SAPIENZA UNIVERSITÀ EDITRICE

ANNALI DEL DIPARTIMENTO DI METODI E MODELLI PER L'ECONOMIA IL TERRITORIO E LA FINANZA
2025 | pp. 169-194

© Author(s)
E-ISSN 2611-6634 | ISSN 2385-0825
DOI: 10.13133/2611-6634/1771

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Research paper

First published online: December 11, 2025

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SOCIAL INDICATORS AND ENVIRONMENTAL PERFORMANCE: AN ANALYSIS OF COMPANIES IN SMART CITIES

Abstract

This study explores the relationship between corporate social responsibility and environmental performance in the context of smart cities—urban environments integrating sustainability and digital technologies. Using a panel dataset of 13,140 firm-year observations from the top 20 smart cities worldwide (2014–2023), the analysis examines how social indicators influence environmental performance. Fixed-effects and dynamic panel (GMM-SYS) regression models reveal that higher social practices are significantly associated with stronger environmental outcomes, even after controlling for firm-specific financial characteristics and addressing potential endogeneity. Among the sub-pillars, workforce and community engagement exert the most substantial influence, underscoring the strategic role of human capital and ethical conduct. The results are particularly relevant for firms operating in innovation-driven urban contexts, as well as for policymakers seeking to promote corporate contributions to sustainable urban development. Limitations and avenues for future research are also discussed.

Keywords: sustainability; strategic management; environmental sustainability; sustainability-oriented strategic management; smart cities

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1 Research introduction

Sustainability is currently one of the key concepts in global scientific and political discourse, often approached from a multidisciplinary perspective and representing a critical challenge for balancing human development with environmental protection (Zerbi, 2007). Within this framework, integrated geography plays a fundamental role as a discipline that examines the interaction between human societies and the geographic environments in which they live and operate. It emerges from the convergence of human geography, which focuses on social, cultural, and economic processes, and physical geography, which analyses natural and territorial dynamics (Waugh, 2000; Urban and Rhoads, 2014). This perspective not only enables a more comprehensive understanding of complex phenomena but also proves highly valuable in practical terms. It allows for the identification of points of friction between human activities and natural systems, thereby facilitating the analysis and definition of so-called environmental problems, situations in which human development comes into conflict with the equilibrium of the biosphere (Grossman, 1981; Waugh, 2000). Since the earliest stages of human history, societies have sought to transform their surrounding environments for their own benefit, using natural resources and energy sources to improve living conditions (Dematteis, 1994; Tucci et al., 2023). However, contemporary economic and technological development has exacerbated a profound structural imbalance: while economic systems are oriented toward continuous growth, ecological and geographic systems are constrained by finite physical and temporal limits (Zinzani, 2020). This misalignment is one of the primary drivers of current environmental crises. Modern economic development, if not properly regulated, can lead to significant disruptions in environmental equilibrium. The unchecked expansion of economic activities compromises the stability of geo-ecological processes, damaging ecosystems and reducing their regenerative capacity. Unlike economic dynamics, which are theoretically open to infinite growth, natural systems operate within fixed physical and biological boundaries that cannot be transgressed without consequences (Chiocchini and Savarese, 2019). Within this context, every development model must contend with what are known as geobiophysical limits, shaped by three core aspects. The first concerns the exhaustibility of resources: natural materials and energy sources on Earth are finite and cannot regenerate at the pace at which they are being consumed. The second relates to the principle of entropy, whereby every productive process leads to increased disorder in natural systems, reducing the availability of usable energy and generating waste and pollution. The third aspect is ecological interdependence: ecosystems rely on a delicate balance between living organisms and their environments, and any significant disruption can trigger cascading effects, undermining the overall system's stability (Tucci et al., 2023). The interaction among these factors reveals a fundamental contradiction: while economic systems evolve through seemingly orderly and continuous progress, natural systems exhibit increasing vulnerability and instability. This results in growing environmental disorder, with harmful impacts on both the planet and the quality of life for human populations. In response to these challenges, sustainability is now understood as a guiding principle for rethinking development models, based on the integration of three fundamental dimensions: economic, social, and environmental. This vision is widely recognized in the literature and

reflected in the United Nations' Sustainable Development Goals (SDGs), which provide a global framework for building more equitable, resilient, and ecologically responsible societies (Musso, 2005). It is within this perspective that the present study is situated. Its aim is to investigate the relationship between social indicators and the environmental performance of businesses operating in smart cities: urban contexts characterized by innovation, where sustainability is pursued through the application of information and communication technologies (ICT) and the adoption of management practices based on ESG - Environmental, Social, and Governance principles (De Filippi and Carbone, 2021). Through an integrated and empirically grounded approach, this work seeks to contribute to the understanding of the dynamics that regulate the balance between economic progress and environmental protection in one of the key laboratories of contemporary transformation: the smart city. This urban complex significantly reshapes service and development paradigms by focusing on environmental resource conservation, improving social objectives such as quality of life and safety, and promoting economic sustainability. None of these goals can be achieved without solid economic planning (Panaro et al., 2023). This study contributes to the literature in three ways. First, it places the ESG–performance debate within the urban sustainability/smart-city framework, where digitally enabled governance, data infrastructures, and dense stakeholder networks shape firms' environmental outcomes (Angelidou, 2015; Neirotti et al., 2014; Bosone et al., 2024). Second, moving beyond an aggregate "social" score, it disaggregates the social pillar into four sub-components: workforce (including diversity and inclusion), human rights, community, and product responsibility, and examines their distinct associations with environmental performance, consistent with evidence that ESG materiality differs across sub-pillars (Khan et al., 2016) and extending prior firm-level work (Buallay et al., 2021). Third, to address endogeneity (reverse causality and omitted variables), it complements fixed-effects estimation with a dynamic panel approach (GMM-SYS), thereby strengthening inference under standard assumptions (Arellano and Bond, 1991). Regardless of the model adopted, the city remains a complex environment and the product of an ongoing evolutionary process. Thanks to growing awareness in design and urban governance, and the application of ESG-aligned best practices, governments and businesses operating in these contexts are increasingly making intelligent and functional use of resources, data, and analytics (Neirotti et al., 2014; Bosone et al. 2024). To explore the relationship between social indicators and the environmental performance of businesses in smart cities, based on an urban development model that integrates sustainability with modern ICT tools for managing city resources and components, this study sets out to test the following research hypotheses:

H1. The corporate social pillar influences the environmental performance of businesses in smart cities.

H1.1. The *workforce* sub-pillar influences the environmental performance of businesses in smart cities.

H1.2. The *human rights* sub-pillar influences the environmental performance of businesses in smart cities.

H1.3. The *community* sub-pillar influences the environmental performance of businesses in smart cities.

H1.4. The *product responsibility* sub-pillar influences the environmental performance of

businesses in smart cities.

The decision to focus on the top 20 smart cities is grounded in their role as global frontrunners in technological innovation, digital infrastructure, and sustainable governance. The selection is based on the IMD Smart City Index (2023), which evaluates cities according to dimensions such as health, safety, mobility, activities, and governance. These urban contexts act as advanced laboratories of sustainability, where firms face stronger institutional and societal pressures to disclose ESG practices and where environmental and social innovation are more likely to emerge. By concentrating on this specific group, the study provides insights into settings where the ESG–performance nexus is most visible, while acknowledging that the results may differ in less advanced or smaller urban environments. The structure of this paper is as follows: Section 2 provides a literature review and a contextual analysis of smart cities, examining how they represent a transformative approach to urban development and service delivery through the integration of ESG practices. Section 3 presents the research data and methodology, outlining the processes and techniques used for data collection and analysis. Section 4 discusses the study's findings, offering a detailed interpretation of the evidence obtained. Section 5 proposes a robustness check to ensure the validity and reliability of the results. Finally, Section 6 offers a critical discussion of the outcomes and their implications, while Section 7 presents the conclusions, research implications, limitations, and potential directions for future investigation. This final section summarizes the study's key contributions and highlights its relevance to the fields of smart urban development and ESG integration.

2 Theoretical background

Despite the growing prominence of sustainability in scientific discourse, environmental concerns remain marginal within the mainstream of economic geography. The discipline still demonstrates limited engagement with environmental challenges, which are often addressed using narrowly technical or empirical approaches. In doing so, it risks neglecting one of the most urgent and complex issues of recent decades: the relationship between social groups and their environment (Gemmiti, 2015). From this very relationship emerges a more holistic and meaningful understanding of sustainability. A widely accepted framework in the literature conceptualizes sustainability as the integration of three interdependent dimensions (economic, social, and environmental, see e.g. Basiago, 1998; Pope et al., 2004; Gibson, 2006; Waas et al., 2011; Moldan et al., 2012; Schoolman et al., 2012; Boyer et al., 2016). Frequently illustrated through the "three pillars" model or Venn diagrams, sustainability is positioned at the intersection of society, environment, and economy. This model has not only become dominant in academic literature but has also been incorporated into global policy frameworks, especially through the United Nations Sustainable Development Goals (SDGs) (Ciccullo et al., 2018). Within this perspective, the concept of the smart city can be interpreted as a tangible and transformative evolution of the sustainability paradigm, one that brings together technology, environmental responsibility, and social equity. Smart cities represent urban environments where service delivery and development strategies are being reimagined through integrated, data-driven governance informed by ESG principles (Zanella et al., 2014).

At the core of the smart city framework are citizens and their perceptions of how digital innovation shapes environmental, social, and economic development. ESG considerations are critical in this context: smart cities must not only be technologically advanced but also equitable, inclusive, and ecologically sound (Hu et al., 2023). The synergy between smart city models and sustainability lies in their shared ambition to integrate environmental stewardship, social justice, and economic resilience into urban planning. The adoption of ESG principles ensures that smart cities are designed and managed with attention to environmental impacts, community well-being, and institutional effectiveness. By embracing sustainable and resilient development models, smart cities are better equipped to meet emerging global challenges while offering safer, more inclusive, and efficient urban environments (Tang et al., 2024). Smart cities thus embody a significant evolution in contemporary urban planning, where digital infrastructure intersects with sustainability to foster communities that are not only more intelligent and responsive but also greener and more socially responsible (Paradiso, 2013; Borruso and Balletto, 2022; Neirotti et al., 2014). In this context, sustainability functions as a development model that seeks to meet present needs without compromising future generations, acknowledging the social, environmental, and economic consequences of today's decisions (Mihelcic et al., 2003). The literature confirms the importance of integrating sustainability principles across a wide range of sectors, from entrepreneurship to tourism, and from consumer behaviour to industrial development (Placet et al., 2005; Shrivastava and Berger, 2010; Khaw et al., 2024). When embedded in smart city design, sustainability contributes to creating more resilient, inclusive, and balanced urban futures, aligning environmental preservation with social cohesion and economic vitality (Caragliu et al., 2011; 2013; Moraci and Fazia, 2013; Vanolo, 2015; Borruso, 2021, de Andreis, 2023). Environmental sustainability specifically focuses on the protection and regeneration of natural systems. It involves addressing major challenges such as climate change, biodiversity loss, pollution, and overexploitation of resources. Strategies include reducing greenhouse gas emissions, adopting renewable energy, promoting biodiversity conservation, and implementing sustainable agriculture and circular economy practices (Barrow, 2006; Auci and Mundula, 2019). Social sustainability emphasizes the importance of equity, human rights, social inclusion, access to healthcare and education, and fair labour practices. It requires effective governance mechanisms that combat poverty, discrimination, and structural inequalities (Dempsey, 2016). Economic sustainability seeks a long-term balance between economic growth, resource efficiency, and social well-being. It involves innovation, responsible resource management, and economic models that support circularity and energy efficiency while contributing to societal and environmental goals (Goodland and Daly, 1996).

Effective management of these three sustainability dimensions is key to addressing contemporary global challenges. The social dimension, in particular, is deeply intertwined with corporate social responsibility (CSR) and ethical governance. Companies that embed ESG values into their core operations are more likely to gain stakeholder trust, attract investment, and foster long-term resilience (Harrison and Wicks, 2013; Croom et al., 2018; Mansell et al., 2020). Over the past two decades, the social pillar of ESG has evolved significantly, particularly in response to technological change and the increasing interconnectedness of global business. Although all three ESG components are interlinked,

the social pillar is increasingly scrutinized by investors who seek to avoid companies with poor labour standards or unethical political affiliations. Companies with strong social performance contribute positively to their overall ESG score and are considered more attractive by institutional investors (Pagano et al., 2018; Matos, 2020; Chen and Xie, 2022; Huang et al., 2024; Wei and Zeng, 2024). Nonetheless, the social pillar remains underdeveloped in both theory and practice due to challenges in measurement, reporting complexity, and definitional ambiguity. Despite this, it plays a central role in shaping public trust and long-term value creation. A socially responsible company attracts and retains talent, customers, and partners, while enhancing reputational capital (Nardella et al., 2019; Deng and Yang, 2022). At its core, the social pillar focuses on how organizations interact with people, internally and externally, through ethical treatment, equity, and care. It covers issues such as workplace safety, human rights, diversity, inclusion, and community engagement (Senadheera et al., 2021; Potharla et al., 2024). Social performance indicators may include income equality, philanthropic activity, injury rates, and supply chain labour practices (Croom et al., 2018). Companies that fail to address systemic inequalities risk contributing to their perpetuation. Globally, social sustainability is increasingly subject to regulation, activism, and stakeholder pressure. Good social performance can reduce costs, enhance brand loyalty, and support strategic positioning. Many companies have evolved CSR into structured ESG programs to meet both ethical standards and competitive needs (Şahin et al., 2022). A company's social orientation (SCO) reflects its strategic commitment to sustainability. It denotes the degree to which social values influence decision-making across all business functions. This includes ensuring that sustainability is embedded in corporate culture, governance, and value chains (Wang et al., 2023; Longoni and Cagliano, 2015; Joyce and Paquin, 2016; Siudek, 2022). Research shows that SCO is shaped by both organizational factors, such as structure, industry, and leadership, and individual traits like gender and cultural background (Marz et al., 2003; Grojean et al., 2004). Further studies explore how SCO affects stakeholder perceptions, management behaviour, and engagement with CSR initiatives (O'Neill et al., 2006; Brickson, 2007; Bingham et al., 2011). However, there remains a gap in understanding how SCO translates into concrete social sustainability practices. Specific components of the social pillar include human capital development, product responsibility, stakeholder trust, and opportunities for social value creation (Feng et al., 2022). These encompass fair employment practices, responsible sourcing, transparent supply chains, and philanthropic outreach (Hastig and Sodhi, 2020; Sharma and Bhat, 2023; Sharma and Hasti, 2024). Ultimately, companies that embrace the social dimension of ESG contribute not only to a more equitable economy but also to the development of smart cities that prioritize well-being, participation, and shared value. As cities become increasingly central in the transition toward sustainable development, the social responsibility of businesses operating within them becomes both a strategic asset and a moral imperative (De Jong et al., 2015; Toti and Johan, 2022).

3 Data and methods

3.1 Descriptive Analysis

This study explores the relationship between firms' environmental and social performance, including its sub-pillars, within the top 20 smart cities (see Table 1), following the approach of Buallay et al. (2021). Specifically, the analysis takes into consideration all firms listed in the top 20 smart cities over a decade-long period (2014–2023), as reported in the Bloomberg/LSEG Workspace database. The choice of this dataset is motivated by its widespread use in academic research and its ability to provide consistent, comparable, and standardized ESG scores at the firm level, thereby ensuring robustness and reliability in empirical analysis (LSEG, 2023). In particular, while LSEG traditionally reports three social sub-pillars (Diversity and Inclusion, Human Rights, and Product Responsibility), the version of the database adopted in this study provides an extended classification. Specifically, the social pillar is disaggregated into four components: workforce, human rights, community, and product responsibility. Each of these dimensions is reported as a separate standardized score based on publicly available company disclosure and weighted according to its relative importance within the ESG framework. The aggregation into the overall social pillar is performed by LSEG through a weighted average of the sub-components, ensuring comparability across firms and over time. By relying on this standardized methodology, the study avoids subjective weighting schemes and guarantees the robustness of the analysis.

It is worth noting that the sample distribution is not uniform across cities: London and New York together account for a substantial share of the observations. This concentration may influence the generalizability of the results, as estimates could reflect the structural and institutional features of these leading financial hubs more than those of other smart cities in the sample.

The analysis is based on a unique dataset comprising 13,140 firm-level observations from LSEG Data and Analytics, covering the period from 2014 to 2023. This reduction due to missing ESG disclosure may introduce a potential selection bias, as companies that actively report ESG data are often larger, more visible, and more committed to sustainability practices than those that do not. Consequently, the findings mainly describe the behavior of firms that disclose ESG information rather than the entire business population in smart cities. The dataset enables the examination of how social performance influences environmental outcomes within smart cities. To ensure robustness, firm-level financial controls and disaggregated social sub-pillars are also incorporated, offering a multidimensional view of the relationship. Regarding the dataset metadata, the Bloomberg/LSEG Workspace provides standardized and comparable ESG information, updated annually and derived from publicly available reports, regulatory filings, and company disclosures. The sample mainly includes large, listed firms across multiple sectors, such as finance, energy, ICT, and manufacturing. However, the distribution of firms across cities is uneven, with some urban areas (e.g., Copenhagen) represented by a limited number of observations. To address data quality issues, extreme outliers (e.g., implausible revenue growth rates above 30,000%) were checked and winsorized at the 1st and 99th percentiles. Moreover, the reduction from 13,140 to 7,621 firm-year observations

Table 1. Top 20 smart cities

City	Freq.	Percent	Cum.
Auckland	400	3.04	3.04
Amsterdam	330	2.51	5.56
Brisbane	300	2.28	7.84
Copenhagen	40	0.30	8.14
Dusseldorf	110	0.84	8.98
Geneve	60	0.46	9.44
Helsinki	320	2.44	11.87
London	2600	19.79	31.66
Manchester	120	0.91	32.57
Melbourne	690	5.25	37.82
Munich	10	0.08	37.90
New York City	2080	15.83	53.73
Oslo	380	2.89	56.62
Singapore	930	7.08	63.70
Stockholm	1290	9.82	73.52
Sydney	890	6.77	80.29
Toronto	1260	9.59	89.88
Taipei City	910	6.93	96.80
Washington	120	0.91	97.72
Zurich	300	2.28	100.00
Total	13140	100.00	

Source: Buallay 2021.

is explained by missing ESG disclosure, which is a common challenge in sustainability research. This structure ensures replication, transparency, and comparability across firms, industries, and cities, thereby providing a reliable basis for empirical analysis. The dependent variable is the environmental pillar score, defined by LSEG as a measure of how effectively a company mitigates environmental risks and capitalizes on environmental opportunities to create long-term shareholder value. The key explanatory variable is the social pillar score, which reflects a company's capacity to generate trust and loyalty with its workforce, customers, and society through the adoption of best management practices (Agnese et al., 2024). This score also serves as a proxy for the firm's reputation and its "license to operate", critical elements of sustained performance. The social pillar includes four sub-pillars: 1. human rights, measuring respect for fundamental human rights conventions; 2. workforce, assessing job satisfaction, safety, diversity, and development opportunities; 3. community, evaluating corporate citizenship, ethical behaviour, and contributions to public health; 4. product Responsibility, reflecting product quality, customer health and safety, and data integrity. All social and environmental scores range from 0 to 100 and are extracted from the LSEG platform, with established methodologies for consistency and comparability. In addition, the following control variables are included:

1. profitability (Return on Equity, ROE), calculated as net income before extraordinary items over average total equity; 2. leverage, the ratio of total debt to total equity (including minority interest and hybrid instruments); 3. size, expressed as the natural logarithm of total assets; 4. market Valuation, calculated by the price-to-book value ratio; 5. growth, representing revenue from core operations, including product sales, services, and energy distribution. A detailed summary of all variables is presented in Table 2. In addition, industry fixed-effects are included to account for sector-specific heterogeneity, since ESG practices and environmental impacts vary substantially across industries (for example, manufacturing versus services, or energy versus finance).

Table 2. Description of variables

Variable	Description	Source
Environmental score (0–100)	Measures environmental impact and management of risks and opportunities	LSEG Workspace
Social pillar score (0–100)	Captures trust and loyalty through social practices	LSEG Workspace
Human rights score (0–100)	Assesses respect for fundamental human rights	LSEG Workspace
Workforce score (0–100)	Evaluates job satisfaction, safety, diversity, development	LSEG Workspace
Community score (0–100)	Measures commitment to citizenship, ethics, public health	LSEG Workspace
Product responsibility (0–100)	Assesses product quality, safety, integrity, data privacy	LSEG Workspace
Total assets (log)	Natural logarithm of total assets	LSEG Workspace
Return on Equity (%)	Net income before extraordinary items / avg. equity	LSEG Workspace
Market valuation	Price-to-book ratio	LSEG Workspace
Leverage (%)	Total debt / total equity	LSEG Workspace
Growth (%)	Revenue from core business operations	LSEG Workspace

Source: authors' elaboration.

Descriptive statistics are reported in Table 3, offering key metrics of central tendency and variability.

Table 3. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Environmental score	7621	37.691	29.504	0	98.995
(S) Social score	7621	48.012	23.710	0.148	98.766
(S1) Human rights	7621	33.111	35.498	0	99.309
(S2) Community	7621	51.589	29.233	0	99.939
(S3) Workforce	7621	56.333	27.987	0.191	99.873
(S4) Product responsibility	7621	43.449	29.394	0	99.864
Return on Equity	10559	0.050	6.572	-102.582	557.750
Total assets	11950	21.115	2.439	2.303	29.096
Leverage ratio	11613	2.026	63.386	0	6656.208
Market valuation	11236	2.606	172.695	-14082.09	4958.596
Growth	10637	6.369	418.994	-41.956	37949.764

Source: authors' elaboration.

The social pillar and its sub-components (human rights, community, workforce, and product responsibility) display substantial heterogeneity among firms. On average, firms score 48.01 on the social pillar, with high dispersion (SD = 23.71), indicating significant

differences in corporate social engagement. Human Rights exhibits the lowest mean (33.11) and the highest variability (SD = 35.49), pointing to inconsistent attention across firms. Community involvement shows a slightly higher mean (51.59) but also broad dispersion. Workforce performance registers the highest average (56.33), suggesting a relatively strong and uniform focus on employee-related policies. Product responsibility falls in the middle (43.45), with considerable variation across the sample. These results underline the uneven implementation of social responsibility initiatives, with workforce-related actions being most common and human rights engagement showing the widest gaps

3.2 Methods

The empirical strategy employs panel data analysis using a fixed-effects (FE) regression framework, which leverages both cross-sectional and time-series components of the dataset (Baltagi, 2008). This method enhances model flexibility, reduces collinearity, and increases degrees of freedom (Greene, 2005; Hsiao, 2014). It also allows the identification of effects that are unobservable in purely cross-sectional or time-series models. The general model specification is as follows:

$$\text{ENVIRONMENT_Perf}_{it} = \beta_0 + \beta_1 \,\text{Social}_{it} + \beta_k \,\text{FinancialControls}_{it} + \gamma_t + \varepsilon_{it} \ ,$$

$$\text{ENVIRONMENT_Perf}_{it} = \beta_0 + \beta_1 \,\text{HumanRights}_{it} + \beta_k \,\text{FinancialControls}_{it} + \gamma_t + \varepsilon_{it} \ ,$$

$$\text{ENVIRONMENT_Perf}_{it} = \beta_0 + \beta_1 \,\text{Workforce}_{it} + \beta_k \,\text{FinancialControls}_{it} + \gamma_t + \varepsilon_{it} \ ,$$

$$\text{ENVIRONMENT_Perf}_{it} = \beta_0 + \beta_1 \,\text{Community}_{it} + \beta_k \,\text{FinancialControls}_{it} + \gamma_t + \varepsilon_{it} \ ,$$

$$\text{ENVIRONMENT_Perf}_{it} = \beta_0 + \beta_1 \,\text{ProductResponsibility}_{it} + \beta_k \,\text{FinancialControls}_{it} + \gamma_t + \varepsilon_{it} \ ,$$

where alternative specifications are estimated for each social sub-pillar:

$\text{Social} \rightarrow \text{Human Rights}$
$\text{Social} \rightarrow \text{Workforce}$

$\text{Social} \rightarrow \text{Community}$

$\text{Social} \rightarrow \text{Product Responsibility}$

The Hausman test is used to determine the appropriate model. If the null hypothesis is not rejected, Random Effect panel model is preferred for efficiency; if rejected, Fixed. Effect panel model is more appropriate due to its consistency (Hausman and Taylor, 1981; Hsiao, 2014). Based on this test, the fixed-effects model was selected as the most suitable approach for this study. To further assess the robustness of the estimations, potential multicollinearity among explanatory variables was examined by inspecting the correlation matrix and checking variance inflation factors (VIF). The results did not indicate problematic levels of collinearity, remaining well below the conventional thresholds typically discussed in the econometric literature (Greene, 2005; Wooldridge, 2010). As an additional robustness check, the analysis also employs a dynamic panel model estimated through the Generalized Method of Moments (GMM), following Arellano and Bond (1991). This approach is particularly suitable for panel data with potential endogeneity issues, as it uses lagged values of the dependent and explanatory variables as instruments. The general specification of the dynamic model is expressed as follows:

$$\mathrm{ENV}_{it} = \alpha + \beta\,\mathrm{SOC}_{it} + \gamma\,\mathrm{X}_{it} + \delta\,\mathrm{ENV}_{i,t-1} + \mu_i + \lambda_t + \varepsilon_{it}\ ,$$

where ENV_{it} denotes the environmental pillar score of firm i at time t, SOC_{it} the social pillar score (or its sub-pillars), X_{it} the set of control variables (firm size, leverage, profitability, industry fixed effects), μ_i firm-specific effects, λ_t year dummies, and ε_{it} the error term. The lagged dependent variable $\mathrm{ENV}_{i,t-1}$ is included to capture persistence and dynamics in environmental performance. The GMM estimation exploits deeper lags of the endogenous regressors as instruments, under the assumption that they are correlated with the explanatory variables but uncorrelated with the error term. This procedure mitigates endogeneity concerns and enhances the robustness of the results.

3.3 Results and findings

This section presents fixed-effects panel results on the association between the social pillar and environmental performance of firms in the 20 smart cities, as shown in Table 4.

Table 4. Fixed-effect regression

Dep. variable: Environmental score	Model I
Social pillar score	0.509***
	(0.026)
Return on equity	-0.004**
	(0.002)
Total assets	1.440**
	(0.682)
Leverage	0.002
	(0.003)
Market valuation	-0.0001*
	(0.000)
Growth	0.002
	(0.005)
Constant	-22.896
	(14.614)
Number of firms	1,116
Year fixed effects	Yes

Note: standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. *Source: authors' elaboration.*

In Model I, the social pillar score shows a strong positive association with the environmental score, suggesting that firms with higher social performance in smart cities tend to achieve better environmental outcomes. This may stem from stronger governance, stakeholder engagement, and integration of environmental practices into CSR strategies (Carroll and Shabana, 2010). Socially responsible firms are more likely to invest in sustainable

innovation, adopt circular models (Bocken et al., 2014), and foster operational efficiency (Hart, 1995). Their collaboration with public bodies and participation in green initiatives further supports environmental progress (Porter and Kramer, 2018), while attracting ESG investments that incentivize environmental improvements (Friede et al., 2015). Estimates for the sub-pillars are provided in Table 5.

Table 5. Fixed-effects regressions: Social sub-pillars

Dep. variable: Environmental score	Model II	Model III	Model IV	Model V
(S1) Human rights score	0.182***			
	[0.017]			
(S2) Workforce score		0.332***		
		[0.020]		
(S3) Community score			0.197***	
			[0.018]	
(S4) Product responsibility				0.175***
				[0.018]
Return on Equity	-0.006***	-0.005*	-0.005	-0.003
	[0.002]	[0.003]	[0.005]	[0.004]
Total assets	2.455***	1.539**	2.622***	2.340***
	[0.766]	[0.755]	[0.745]	[0.728]
Leverage	-0.008***	0.003	-0.002	0.008***
	[0.003]	[0.005]	[0.003]	[0.002]
Market valuation	-0.0001*	-0.0001	-0.0001	-0.0001
	[0.000]	[0.000]	[0.000]	[0.000]
Growth	-0.001	0.003	-0.000	-0.001
	[0.007]	[0.005]	[0.007]	[0.008]
Constant	-29.874*	-22.483	-39.272**	-30.248*
	[16.489]	[16.088]	[16.064]	[15.651]
Number of firms	1,116	1,116	1,116	1,116
Year fixed effects	YES	YES	YES	YES

Note: standard errors in brackets. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. *Source: authors' elaboration.*

Model II indicates that the human rights sub-pillar has a statistically significant positive coefficient, suggesting that firms committed to upholding human rights conventions tend to exhibit stronger environmental performance. In Model III, the workforce sub-pillar score suggests that prioritizing job satisfaction, workplace safety, diversity, and employee development enhance environmental outcomes (Channa et al., 2021). Model IV finds a positive association between the community sub-pillar and environmental scores, implying that ethical business conduct and public health protection contribute to better performance. Similarly, Model V shows that the product responsibility sub-pillar correlates positively with environmental outcomes, reflecting the benefits of responsible production practices. Across all models, firm size has a pronounced effect, with larger firms consistently

outperforming smaller ones in environmental metrics. This supports the view that larger firms are more capable of managing CSR practices effectively (Reverte et al., 2016; Udayasankar, 2008).

4 Robustness check

To ensure the robustness of our findings, we employed the dynamic panel model known as GMM-SYS version of the Arellano-Bond estimator (Arellano and Bond, 1991; Arellano and Bover, 1995; Blundell and Bond, 1998). This is because traditional empirical techniques, such as OLS or instrumental variables estimation, are unsuitable due to the strong persistence observed in the dependent variable (Arellano and Bond, 1991; Arellano and Bover, 1995; Cerciello et al., 2023;). Neglecting this persistence would result in omitted variable bias, leading to inconsistent estimates. Following, the equation of the GMM-SYS version of the Arellano-Bond estimator is based on this form:

$$Y_t = \rho Y_{t-1} + X_t\beta + \varepsilon_t \ ,$$

where the dependent variable Y_t is an $N \times 1$ vector representing, alternatively, the LSEG Workspace environmental pillar score. X_t is an $N \times K$ matrix containing the explanatory variables, β is a $K \times 1$ vector of marginal effects, and ε_t is an $N \times 1$ vector of error terms, assumed to be appropriately distributed. The scalar parameter ρ captures the inertia in the dependent variable over time, while Y_{t-1} represents the autoregressive component of the model. This econometric technique is widely applied in ESG research (e.g., Cerciello et al., 2023; Taddeo et al., 2024; Carè et al., 2024) and is well established in the financial literature.

First, as ESG data typically span multiple entities over time, the dynamic panel data approach effectively captures both cross-sectional and temporal variations. Second, it provides a robust framework for addressing key econometric issues such as endogeneity, omitted variable bias, and selection bias, leading to more consistent and reliable estimates. Specifically, these issues may arise through two main channels.

On the one hand, the presence of Y_{t-1} among the regressors induces an endogeneity problem. Therefore, Y_{t-1} must be instrumented using deeper lags of the dependent variable, both in levels and in first differences. On the other hand, an additional source of endogeneity stems from the potential simultaneity between the dependent variable and the covariates included in the X_t matrix. In this context, the dynamic Arellano–Bond model addresses endogeneity by introducing appropriate instrumental variables. Specifically, the GMM-SYS version of the Arellano–Bond estimator exploits both levels and first differences of deeper lags of the dependent variable as instruments for the first lag, together with deep lags of endogenous covariates (Cheng and Bang, 2021).

To assess the validity of the instrument set, the Arellano–Bond autocorrelation tests and the Sargan and Hansen overidentification tests are employed. Failure to reject the null hypothesis indicates that the instruments are valid (Bowsher, 2002). Table 6 reports the corresponding regression results.

Table 6 presents the estimation results, revealing significant and insightful implications. First, the lagged covariates indicate strong persistence in the social pillar and its sub-pillars,

Table 6. Dynamic panel GMM estimations

Dep. variable: Environmental score	Model V	Model VI	Model VII	Model VIII	Model IX
Lagged dep. variable	0.529***	0.566***	0.856***	0.816***	0.840***
	[0.166]	[0.147]	[0.064]	[0.099]	[0.041]
Social score	0.392***				
	[0.233]				
(S1) Human rights score		0.164***			
		[0.079]			
(S2) Workforce score			0.104***		
			[0.062]		
(S3) Community score				0.263***	
				[0.129]	
(S4) Product responsibility					0.038***
					[0.016]
Control variables	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES
City fixed effects	YES	YES	YES	YES	YES
Sargan test	13.07	11.54	22.04	16.65	22.39
	[0.732]	[0.827]	[0.107]	[0.478]	[0.215]
Hansen test	12.93	13.03	14.54	23.69	16.35
	[0.741]	[0.734]	[0.485]	[0.128]	[0.568]
AR(1)	-3.53	-4.11	-9.32	-6.71	-11.15
	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***
AR(2)	0.89	1.64	1.27	0.86	1.38
	[0.376]	[0.102]	[0.206]	[0.390]	[0.167]
AR(3)	-0.70	-0.31	-0.54	-0.31	-0.89
	[0.483]	[0.756]	[0.592]	[0.757]	[0.371]

Note: endogenous variables are suitably instrumented. Standard errors are reported in brackets for covariates, while p-values are reported in brackets for tests. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. *Source: authors' elaboration.*

suggesting that firms' social performance follows a stable trajectory over time, highlighting the need to account for this inertia to avoid biased estimates. Second, the AR tests, along with the Sargan and Hansen tests, validate the instrument set, which includes deeper lags of both endogenous and exogenous variables. The robustness checks support the research hypothesis: firms in the top 20 smart cities with higher corporate social performance tend to achieve better environmental outcomes. This reinforces the idea that in smart cities, strong environmental and social performance contributes to sustainable urban development by aligning economic growth with ecological and social goals.

5 Discussion

The integration of social responsibility with environmental management is increasingly recognized as a core component of corporate sustainability. Firms with strong social practices tend to adopt more comprehensive sustainability strategies, aligning ethical, environmental, and stakeholder-oriented objectives. This integrated approach embeds

environmental initiatives within broader CSR frameworks, facilitating their adoption and enhancing stakeholder engagement (Carter and Rogers, 2008; Behringer and Szegedi, 2016; Ivaşcu et al., 2022). Integrating social and environmental goals provides several strategic advantages. It enables firms to address the interconnectedness of sustainability challenges and promotes innovation by encouraging solutions that account for both social and environmental dimensions. For instance, organizations that invest in employee well-being often benefit from a more engaged workforce that actively supports environmental initiatives, resulting in synergistic improvements in sustainability performance. Furthermore, such integration contributes to enhanced financial performance and competitive positioning, particularly as investors and consumers increasingly favour firms committed to sustainability (O'Shannassy, 2008). However, challenges persist. One major risk is the superficial adoption of sustainability practices for reputational gain rather than genuine strategic alignment. Authentic integration requires a commitment rooted in corporate values, supported by clear communication, measurable goals, and leadership engagement (Khan et al., 2021). Another challenge lies in coordinating diverse departments and stakeholders under a unified sustainability vision, which demands internal coherence and effective cross-functional collaboration. Strong social performance also enhances regulatory compliance, an increasingly vital factor in complex legal environments. Firms with integrated sustainability strategies are typically better equipped to anticipate and adapt to evolving environmental regulations, reducing legal risks and improving reputational standing (Jose and Lee, 2006). Proactive alignment with regulatory standards often results in cost efficiencies and broader market opportunities. Nonetheless, navigating multi-jurisdictional regulatory frameworks poses significant challenges for multinational enterprises. Regulatory fragmentation increases compliance complexity and operational costs. To mitigate these risks, firms can adopt strategic compliance management systems, engage with policymakers, and participate in industry-level initiatives to harmonize standards (Apeh et al., 2023). Public policy also plays a central role in shaping corporate sustainability. Through incentives such as tax relief and grants, governments can support firms in aligning business models with environmental and social priorities (Na et al., 2021). These policy instruments are essential in fostering a sustainability-oriented business environment. The link between sustainability and long-term corporate value is now widely acknowledged. A holistic sustainability strategy enhances corporate reputation, stakeholder trust, and financial performance. Investors increasingly view sustainability as a long-term value driver rather than a peripheral concern (Alkhodary, 2023). Despite these benefits, measuring the long-term value of sustainability remains complex. The absence of standardized metrics complicates the evaluation and communication of impacts. To address this, firms are encouraged to adopt comprehensive sustainability reporting practices, incorporating both quantitative and qualitative metrics. By capturing financial, environmental, and social dimensions, companies can better demonstrate their value creation to stakeholders (Thompson et al., 2022). Innovation and collaboration are fundamental enablers of sustainable value. Investment in green technologies and business model innovation enhances sustainability outcomes, while partnerships with governments, NGOs, and other businesses amplify collective capacity to address complex challenges (Mariani et al., 2022). These dynamics converge in the context of smart

cities–urban ecosystems that rely on technological integration, infrastructure, and civic participation to achieve sustainability objectives. In smart cities, the active engagement of employees and local communities is critical for the success of sustainability initiatives (Bibri and Krogstie, 2017). Community and workforce engagement fosters social resilience and supports collective efforts toward environmental goals. The stronger effect of the workforce sub-pillar may be explained by the role of human capital in fostering innovation, operational efficiency, and the adoption of environmentally friendly practices. Employees' skills, motivation, and engagement represent crucial drivers of sustainability-oriented change. Similarly, the significance of the community dimension reflects the importance of stakeholder engagement and local legitimacy: firms embedded in proactive communities face stronger social pressure and reputational incentives, which can translate into higher environmental performance. However, fostering such engagement is not without obstacles. Technological and infrastructural investments are required to enable inclusive participation, and digital inequalities may hinder access. To address these gaps, smart cities should promote digital literacy, ensure equitable access to digital services, and involve stakeholders in planning and implementation processes (Bibri and Krogstie, 2017). Technology itself is a crucial tool in enhancing participation. Smart platforms, sensors, and data analytics facilitate more responsive and transparent urban governance. Innovation in digital engagement also supports more collaborative, data-driven sustainability efforts, ultimately reinforcing the creation of long-term social and environmental value. These findings highlight that the positive link between social and environmental performance remains consistent across all tested specifications. Importantly, the consistency of results across both fixed-effects and GMM estimations reinforces the robustness of the empirical evidence, confirming that the observed relationships are not driven by model specification or endogeneity concerns. This strengthens confidence in the validity of the results and supports the theoretical framework underlying the hypotheses.

6 Conclusions, limitations, and future research avenue

This study examined the association between corporate social indicators and environmental performance within the context of smart cities-urban environments characterized by the integration of sustainability principles and digital technologies. The analysis aimed to test the hypothesis that the corporate social pillar, along with its constituent sub-pillars (workforce, human rights, community engagement, and product responsibility), exerts a significant influence on firms' environmental performance. Empirical evidence from the fixed-effects panel model supports a positive and statistically significant relationship between the overall social pillar and environmental performance. Firms demonstrating strong performance in areas such as employee well-being, workplace safety, diversity, and development opportunities were found to exhibit superior environmental outcomes. Similarly, higher levels of commitment to human rights, community engagement, and product responsibility were associated with elevated environmental scores, indicating that socially responsible firms tend to adopt more environmentally sustainable practices. To address concerns related to endogeneity, particularly reverse causality and omitted variable bias, a panel instrumental variable

(IV) regression was conducted using lagged social variables as instruments. The results reaffirm the robustness of the observed associations, suggesting that historical social performance contributes meaningfully to subsequent environmental outcomes. These findings highlight the critical interdependence of social and environmental dimensions within smart city governance and corporate sustainability. In such urban ecosystems, the integration of social responsibility with environmental stewardship emerges not only as a normative commitment but also as a strategic imperative, reinforcing alignment with regulatory expectations, stakeholder demands, and long-term value creation objectives. The study offers several implications for practice and policy. For corporate actors, the results underscore the importance of embedding social responsibility into environmental strategy, particularly in innovation-driven urban contexts. For policymakers and urban planners, the findings emphasize the relevance of fostering socio-environmental synergies as part of broader efforts to promote sustainable urban development. From a policy perspective, the results suggest that urban governance frameworks in smart cities should foster both corporate workforce development and community engagement. Municipal authorities and regulators could incentivize ESG disclosure and integrate social sustainability objectives into local policy agendas. Public–private partnerships, community-based initiatives, and targeted programs for diversity and inclusion may reinforce the positive spillovers of social performance on environmental outcomes, thereby aligning corporate practices with broader urban sustainability goals. Notwithstanding the robustness of the findings, the study is not without limitations. First, the focus on the top 20 smart cities, which represent innovation-driven contexts and therefore cases of excellence in urban sustainability, may restrict the generalizability of the results. The evidence mainly applies to large, listed firms operating in technologically advanced urban environments, while different dynamics may emerge in smaller cities or in contexts with lower levels of innovation. Second, the lack of a counterfactual comparison with non-smart cities limits the scope of the analysis. Third, the classification of social sub-pillars differs from the standard LSEG taxonomy. While LSEG traditionally reports three dimensions (diversity and inclusion, human rights, and product responsibility), our dataset version includes four (workforce, human rights, community, and product responsibility). Although this disaggregation allows for greater analytical depth, it may reduce direct comparability with studies adopting the standard taxonomy. Finally, a potential selection bias may arise from the reliance on ESG scores, which are based on companies' voluntary disclosure. Firms that are more proactive in reporting may also be those with stronger sustainability practices, potentially leading to an overestimation of the relationship between social indicators and environmental performance. As a result, the findings cannot be directly generalized to medium-sized urban areas or to developing contexts, where institutional and social dynamics may differ substantially. Future studies should extend the scope to cities with different characteristics and governance models, in order to test the robustness of the observed relationships across more diverse contexts. Additionally, further research may adopt mixed-method approaches, combining quantitative analyses with qualitative investigations, in order to capture the mechanisms underlying the relationship between ESG performance and urban sustainability. This would provide a more comprehensive understanding of how firms' social and environmental practices interact with the specific features of smart cities. In conclusion, this study contributes to the

growing literature on ESG and urban sustainability by summarizing the main results of this research. Summarizing, the integration of social and environmental dimensions within the framework of smart cities constitutes a promising pathway toward sustainable development and corporate resilience. By fostering alignment between organizational practices and socio-environmental goals, firms can contribute meaningfully to the transformation of urban spaces into inclusive, technologically advanced, and ecologically responsible environments.

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