enterprise considerations combined with the challenges outlined in the literature review emphasize the critical role that DA and digital tools play in fostering sustainability within SMEs. Our initiative hypotheses were rejected regarding these. The study highlights the barriers SMEs face, such as lack of knowledge, skilled employees, and the capability to implement digital strategies. This is mirrored almost in every collected adoption data trend, where smaller enterprises show relatively low digital tool usage compared to their larger counterparts. The significance of embracing data-driven decision-making, as evidenced by the higher BI adoption rates in larger companies, becomes clear, smaller companies need to realize the potential advantages of going digital and embrace changes. SMEs can leverage tailored data analysis and AI-driven insights to identify sustainability opportunities and ensure compliance with future ESG requirements. Integrating BI into business processes not only addresses the immediate need for more efficient operations, but also supports long-term competitiveness and digital maturity. The use of tools like the altered Ecocanvas sustainability modeling framework can aid SMEs in mapping their business processes against sustainability goals and digital solutions, helping them overcome their current constraints and navigate the evolving regulatory landscape. This framework, along with data-driven insights, offers practical pathways for SMEs to transition into more sustainable and digitally mature organizations, ensuring they are better prepared to meet future challenges while aligning with environmental and social expectations.

As with all papers, ours has its limitations also. The defined implementation and transformation barriers were collected through a literature review; they may not apply to all sectors. Analyzing them by only considering one specific industry in the comparison or using case studies, corporate surveys could resolve that problem, even if the factors could be weighted with the Analytical Hierarchy Processing method (AHP). Involving industry professionals to redefine business models or even creating KPIs or measuring processes can also ease SME constraints regarding knowledge gaps. The environmental ICT consideration variable was collected and released for the year 2022 only. Actual trends could be different from 2023, but for all collected variables in newer secondary research.

For future outlooks, incorporating financial and sustainability perspectives into business strategies is becoming increasingly important, allowing businesses to align their strategic goals with measurable outcomes. The implementation of ESG reporting, supported by even AI-driven text mining, could provide valuable insights for enterprises already required to comply with sustainability regulations. Tailoring digital solutions to individual businesses is essential for improving data collection, reporting, and monitoring key sustainability indicators, such as security, execution plans, and governance strategies. Through these processes, organizations can make informed, data-driven strategic decisions, contributing to emission reductions and overall company sustainability.

While this study focuses on an altered Ecocanvas model as a practical tool for SMEs to navigate sustainability and digitalization from the first step to goal setting and execution, future research could expand on international comparisons. Looking ahead, a global comparative analysis between the EU and other major economies could provide deeper insights into digital and sustainable transformation trends at the SME level. The Ecocanvas framework serves as a valuable guide for businesses to assess their current position, set achievable and impactful targets, and align their sustainability strategies with economic and social value in an environmentally responsible manner.

The study highlights how tailored and functional detailed data analysis and data-driven insights can pinpoint key areas for sustainability improvements within SMEs,

ensuring alignment with future ESG requirements and fostering long-term competitiveness and firm digital maturity levels.

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Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

SME	Small- and medium sized enterprises
DA	Data Analytics
ICT	Information communication technology
AI	Artificial Intelligence
CRM	Customer Resource Management
ERP	Enterprise Resource Planning
DT	Digital transformation
ML	Machine Learning
BI	Business Intelligence

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