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Bugase Franklin
PhD Candidate,
Sumy State University
ORCID: https://orcid.org/0009-0000-4643-3985

Бугасе Франклін
Сумський державний університет

MULTIFACETED DYNAMICS OF INNOVATION IN ENVIRONMENTAL REPORTING: A STAKEHOLDER-CENTRIC APPROACH

Environmental reporting is increasingly important as organisations face pressure to account for environmental impacts. This study examines how innovation and technology affect reporting effectiveness. Data were collected through structured questionnaires from 350 randomly selected corporate accountants, auditors and reporting professionals. SPSS was used for descriptive statistics and multiple regression. Technological impact, big data efficiency, dynamic environmental impact capture, perceived need for technology renewal and comprehensive data assessment significantly influenced perceived environmental reporting effectiveness (PEERT). The study recommends investing in reporting technologies and data analytics to improve transparency, reporting quality and responses to environmental challenges.

Keywords: *innovation, environmental reporting, technology, Big Data, corporate accountants.*

Formulation of the problem. Environmental reporting has evolved beyond being a simple obligation to comply with, and has instead become a strategic instrument for organisations to navigate the intricate aspects of sustainability and fulfil the expectations of stakeholders. Environmental reporting was pioneered by chemical firms with image issues in the late 1980s. Numerous companies now issue yearly sustainability reports, also known as non-financial reports or CSR reports, or publish sustainability data in other report formats, such as consolidated annual reports, shareholders' reports, and director's reports. Another trend is environmental disclosure, when firms disclose their environmental impact. Other disclosure methods include entering data, such as carbon emissions statistics, into a public platform. UNEP's fifth Global Environmental Outlook (GEO-5) and Millennium Ecosystem Assessment studies have shown humans' impact on nature. As of 2013, the Economics of Ecosystems and Biodiversity (TEEB) initiative estimated that the world's top 100 externalities cost the global economy US$ 4.7 trillion in environmental and social costs of lost ecosystem services and pollution [1].

Businesses in this setting acknowledge that environmental reporting serves several purposes. It not only reduces risks and assures compliance with regulations, but also improves brand reputation, builds customer trust, and provides a competitive edge. The increasing public knowledge and activism surrounding environmental concerns are expected to lead to a greater need for clear and responsible environmental reporting. This will have a significant impact on corporate strategy and contribute to the development of a more sustainable global business environment [2; 1]. The increasing public knowledge and activism surrounding environmental concerns are expected to lead to a greater need for clear and responsible environmental reporting, with implications for corporate strategy and sustainable development [3].

Traditional methods of reporting on environmental matters face several obstacles and restrictions that impede their ability to present a thorough and precise depiction of a company's ecological influence. The use of indicators in conventional reports is frequently selective and partial, which obscures important parts of a company's footprint and restricts comprehensive knowledge of environmental performance [1]. The lack of standardised reporting standards across industries results in inconsistencies and hinders meaningful comparisons between organisations [2]. Manual data gathering can lead to errors, while the absence of real-time reporting can reduce the dependability of information [1; 3]. The emphasis on short-term goals and direct emissions from internal operations can hinder the identification of long-term patterns and wider environmental consequences linked to indirect emissions along the value chain [2]. The inadequate incorporation of technology and difficulties in evaluating broader environmental effects further emphasise the need for more advanced reporting systems [1; 3].

Existing studies provide useful evidence on environmental reporting, but important gaps remain. Prior work gives limited attention to the combined role

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of technological capability, big data efficiency, dynamic environmental impact capture and comprehensive data assessment in reporting effectiveness. There is also limited empirical evidence from Ghana based on the perceptions of professionals directly involved in accounting, auditing and environmental reporting. The present study addresses these gaps [1; 2; 3].

Analysis of recent research and publications. Stakeholder Theory explains how organisational reporting responds to the expectations and information needs of investors, customers, regulators, non-governmental organisations and local communities. Environmental disclosure can therefore be understood as a response to external pressures and demands for accountability. Yin and Wang [4] examine the relationship between corporate environmental disclosure and environmental innovation, while Guenther et al. [5] discuss the influence of stakeholder interests on reporting decisions. Innovation Diffusion Theory complements this perspective by explaining how organisations adopt new technologies, practices and information systems. Hämäläinen and Inkinen [1] discuss disruptive technologies and big data in environmental reporting, while Lv [6] links green organisational responses with innovation performance. Together, these theories provide a basis for examining the influence of stakeholder expectations and technological adoption on reporting effectiveness.

Empirical research has linked environmental reporting with innovation, management accounting and organisational strategy. García-Sánchez, Raimo and Vitolla [7] find that environmentally innovative firms are more likely to adopt integrated environmental disclosure policies. Dhyanasaridewi and Murwaningsari [8] show that environmental performance conditions the relationship between sustainability disclosure, innovation and earnings informativeness. Ariani and Zulhawati [9] also indicate that environmental management accounting and organisational strategy can support innovation by integrating environmental information into managerial decisions. Other studies examine the relationship between sustainability reporting and organisational performance [10], environmental accounting and disclosure practices [25; 27; 28], and the application of big data to sustainability reporting [11]. These contributions establish the relevance of innovation and information systems, although the factors are often investigated separately.

Digital technologies offer opportunities to automate data processing, integrate information across systems and improve the timeliness of environmental reporting. These capabilities matter because environmental information may originate from several operational and external sources. Conventional systems that depend on periodic data collection and manual processing may limit the speed and scope of reporting [12; 13; 14; 15; 16]. Studies of big-data accounting and business reporting emphasise the need to adapt information systems to changing data environments [17; 18; 30]. Nevertheless, the availability of large datasets does not automatically improve reporting. Data quality, system integration and analytical capability remain necessary for producing reliable and useful information [17; 24; 30].

The capacity to capture changing environmental impacts is another consideration. Environmental conditions and associated risks may change over time, requiring organisations to update their information as new evidence becomes available [12; 13; 14]. Reporting systems must also adapt to changes in software, analytical tools and data standards. When technologies become outdated, organisations may face additional costs associated with system upgrades or replacement. Although technological adaptation has been discussed in the wider digital transformation literature [23; 25; 29], the relationship between perceived technology obsolescence and environmental reporting effectiveness requires further investigation.

The reviewed literature shows that technological innovation and data management are increasingly relevant to environmental reporting. Technologies that support information processing, the monitoring of changing environmental impacts and comprehensive data assessment can contribute to the preparation of timely and useful environmental information. The continued development of digital systems also raises considerations regarding technological obsolescence and the need to update reporting processes. These factors provide the basis for examining perceived environmental reporting effectiveness from the perspective of professionals involved in corporate reporting. Accordingly, this study investigates the relationships between technological impact, big data efficiency, dynamic environmental impact capture, perceived technology obsolescence and comprehensive data assessment. The analysis draws on questionnaire responses from 350 randomly selected corporate accountants, auditors and reporting professionals in Ghana. Descriptive statistics and multiple regression are used to summarise respondents' assessments and examine the associations between the five factors and perceived environmental reporting effectiveness.

The literature reviewed indicates that environmental reporting is increasingly shaped by technological innovation, digital information systems and the growing need for reliable environmental data. However, these developments have not been sufficiently examined as interconnected factors influencing reporting effectiveness. Much of the available research considers technological innovation, environmental accounting, data analytics and disclosure practices separately. Consequently, there is limited empirical evidence on how these dimensions work together to influence the effectiveness of environmental reporting.

A further gap concerns the specific technological and informational capabilities that may improve reporting. The efficiency of big data processing, the ability to capture changes in environmental impacts, comprehensive data assessment and the perceived obsolescence of reporting technologies require closer investigation. Although

digital tools provide opportunities to improve information collection and analysis, their practical contribution to reporting effectiveness cannot be assumed. The quality of environmental reporting may depend on how organisations integrate, assess and update the information generated by these technologies.

There is also a need for empirical evidence from the professionals directly involved in preparing, auditing and interpreting corporate environmental information. Their assessments can provide useful insight into the practical benefits and limitations of technology-enabled reporting systems. The present study addresses these gaps by examining the relationship between five factors, namely technological impact, big data efficiency, dynamic environmental impact capture, perceived technology obsolescence and comprehensive data assessment, and perceived environmental reporting effectiveness. Using questionnaire data from 350 corporate accountants, auditors and reporting professionals, the study brings these factors together within a single empirical framework. Its relevance lies in identifying the technological and data-related considerations associated with reporting effectiveness and providing evidence that may inform decisions on the development and improvement of environmental reporting systems.

Formulation of the purpose of the article. The purpose of this article is to examine the factors influencing the transformation and effectiveness of environmental reporting through innovation and technology. Specifically, the study assesses the effects of Technological Impact (TI), Big Data Efficiency (BDE), Dynamic Environmental Impacts Capture (DEIC), and Comprehensive Data Assessment (CDA) on Perceived Effectiveness of Environmental Reporting Transformation (PEERT) among corporate accountants, auditors and environmental reporting professionals in Ghana.

Material and methods. The study adopted a quantitative survey design to examine factors associated with innovation in environmental reporting. The target population comprised corporate accountants, auditors and professionals involved in financial and sustainability reporting in Ghana. A stratified random sampling technique was used to select 350 respondents to capture perspectives across different organisational settings. Data were collected between October and December 2023 using structured questionnaires. A five-point Likert scale, ranging from "strongly disagree" to "strongly agree," measured respondents' perceptions of technological impact, big data efficiency, dynamic environmental impact capture, perceived technology obsolescence, comprehensive data assessment and perceived environmental reporting effectiveness. Email invitations and reminders were used to facilitate participation.

Data were analysed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics, including means, standard deviations, frequencies and percentages, summarised the data. Multiple regression analysis was then applied to examine the relationships between the innovation-related factors and perceived environmental reporting effectiveness. Statistical significance and the direction of the estimated relationships were used to assess the study's findings.

Presentation of the main research material. This section examines respondents' perceptions of innovation in environmental reporting and analyses the technological and data-related factors associated with perceived environmental reporting effectiveness (PEERT). Descriptive statistics are first used to assess the importance respondents attach to different aspects of environmental reporting innovation. Multiple regression analysis is then applied to examine the relationships between technological impact, big data efficiency, dynamic environmental impact capture, perceived need for technology renewal and comprehensive data assessment. This approach establishes the context for the regression findings and identifies the factors associated with perceived reporting effectiveness.

The descriptive statistics indicate that respondents generally recognised the importance of innovation in environmental reporting, although their assessments differed across the dimensions examined. Global environmental challenges recorded the highest possible mean and median scores of 5.00, with a standard deviation of zero. Assuming the variable was measured on a five-point scale and coded correctly, this indicates that all 350 respondents assigned the maximum rating to this item. Efficiency improvement also received a high mean

Table 1

Descriptive Statistics on the Importance of Innovation in Environmental Reporting

Variable	N	Mean	Median	SD
Transparency and Accountability (STA)	350	3.45	4.00	1.297
Data Accuracy (DA)	350	3.16	3.00	1.389
Global Environmental Challenges (GEC)	350	5.00	5.00	0.000
Efficiency Improvement (EI)	350	4.55	5.00	0.976
Corporate Image and Reputation (CIR)	350	3.31	4.00	1.665
Stakeholder Expectations (SE)	350	3.06	3.00	1.270
Keeping Up-to-Date (KUD)	350	3.74	4.00	1.001
Beyond Regulatory Compliance (BRC)	350	3.62	4.00	1.087
Competitive Advantage (CA)	350	4.92	5.00	0.374
Priority for Long-term Sustainability (PLS)	350	4.76	5.00	0.746

Source: Field data, 2023

of 4.55 and a median of 5.00, suggesting that respondents generally viewed innovation as a means of improving reporting processes.

Competitive advantage recorded a mean of 4.92 and a standard deviation of 0.374, indicating strong agreement among respondents. Similarly, the mean of 4.76 for long-term sustainability suggests that respondents regarded sustainability as an important consideration in environmental reporting. Keeping up-to-date and going beyond regulatory compliance recorded means of 3.74 and 3.62, respectively. By comparison, data accuracy and stakeholder expectations recorded means of 3.16 and 3.06. Corporate image and reputation had a mean of 3.31 and the highest standard deviation of 1.665, indicating greater variation in respondents' assessments of this dimension.

These findings suggest that respondents placed particular emphasis on addressing global environmental challenges, improving efficiency, gaining competitive advantage and supporting long-term sustainability. Their assessments were less uniform regarding data accuracy, stakeholder expectations and corporate reputation. This generally favourable assessment of innovation provides a useful basis for examining whether specific technological and data-related capabilities are associated with perceived reporting effectiveness. The pattern is also consistent with research examining technological change, big data and environmental management [1; 2; 12; 13].

To investigate these relationships, multiple regression analysis was conducted using five explanatory variables: Technological Impact (TI), Big Data Efficiency (BDE), Dynamic Environmental Impact Capture (DEIC), Perceived Need for Technology Renewal (PNTR) and Comprehensive Data Assessment (CDA). The results are presented in Table 2.

The regression model was statistically significant overall ((F = 14.1), (p < .001)), with an (R2) of 0.170. This indicates that the five predictors jointly explained 17.0% of the variation in PEERT. The multiple correlation coefficient was 0.412, indicating a positive association between observed and model-predicted values. Although the overall model was statistically significant, its explanatory power was modest, suggesting that other technological, organisational and institutional factors may also influence perceived environmental reporting effectiveness.

Technological Impact recorded a positive coefficient of 0.1023 and was statistically significant ((p = .019)). Holding the other predictors constant, a one-unit increase in TI was associated with a 0.1023-unit increase in PEERT. This finding suggests that respondents who perceived technology as contributing positively to reporting also tended to report higher perceived effectiveness. It is consistent with Hämäläinen and Inkinen [1], who examine technology-enabled environmental reporting, and Dai and Liang [12], who investigate the role of big data capabilities in innovation. Research on environmental monitoring and organisational adoption of big data also provides relevant context for this association [3; 14; 15].

Big Data Efficiency was likewise positively associated with PEERT, recording a coefficient of 0.1264 ((p = .002)). This indicates that higher BDE scores were associated with higher perceived reporting effectiveness, conditional on the other predictors. The finding accords with studies examining big data and environmental management, which highlight the relevance of effective information processing and analysis to monitoring and decision-making [2; 3; 12]. It also suggests that the perceived value of environmental data depends on the ability to process and use information efficiently rather than simply collecting large volumes of it.

Dynamic Environmental Impact Capture recorded the largest estimated coefficient in the model (0.3190, (p < .001)). This indicates that DEIC had the strongest positive estimated association with PEERT among the five predictors. The finding suggests that respondents placed considerable importance on the ability to identify and record changes in environmental conditions. Hämäläinen and Inkinen [1] discuss technology-enabled environmental reporting, while Qian et al. [3] examine environmental monitoring using remote sensing and deep learning. Song et al. [14] similarly investigate the application of big data to environmental performance evaluation. These studies provide context for the observed association between dynamic environmental monitoring and perceived reporting effectiveness.

Comprehensive Data Assessment recorded the second-largest estimated coefficient, 0.3125, and was statistically significant ((p < .001)). Higher CDA scores were associated with higher PEERT scores, holding the other predictors constant. This finding suggests that respondents regarded

Table 2

Multiple Regression Results for Perceived Environmental Reporting Effectiveness (PEERT)

Predictor	Estimate	SE	t	p
Intercept	3.2334	0.3662	8.831	< .001
Technological Impact (TI)	0.1023	0.0435	2.354	.019
Big Data Efficiency (BDE)	0.1264	0.0412	3.069	.002
Dynamic Environmental Impact Capture (DEIC)	0.3190	0.0415	7.690	< .001
Perceived Need for Technology Renewal (PNTR)	0.1000	0.0434	2.310	.022
Comprehensive Data Assessment (CDA)	0.3125	0.0420	7.435	< .001

Model summary: (R = 0.412); (R^2 = 0.170); (F = 14.1), (p < .001); Durbin–Watson statistic = 1.83, reported (p = .072); VIF = 1.17; tolerance = 0.52.

Source: Field data, 2023

the systematic evaluation of environmental information as relevant to reporting effectiveness. Research on big data capabilities and environmental monitoring provides a related context for this relationship [3; 12; 14]. Evaluating information from different sources may help organisations develop a more complete understanding of environmental conditions and prepare more informative reports.

Perceived Need for Technology Renewal recorded a positive and statistically significant coefficient of 0.1000 ((p = .022)). This indicates that higher PNTR scores were associated with higher perceived environmental reporting effectiveness, holding the other predictors constant. The result suggests that respondents who placed greater emphasis on the need to update or renew reporting technologies also tended to assess environmental reporting effectiveness more favourably. This relationship is relevant to the study because reporting systems may need to evolve as data requirements and technological capabilities change. Nevertheless, the result establishes a statistical association and does not demonstrate that the perceived need for technology renewal causes improvements in reporting effectiveness.

The reported variance inflation factor was 1.17, while the tolerance value was 0.52. The VIF suggests that severe multicollinearity is unlikely to be a major concern. However, these values should be checked against the original statistical output because they are not reciprocal values for the same predictor. The Durbin–Watson statistic was 1.83, with a reported (p)-value of .072. Since the study uses cross-sectional survey data, the relevance of this diagnostic depends on whether the ordering of observations has a meaningful structure.

Overall, all five predictors were positively and statistically significantly associated with PEERT. Dynamic Environmental Impact Capture and Comprehensive Data Assessment had the largest estimated coefficients, followed by Big Data Efficiency, Technological Impact and Perceived Need for Technology Renewal. These findings suggest that respondents' assessments of environmental reporting effectiveness were associated with the ability to capture changing environmental conditions, evaluate information comprehensively, process data efficiently and recognise the need to update reporting technologies. However, the model explains only 17.0% of the variation in PEERT, and the cross-sectional survey design does not establish causality. The findings should therefore be interpreted as evidence of statistical associations rather than proof that changes in these factors will necessarily cause improvements in environmental reporting effectiveness.

Conclusions. This study examines the influence of technology and big data on environmental reporting, emphasising the significance of tackling worldwide environmental issues. The key factors that may be used to forecast outcomes include the influence of technology, the efficiency of handling large amounts of data, the ability to capture dynamic environmental influences, the perception of technology becoming outdated, and the thorough review of data. Stakeholders appreciate organisations that adopt technological breakthroughs, effectively manage large amounts of data, adapt to evolving environmental implications, and tackle technology obsolescence. Implementing strategic investments in state-of-the-art technologies and rigorous data evaluation procedures may significantly improve the efficacy of environmental reporting. This study offers significant insights for organisations aiming to utilise these technologies to fulfil regulatory obligations and contribute to global sustainability goals. The study's findings on environmental reporting effectiveness in technological innovations are limited due to its unique sample and cross-sectional form, potential self-report bias, and focus on specific variables. The study's use of regression analysis and lack of geographical and industry disparities may limit comprehension. Future research should consider a broader perspective by examine the impact of evolving technologies and adaptability on environmental reporting effectiveness.

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БАГАТОГРАННА ДИНАМІКА ІННОВАЦІЙ У ЕКОЛОГІЧНІЙ ЗВІТНОСТІ: ПІДХІД, ОРІЄНТОВАНИЙ НА ЗАЦІКАВЛЕНІ СТОРОНИ

Екологічна звітність набуває дедалі більшого значення, оскільки організації зазнають зростаючого тиску щодо розкриття інформації про вплив своєї діяльності на довкілля. Ефективність такої звітності залежить від здатності збирати, обробляти, оцінювати та своєчасно подавати екологічні дані. У дослідженні розглянуто технологічні й інформаційні чинники, пов'язані зі сприйнятою ефективністю трансформації екологічної звітності (PEERT). Дані зібрано за допомогою структурованих анкет від 350 респондентів, випадково відібраних серед корпоративних бухгалтерів, аудиторів і фахівців зі звітності в Гані. Для аналізу застосовано програмне забезпечення SPSS, описову статистику та множинну регресію. Досліджено зв'язки між технологічним впливом, ефективністю використання великих даних, динамічним відстеженням змін довкілля, сприйняттям потреби в оновленні технологій і комплексним оцінюванням даних та PEERT. Результати свідчать, що всі п'ять чинників мали позитивний і статистично значущий зв'язок із PEERT. Найбільші оцінені коефіцієнти отримано для динамічного відстеження змін довкілля та комплексного оцінювання даних, за якими йдуть ефективність використання великих даних, технологічний вплив і сприйняття потреби в оновленні технологій. Модель пояснювала 17,0% варіації PEERT, що вказує на наявність інших чинників, які також можуть бути пов'язані з ефективністю звітності. Оскільки дослідження ґрунтується на поперечних опитувальних даних, результати відображають статистичні взаємозв'язки й не доводять причинно-наслідкових залежностей. Отримані результати свідчать про важливість технологічних можливостей, ефективного опрацювання великих масивів інформації, своєчасного фіксування екологічних змін і всебічного оцінювання даних для підвищення сприйнятої ефективності екологічної звітності. Практичні рекомендації передбачають інвестування в технології звітності та аналітику даних, а також регулярний перегляд і оновлення технологічних систем відповідно до змін у вимогах до інформації. Водночас позитивний зв'язок зі сприйняттям потреби в оновленні технологій слід тлумачити обережно: він не означає, що застарілі системи самі по собі покращують звітність. Висновки можуть бути корисними для організацій, які прагнуть удосконалити процеси збирання, аналізу та подання екологічної інформації.

Ключові слова: *інновації, екологічна звітність, технології, великі дані, корпоративні бухгалтери.*

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