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Carbon Intensity, Regulatory Quality, and Transition Risk

Ayça Tekin-Koru,
Işıl Sevilay Yılmaz
and İlkay Şendeniz-Yüncü

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Mind the Gap:
Financial Transparency, Carbon Intensity and Sustainability Performance in MENA

Ayça Tekin-Koru[*]
TEDU, ERF

Işıl Sevilay Yılmaz[†]
TEDU

İlkay Şendeniz-Yüncü[‡]
METU

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Abstract

This paper examines the sustainability performance of Middle East and North Africa (MENA) economies using the sustainability gap, defined as the deviation between actual GDP per capita and the sustainability-consistent income implied by ESG fundamentals. Using an annual panel of advanced, emerging, and resource-rich economies from 2000 to 2023, we evaluate how production-based and per-capita CO_2 emissions, together with financial transparency, shape both the level of the sustainability gap and its five-year momentum. The results show that high production-based carbon intensity imposes a large and significant sustainability penalty. A one standard deviation increase in CO_2 per USD 10,000 of GDP lowers the sustainability gap by 4 to 7 percentage points in non-MENA economies, and by 1.3 to 1.5 points in MENA. Financial transparency moderates this penalty outside the region, but its mitigating effect is close to zero in MENA and especially in resource-rich MENA. By contrast, per-capita emissions display only weak associations with sustainability performance and no meaningful interaction with transparency. Five-year momentum estimates show limited institutional influence and indicate slow structural adjustment throughout the region. Counterfactual simulations confirm these patterns. Raising financial transparency in MENA to advanced-economy levels improves the sustainability gap by less than 1 percentage point for most countries, while reducing production-based CO_2 intensity to global benchmarks yields improvements of 3 to 4 points for the most carbon-intensive producers. These findings highlight that MENA's sustainability penalties are primarily structural in origin, and that credible long-term decarbonization requires substantial changes in production systems supported by, but not driven by, institutional reform.

Keywords. Financial transparency. Carbon intensity. Sustainability gap. ESG-adjusted income. MENA. Transition risk.
JEL Codes: G18; O13; O43; Q54; Q56

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[*] ayca.tekinkoru@tedu.edu.tr, TED University, Faculty of Economics and Administrative Sciences, Department of Economics, Ziya Gökalp Cad. No: 47, Ankara, Türkiye; +90 312 5850034, ORCID: 0000-0002-0817-905

[†] isil.yilmaz@tedu.edu.tr, TED University, Faculty of Economics and Administrative Sciences, Department of Business Administration, Ziya Gökalp Cad. No: 47, Ankara, Türkiye, +90 312 5850284, ORCID: 0000-0001-9499-5245

[‡] sendeniz@metu.edu.tr, Middle East Technical University, Department of Business Administration, Dumlupınar Blv No:1 06800 Çankaya Ankara, Türkiye; +90 312 2102050, ORCID: 0000-0002-6065-4204

1 Introduction

The challenge of balancing economic growth with environmental sustainability has become increasingly pronounced in recent decades. Global decarbonization pressures, international climate commitments, and the growing financial relevance of Environmental, Social, and Governance (ESG) performance have placed national development models, particularly those in resource-exporting regions such as the Middle East and North Africa (MENA), under increasingly close evaluation. Sustainability considerations have shifted from abstract ideals to measurable financial determinants, directly influencing sovereign risk assessments, international capital allocation, market access, and long-term fiscal resilience. Nevertheless, despite relatively high reported ESG scores in several MENA economies, empirical evidence points to a persistent misalignment between these institutional and resource endowments and realized sustainability-aligned income gains. A misalignment between reported ESG metrics and tangible sustainability achievements arises from the joint effects of high carbon intensity in production and restricted transparency in fiscal and corporate governance. Understanding the determinants of this gap has become essential for investors, creditors, and policymakers seeking to evaluate sovereign transition risks and the long-run viability of hydrocarbon-dependent growth models.

This paper examines the sustainability performance of MENA economies through the concept of the sustainability gap, defined as the deviation between actual GDP per capita (GDPpc) and ESG-implied, sustainability-consistent GDPpc. A positive gap indicates that a country's fundamental ESG position is stronger than its realized income, implying unused sustainability capacity that financial markets may eventually recognize as latent upside potential. A negative gap, in contrast, represents a sustainability penalty, whereby current income levels exceed what is supported by ESG fundamentals. These shortfalls may represent unpriced transition risks, including potential future declines in income, deterioration of fiscal buffers, or weakening of sovereign creditworthiness as economies face increasingly stringent global decarbonization requirements. By focusing on this gap, this study assesses how effectively MENA economies convert ESG fundamentals into sustainability-adjusted income and identifies the institutional and structural constraints that condition this conversion.

The core objective of the analysis is to evaluate how carbon intensity and financial transparency jointly shape the magnitude of sustainability rewards and penalties. Carbon intensity serves as a proxy for transition-risk exposure, long-term productivity limitations, and vulnerability to external carbon-pricing mechanisms. Financial transparency captures the credibility of the institutional framework, thereby influencing sovereign information risk, investor confidence, and the reliability of sustainability-related disclosures. The framework proposed here suggests that the impact of emissions on sustainability performance depends on institutional quality: high carbon intensity leads to larger sustainability penalties when financial transparency is weak, while strong governance can mitigate these penalties by improving information flow, strengthening policy credibility, and ensuring that reported ESG performance more accurately reflects actual environmental and institutional conditions.

The empirical analysis draws on a comprehensive panel covering advanced, emerging, and resource-rich economies from 2000 to 2023. The main dependent variable is the static sustainability gap, obtained from the LSEG Sovereign Sustainability Solutions dataset, which benchmarks GDPpc against sustainability-consistent income levels derived from ESG fundamentals. To capture dynamic adjustment, a five-year momentum measure is constructed, reflecting the rate at which countries converge toward or diverge from their sustainability-consistent income paths in the medium run. The key explanatory variables include two measures of carbon intensity; production-based CO_2 emissions per unit of GDP and per-capita fossil CO_2 emissions, and institutional indicators representing financial transparency and governance integrity. Country fixed effects absorb time-invariant unobserved heterogeneity, while year fixed effects account for global shocks and reporting-standard changes.

Explanatory variables are lagged one year to mitigate simultaneity concerns and ensure that institutional and environmental predictors precede observed sustainability outcomes.

The empirical strategy further incorporates structural and regional heterogeneity by testing whether the carbon-intensity penalty and the moderating role of financial transparency differ across emerging economies, the broader MENA region, and resource-rich MENA economies. Interaction and triple-interaction terms are used to formally assess these conditional effects. This allows the analysis to distinguish between institutional contingencies, i.e. how governance quality influences sustainability conversion, and structural constraints such as fossil-fuel dependence and energy-intensive production technologies. These distinctions are central to understanding differential sovereign transition risks, the credibility of ESG disclosures, and the long-term fiscal implications of carbon-dependent development strategies.

The study focuses on two core research questions. First, how do production-based CO_2 emissions affect the ESG-adjusted GDPpc gap, and to what extent does financial transparency moderate this relationship? This question addresses the static dimension of sustainability performance, capturing whether high-emission economies exhibit weaker sustainability-adjusted income relative to their ESG fundamentals, and whether financial transparency can mitigate the associated penalties. Second, how do CO_2 emissions influence the five-year momentum of the sustainability-adjusted income gap, and does financial transparency condition this dynamic adjustment? This question extends the analysis to medium-term trajectories, evaluating whether economies are converging toward or diverging from their sustainability-consistent income potential and how institutional quality affects the speed and strength of this adjustment. By addressing these questions, the paper provides a comprehensive assessment of both static and dynamic sustainability gaps in MENA economies, offering insights of relevance for academic research, sovereign risk analysis, and financial-sector decision-making. The findings highlight that credible institutions and structural decarbonization must operate in tandem to transform sustainability penalties into enduring rewards, environmentally, economically, and financially. In line with theory and prior empirical evidence, we hypothesize that higher carbon intensity is associated with more negative sustainability-adjusted performance, that greater financial transparency improves outcomes, and that transparency moderates the adverse effect of emissions, with the moderating influence being particularly pronounced in countries with weaker baseline governance capacity.

The paper contributes to several strands of the finance, economics, and sustainability literature. First, it advances the ESG-performance and sustainability-gap framework by applying it to a region characterized by relatively high reported ESG scores but weaker observed sustainability outcomes, thereby highlighting the distinction between disclosure-based ESG ratings and economically meaningful sustainability performance. Second, it integrates institutional and structural perspectives to demonstrate how governance interacts with carbon intensity in shaping sustainability rewards and penalties, insights highly relevant for sovereign investors, credit-rating methodologies, and policy institutions. Third, the incorporation of dynamic momentum analysis explains the adjustment process toward sustainability-consistent income, revealing the speed and persistence of sustainability transitions. Finally, the study provides policy-relevant insights on energy-system reform, institutional modernization, and economic diversification, key pillars of long-term sovereign resilience and financial stability in resource-dependent economies.

The remainder of the paper is structured as follows: Section 2 presents the background and theoretical context, and reviews the literature on ESG performance, carbon intensity, institutional governance, and financial transparency, emphasizing gaps in existing research on MENA economies. Section 3 develops the conceptual framework, outlining the theoretical mechanisms linking carbon-intensive production, financial transparency, and sustainability-adjusted income, and states the study hypotheses. Section 4 describes the data sources and the construction of sustainability-consistent income and performance-gap measures. Section 5 outlines the empirical methodology for the static and dynamic analyses. Section 6 presents the results, including static gap estimations, five-year momentum dynamics, and counterfactual exercises isolating institutional and structural drivers. Section 7 discusses policy implications, emphasizing the interaction between financial transparency reforms, and concludes by summarizing key insights and identifying avenues for future research on climate-economy-finance linkages in resource-dependent and emerging regions.

2 Background and Theoretical Context

2.1 From Environmental Efficiency to Sustainable GDP

Recent developments in the measurement of sovereign sustainability highlight the limitations of traditional macroeconomic indicators when assessing long-term economic resilience. Conventional GDP-based metrics capture the scale of economic activity but remain silent on the ecological constraints that shape countries' future growth trajectories. This critique is particularly relevant for resource-dependent economies where high output levels are frequently sustained through depletion of natural capital. To address this gap, a growing body of literature has advanced sustainability-adjusted measures of economic performance, including Green GDP, biocapacity-adjusted GDP, and other environmental efficiency indicators, designed to align national income accounting with ecological boundaries (Gratcheva et al., 2020; Necula, 2024).

Beyond Ratings' "*Global Sustainable GDP Gap"* indicator operationalizes this conceptual shift by benchmarking actual GDPpc against a theoretically sustainable level of income that fully accounts for ecosystem degradation, resource depletion, and environmental carrying capacity. The resulting "*GDPpc Gap*" captures the extent to which current production levels exceed the sustainable frontier. As such, it functions not merely as an environmental metric but as an indicator of sustainability-adjusted efficiency**,** reflecting the degree of misalignment between economic activity and long-term ESG viability.

This type of sustainability-adjusted income measure is particularly instructive for the MENA region, where many economies exhibit structurally inflated GDPpc levels driven by hydrocarbon rents, resource extraction, and energy-intensive production systems. As documented in studies on ecological footprint dynamics in MENA countries, such income patterns often coexist with substantial ecological deficits**,** meaning that national biocapacity is insufficient to absorb the environmental pressures created by economic activity (Ramezani et al., 2022). These deficits reveal structural vulnerabilities that conventional GDP figures tend to mask, including dependence on carbon-intensive sectors, limited diversification, heightened exposure to transition risks, and long-term fiscal fragility. In this sense, examining gaps between reported GDPpc and sustainability-adjusted performance indicators provides a clearer view of the region's underlying environmental-economic imbalance.

2.2 CO_2 Emissions and Sustainable Performance

Production-based CO_2 emissions provide a direct gauge of the carbon intensity embedded within national production systems. High emissions per unit of output often reflect heavy reliance on fossil-fuel-based energy infrastructures, inefficient technologies, and industrial structures that are difficult to decarbonize. These features tend to erode environmental performance and weaken long-run economic efficiency.

Empirical work strongly supports this association. Mehmood et al. (2025), examining the world's 18 largest emitters over 1990–2019, show that higher fossil-fuel-driven energy consumption and rapid urbanization significantly reduce carbon productivity, indicating a persistent trade-off between emissions-heavy production and sustainable growth. Similarly, Li et al. (2018), analyzing 19 G20 economies from 1990 to 2015, demonstrate that elevated CO_2 emission intensity and energy-use inefficiencies constitute major barriers to sustainable development, especially in economies where the energy mix remains dominated by fossil sources.

For resource-dependent MENA economies, these dynamics are especially pronounced. Hydrocarbon-based production structures generate substantial emissions, contributing to persistent ecological and sustainability-adjusted income gaps (Ramezani et al., 2022) and heightening exposure to emerging international climate policies such as the EU's Carbon Border Adjustment Mechanism (CBAM). Such mechanisms impose implicit carbon prices on carbon-intensive exports, amplifying the macroeconomic costs of high-emissions production. Limited regulatory capacity in several MENA countries further constrains the implementation of environmental standards and slows progress on industrial upgrading and green investment.

Evidence therefore suggests that reducing CO_2 intensity through efficiency improvements, industrial modernization, or renewable-energy expansion yields dual benefits: improving environmental outcomes while also strengthening productivity, competitiveness, and fiscal resilience.

2.3 Financial Transparency and Institutional Credibility

Financial transparency, measured here through regulatory quality and control of corruption indicators from the Worldwide Governance Indicators (WGI), captures the credibility and effectiveness of the institutional framework. It shapes the reliability of sustainability-related disclosures, influences sovereign information risk, and affects investor confidence. As such, financial transparency operates as a key governance mechanism that strengthens accountability, reduces informational frictions, and supports policy credibility.

In the context of sustainability-adjusted economic performance, financial transparency interacts with carbon intensity. Production-based CO_2 emissions proxy the structural carbon intensity of national production systems, reflecting energy inefficiency, fossil-fuel dependence, and transition-resistant industrial processes. High emissions tend to depress sustainability-adjusted outcomes, particularly where financial transparency is weak. Strong governance can attenuate these penalties by enhancing information flows, aligning reported ESG performance with actual environmental and institutional conditions, and enabling more effective policy responses.

Structural factors such as state-owned enterprise dominance, fragmented reporting systems, and historically weak institutional oversight limit financial transparency and exacerbate sustainability risks. Improving regulatory quality and anti-corruption measures strengthens the credibility of fiscal and environmental reporting, facilitates assessment of transition risks, and supports the integration of climate objectives into budgetary and economic policy. Economies with stronger institutional credibility are better positioned to implement carbon pricing, attract green investment, and manage climate-related risks.

Institutional heterogeneity further conditions these outcomes. High-income hydrocarbon exporters typically rely on concentrated rent-based fiscal structures, whereas middle-income reformers undertake broader governance and regulatory reforms. Financial transparency improvements therefore tend to yield larger marginal benefits where baseline governance is weaker. These dynamics align with Environmental Kuznets-type reasoning: stronger institutions enable earlier decoupling of growth from environmental degradation, while institutional gaps can lock economies into carbon-intensive pathways. For MENA countries, enhancing transparency and institutional credibility is both an economic and environmental priority, forming a foundation for effective low-carbon transitions and more credible realization of ESG-aligned outcomes.

2.4 Literature Review

A broad body of literature examines the linkages between sustainability, ESG disclosure, financial transparency, and macroeconomic performance, highlighting both conceptual advances and unresolved challenges. ESG disclosure has emerged as a central mechanism through which institutions communicate environmental and social risks to stakeholders. Oncioiu et al. (2020) argue that robust ESG reporting enhances financial transparency, strengthens accountability, and improves the informational environment for investors and regulators. Empirical evidence shows that higher transparency in banks' socio-environmental policies reduces the likelihood of financial stress (De Moraes and De Mello, 2025).

Daugaard and Ding (2022) identify three critical areas requiring further investigation: the influence of countries' development stages on ESG adoption, the relative effectiveness of different regulatory environments in fostering sustainable finance, and the extent to which socially responsible investment can drive ESG performance. These issues carry substantial implications for investment management and public policy, particularly in emerging and resource-dependent economies.

Measurement challenges further complicate empirical ESG research. Adrangi and Kerr (2022) highlight persistent difficulties in operationalizing Sustainable Development Goal (SDG) indicators, limiting the statistical robustness of cross-country comparisons. D'Orazio and Popoyan (2019) document substantial cross-country variation in the adoption of green prudential instruments and regulatory mandates, highlighting differences in governance structures and the types of climate-related requirements implemented.

Stakeholder theory provides a dominant explanation for ESG adoption. Organizations face multidirectional pressures, from investors, regulators, and society, to demonstrate environmental and social responsibility. Transparency acts as the mechanism through which these pressures translate into improved governance and performance (Oncioiu et al., 2020). Institutional isomorphism complements this perspective: Daugaard and Ding (2022) show that firms and governments often converge toward similar ESG practices due to coercive regulatory requirements, normative professional standards, and mimetic imitation under uncertainty. This framework helps explain cross-country variation in ESG uptake and the diffusion of disclosure practices across regions and sectors.

While Oncioiu et al. (2020) highlight ESG disclosure as a tool for financial transparency and stakeholder communication, broader literature cautions that ESG-driven initiatives may sometimes create unintended consequences when not supported by strong governance. Without adequate governance and accountability, ESG actions driven primarily by reputational incentives may exacerbate problems or create new risks. This tension between profit maximization and social responsibility underscores the need for rigorous empirical evaluation of ESG policies and disclosure frameworks.

Institutional quality and governance capacity play a decisive role in translating ESG measures into tangible environmental outcomes. Vasylieva et al. (2019) find that renewable energy adoption and reduced corruption significantly lower emissions, consistent with Environmental Kuznets Curve dynamics. Adrangi and Kerr (2022) similarly show that economic growth in emerging economies does not automatically improve SDG performance; sustainability benefits hinge on governance strength and institutional design.

Green macroprudential regulation adds an important macro-financial dimension to the literature. D'Orazio and Popoyan (2019) document substantial variation in countries' adoption of green prudential tools, ranging from climate-related disclosure mandates to differentiated reserve requirements and stress-testing frameworks. Dikau and Volz (2021) observe that, although few central banks have explicit sustainability mandates, climate-related risks increasingly intersect with traditional macroeconomic and financial stability objectives.

Vasylieva et al. (2019) show that corruption significantly worsens environmental outcomes, reinforcing the importance of governance quality for emissions reduction, while De Moraes and De Mello (2025) show that low transparency exacerbates financial fragility. These findings highlight that ESG disclosure and sustainable performance are inseparable from governance credibility.

Overall, the literature portrays a complex picture: ESG disclosure enhances financial stability, but its effectiveness is mediated by governance quality, institutional capacity, regulatory design, and sectoral characteristics. Renewable energy adoption, anti-corruption measures, and robust macroprudential frameworks constitute critical transmission channels through which transparency and ESG reporting contribute to sustainability outcomes. Persistent data gaps, measurement inconsistencies, and theoretical uncertainties, however, complicate empirical assessment and limit the generalizability of findings.

For MENA economies, particularly the ones characterized by hydrocarbon dependence, institutional heterogeneity, and fiscal opacity, these insights are particularly salient. Structural vulnerabilities magnify the costs of carbon-intensive growth while enlarging the potential gains from transparency-oriented reforms and ESG-aligned policy interventions. Understanding the ESG–financial stability–environment nexus in such contexts is therefore central to designing effective low-carbon development strategies.

3 Conceptual Framework and Hypotheses

The conceptual foundation rests on two core propositions. First, carbon-intensive development creates structural inefficiencies that depress long-run, sustainability-aligned economic performance. Second, the magnitude of this penalty depends not only on the emissions themselves but also on a country's institutional capacity to disclose, internalize, and act upon environmental externalities. In this sense, financial transparency functions as a governance mechanism that determines the degree to which environmental costs are incorporated into national economic outcomes.

3.1 Emissions, Sustainability Efficiency, and the ESG-Adjusted GDP Gap

The dependent variable**,** the ESG-adjusted GDPpc gap, is derived from Beyond Ratings' Global Sustainable GDP framework, which evaluates whether countries' environmental and institutional fundamentals place them above or below their sustainability-consistent income potential. A negative gap indicates underperformance relative to this sustainability benchmark: countries produce less GDPpc than their ecological and institutional endowments would allow under a long-run, resource-efficient equilibrium.

Production-based CO_2 emissions enter this structure as a direct proxy for the carbon intensity and environmental inefficiency embedded in domestic production systems. Even when high-emission economies achieve strong headline GDP growth, such growth is generated through processes that deplete natural capital, heighten transition risk, and increase vulnerability to carbon-pricing regimes such as CBAM. Emissions therefore serve as a signal of the structural misalignment between short-run economic gains and long-term sustainability.

The first research question follows from this reasoning:

R1: *How do production-based CO_2 emissions affect the ESG-adjusted GDPpc gap, and does financial transparency moderate this relationship?*

From this, the first hypothesis (H1) posits a negative association between emissions and the sustainability gap:

H1: Higher production-based CO_2 emissions are associated with a more negative ESG-adjusted GDPpc gap, indicating that emission-intensive economies exhibit weaker sustainability-adjusted performance.

This hypothesis reflects a central insight from sustainable development theory: environmental degradation diminishes the quality-adjusted returns to growth.

3.2 Financial Transparency as a Conditioning Mechanism

In the context of sustainability-adjusted economic performance, financial transparency operates through several channels: (i) Information discipline: Transparent governments face stronger market and institutional pressure to account for environmental liabilities. (ii) Credible policy frameworks: High-quality disclosure reduces uncertainty, fostering investor confidence in long-run sustainability reforms. (iii) Internalization of externalities: When environmental inefficiencies become visible in official accounts, policymakers are more likely to correct them through regulation, investment, and carbon-pricing mechanisms.

Thus, transparent economies are expected to exhibit stronger sustainability-aligned performance regardless of emissions levels:

H2: Greater financial transparency improves sustainability-aligned performance, resulting in a less negative (or more balanced) ESG-adjusted GDPpc gap.

3.3 The Moderating Role of Financial Transparency

The conceptual core of this study lies in the interaction between emissions and financial transparency. Financial transparency is theorized to moderate the negative effect of emissions by strengthening the feedback loop between environmental outcomes and economic decision-making. Through improved disclosure, environmentally costly activities become visible sooner, enabling more rapid policy correction and accelerating the adoption of cleaner technologies.

Financial transparency also improves the allocative efficiency of financial markets, channeling capital toward low-carbon sectors and away from pollution-intensive activities. For governments, it increases the credibility of national climate pledges and enhances compliance with emerging global carbon-pricing frameworks, reducing the sustainability penalty associated with emissions. Accordingly:

H3: Financial transparency mitigates the negative effect of CO_2 emissions on the ESG-adjusted GDPpc gap. In more transparent economies, the adverse sustainability impact of emissions is weaker.

3.4 Regional and Developmental Heterogeneity: The Case of MENA

The moderating effect of financial transparency is unlikely to be uniform across countries. Building on insights from the Background and Theoretical Context (Section 2), the conceptual model anticipates stronger moderation effects in countries with weaker initial institutional baselines, where financial transparency reforms produce larger informational and governance gains.

The MENA region provides a salient test case. Many MENA economies exhibit: structural dependence on carbon-intensive sectors, low to moderate baseline financial transparency, and ongoing reforms aimed at enhancing disclosure and strengthening regulatory quality. In such environments, incremental improvements in financial transparency can generate disproportionate sustainability gains by tightening accountability, reducing policy uncertainty, and enhancing the credibility of transition strategies. Thus:

H4: The moderating effect of financial transparency is stronger in MENA, where improvements in disclosure and accountability yield greater sustainability gains.

3.5 A Dynamic Perspective: Sustainability Momentum

The second research question extends the conceptual logic from static performance to dynamic sustainability momentum, defined as the five-year change in the ESG-adjusted GDPpc gap:

R2: *How do CO_2 emissions affect the five-year momentum of the sustainability-adjusted GDP gap, and does financial transparency moderate this relationship?*

Momentum captures whether economies are converging toward or diverging from their sustainability-consistent income potential. High emissions are expected to slow convergence by reinforcing carbon lock-in, amplifying transition risks, and delaying structural diversification. Thus:

H1 (Dynamic): Higher production-based CO_2 emissions lead to a more negative five-year change in the ESG-adjusted GDPpc gap, reflecting slower progress toward sustainable efficiency.

Financial transparency should accelerate sustainability momentum by improving policy credibility, reducing uncertainty, and mobilizing green investment:

H2 (Dynamic): Higher financial transparency enhances the five-year momentum of the ESG-adjusted GDPpc gap by fostering investor discipline, green investment, and policy credibility.

Moreover, financial transparency is expected to reduce the persistence of environmentally inefficient pathways by enabling more rapid corrective action:

H3 (Dynamic): Financial transparency moderates the impact of CO_2 emissions on the ESG-adjusted GDPpc momentum, reducing the strength of the negative association.

Finally, following the same logic as in the static framework, the dynamic moderating effect is expected to be stronger in the MENA region:

H4 (Dynamic): The moderating effect of financial transparency is more pronounced in MENA countries, where incremental improvements in reporting standards generate larger sustainability benefits.

4 Data and Descriptive Evidence

4.1 Data

We assemble an annual country panel for $j = 1, \ldots, J$ and $t = 2000, \ldots, 2023$. The left-hand-side (LHS) variables are taken from LSEG Sovereign Sustainability Solutions (ESG Factor-In, 2025), which provides (i) a sustainability-consistent income level and (ii) a relative performance gap derived from ESG. Explanatory variables come primarily from EDGAR and WGI. Countries are mapped to one of five income groups g as in the Appendix A (low, lower-middle, upper-middle, high non-OECD, high OECD). Summary tables of variable descriptions, sources as well as correlations are presented in Appendix B.

We harmonize series to PPP-adjusted USD (where relevant) and retain the balanced panel wherever possible; robustness uses the available unbalanced panel when five-year differences are formed.

4.2 Dependent variables

4.2.1 Sustainability-consistent income and static performance gap

Let Y_{jt} denote actual GDPpc (PPP). For each pillar $q \in \{E, S, G\}$ and income group g, LSEG's PLS produces a sustainability-consistent income component

$$\hat{Y}_{jt,g}^{(q)} = \alpha_{g,q} + \sum_{i \in q} w_{i,g}^{(q)} X_{ijt},$$

which the Appendix A writes as (A.2)-(A.6). The composite ESG-consistent income is the pillar average

$$\hat{Y}_{jt,g}^{(ESG)} = \frac{1}{3} \left(\hat{Y}_{jt,g}^{(E)} + \hat{Y}_{jt,g}^{(S)} + \hat{Y}_{jt,g}^{(G)} \right),$$

matching (A.7). For exposition below we drop the explicit g in the subscript and write $\hat{Y}_{jt}^{(ESG)}$, with the understanding that it is constructed conditional on group g.

The static performance gap (our primary LHS variable) follows the (A.10):

$$\text{Perf}_{jt}^{(ESG)} \equiv \frac{\hat{Y}_{jt}^{(ESG)} - Y_{jt}}{Y_{jt}}. \tag{4.1}$$

By construction, $\text{Perf}_{jt}^{(ESG)}$ is a dimensionless percentage deviation measuring how actual GDPpc compares with the sustainability-consistent benchmark. Positive values indicate that a country's ESG fundamentals are stronger than its realized income (ahead of peers), whereas negative values reflect that realized income exceeds ESG-implied fundamentals (behind peers). The indicator is unbounded, although empirically most observations lie between roughly −70% and +150%

For compactness in the estimations, we denote

$$G_{jt} \equiv \text{Perf}_{jt}^{(ESG)} \tag{4.2}$$

4.2.2 Five-year momentum of the gap

To capture medium-term dynamics in sustainability-adjusted performance we define the five-year momentum:

$$\Delta^5 G_{jt} \equiv G_{jt} - G_{j,t-5} \qquad (4.3)$$

A positive $\Delta^5 G_{jt}$ means the gap has improved (become less negative or more positive) over the preceding five years; a negative value signals deterioration. As a difference of (4.2), $\Delta^5 G_{jt}$ is also dimensionless.

4.3 Independent variables

We rely on two complementary measures of carbon intensity and two institutional-quality indicators, which we use interchangeably for robustness. This subsection documents their construction and justification.

4.3.1 Carbon Intensity Variables

To capture carbon intensity, we employ two alternative indicators derived from the EDGAR 2024 GHG database (fossil CO_2 only). Both are expressed in metric tons of CO_2 equivalent and provide distinct but complementary representations of environmental inefficiency.

Our baseline regressor is the fossil CO_2 intensity of production, measured as:

$$C_{j,t} \equiv \text{CO2/GDP}_{j,t}^{(10k)}$$

where the underlying EDGAR series reports:

$$\text{CO2/GDP}_{j,t} = \text{tons of CO}_2 \text{ per USD 1,000 of GDP.}$$

For interpretability, we rescale the variable by a factor of 10 so that:

$$\text{CO2/GDP}_{j,t}^{(10k)} = 10 \times \text{CO2/GDP}_{j,t},$$

which transforms the unit to tons of CO_2 per USD 10,000 of GDP—a meaningful scale of economic output. Higher values indicate greater carbon inefficiency, i.e., more emissions per unit of economic production.

As an alternative specification, we use per-capita fossil CO_2 emissions:

$$C_{j,t} \equiv \text{CO2 per capita}_{j,t},$$

measured in tons of CO_2 per person per year. This metric reflects consumption-adjusted or lifestyle-related carbon footprints and provides an individual-level analogue to the production-based measure. Using both variables allows us to assess whether sustainability-adjusted GDP gaps respond to carbon intensity at the production system level or at the population exposure level.

4.3.2 Financial Transparency / Institutional-Quality Variables

A key empirical challenge is the lack of a consistent panel dataset on financial transparency, disclosure standards, or accounting quality that covers our full sample of countries and years. The most relevant datasets such as the Financial Secrecy Index, GFDD banking disclosure indicators, or IFRS adoption variables have limited temporal coverage or substantial missingness for non-OECD economies. Given these constraints, our moderator of interest is financial and regulatory governance quality, proxied by two percentile-rank indicators from WGI. Both are rescaled to the interval $[0, 100]$ for interpretability.

We adopt the WGI "Regulatory Quality" measure as a reduced-form proxy for the institutional underpinnings of transparency. Although "Regulatory Quality" does not directly measure financial disclosure, the indicator is built from expert surveys and business assessments that capture perceptions of policy credibility, regulatory predictability, and the quality of market-supporting institutions. These features contribute structurally to financial transparency: countries with stronger and more predictable regulatory regimes tend to have more reliable reporting routines, better enforcement of disclosure requirements, and fewer administrative distortions that obscure financial information. Regulatory Quality captures the government's capacity to formulate, implement, and enforce sound regulations that support private-sector development. We use this indicator as our core financial transparency proxy, motivated by the theoretical argument that credible regulatory institutions enhance the informational environment and moderate the sustainability impact of carbon intensity.

$$T_{j,t} \equiv \text{Regulatory Quality}_{j,t}$$

As an additional robustness measure, we also include "Control of Corruption," which is closely related to the integrity of financial reporting. High corruption environments typically weaken enforcement, encourage off-balance-sheet practices, and reduce the reliability of official financial data. The combination of these two governance dimensions provides a pragmatic and empirically defensible proxy for the institutional environment in which financial transparency (or opacity) operates.

Control of Corruption (Appendix B) reflects the extent to which public authority is exercised transparently and free from both petty and grand corruption. It provides a governance-integrity channel distinct from technical regulatory quality. Using both variables ensures that our financial transparency effects are not driven by a single institutional dimension.

$$T_{j,t} \equiv \text{Control of Corruption}_{j,t}$$

This approach is consistent with prior cross-country studies that rely on governance indicators when direct transparency metrics are unavailable.

4.3.3 Other Variables

To study how the sustainability penalty of carbon intensity varies across development stages and regional structures, we include a generic group indicator D_j, which is defined differently across specifications. Formally:

$$D_j \in \{\text{EMR, MENA, RR MENA}\},$$

where each definition is applied in a separate model:

$EMR_j = 1$ if country j is an *emerging or developing* economy, and 0 otherwise.

$MENA_j = 1$ if country j belongs to the Middle East and North Africa region, and 0 otherwise.

$RR\ MENA_j = 1$ if country j is a *resource-rich* MENA economy, and 0 otherwise.

Country lists for each category are provided in Appendix B.

These indicators enter the regressions via interaction and triple-interaction terms such as:

$$C_{j,t-1} \times D_j, \qquad T_{j,t-1} \times D_j, \qquad C_{j,t-1} \times T_{j,t-1} \times D_j,$$

allowing us to test whether (i) the emissions penalty differs across structural groups, (ii) financial transparency operates differently depending on development level or fossil-revenue dependence, and (iii) governance moderates carbon inefficiency more strongly in MENA and resource-rich MENA.

In accordance with the identification strategy (Section 5), all right-hand-side variables enter with a one-year lag: $C_{j,t-1}$, $T_{j,t-1}$, and their interactions. This isolates predetermined carbon intensity and governance characteristics from contemporaneous movements in sustainability performance. Country fixed effects μ_j absorb all time-invariant heterogeneity—including baseline development status and region-specific materiality differences embedded in the LSEG PLS—while year fixed effects τ_t absorb common global shocks such as energy price cycles and reporting reforms. Summary statistics for main variables are provided in Table 1.

Table 1. Summary Statistics

Variable	N	mean	sd	min	max	p1	p99
G_{jt} (%)	1,822	-1.01	12.71	-35.50	21.90	-31.75	17.98
$\Delta^5 G_{jt}$ (%)	1,442	0.75	2.99	-9.90	10.40	-6.20	7.66
$\text{CO2/GDP}^{(10k)}_{j,t}$	1,822	2.32	1.35	0.38	9.49	0.53	6.64
CO2 per capita$_{j,t}$	1,822	7.78	7.30	0.06	56.07	0.14	42.37
Regulatory Quality$_{j,t}$ (0-100)	1,746	64.47	26.91	0.48	100.00	1.93	100.00
Control of Corruption$_{j,t}$ (0-100)	1,746	59.80	29.15	0.00	100.00	2.86	100.00

4.4 Descriptive evidence

The summary statistics in Table 1 provide an initial overview of the distribution and variability of the key variables used in the analysis. The sustainability performance gap (G_{jt}) exhibits substantial dispersion, ranging from -35.5% to 21.9%, with a mean close to zero but a relatively large standard deviation, indicating pronounced cross-country heterogeneity in sustainability alignment. The five-year momentum measure shows smaller variation but still meaningful fluctuations around its mean of 0.75%. Both carbon indicators -CO_2 emissions per 10,000 USD of GDP (CO_2/GDP) and CO_2 emissions per capita- also display wide ranges, particularly per-capita emissions, which vary from near zero to more than 56 metric tons. Institutional variables exhibit similarly broad distributions, especially at the lower end, reflecting substantial differences in regulatory capacity and governance quality across countries.

The pairwise correlations reported in Table B.3 in the Appendix B reveal systematic relationships among the main variables. Sustainability performance is negatively correlated with both CO_2/GDP (-0.51) and CO_2 per capita (-0.47), indicating that countries with higher carbon intensity or higher per-capita emissions tend to show larger sustainability gaps. Institutional quality measures exhibit strong internal coherence -regulatory quality and control of corruption are highly correlated (0.92)- and both are positively associated with sustainability performance, consistent with the notion that stronger governance supports better sustainability outcomes. At the same time, correlations between momentum and other variables remain modest, suggesting that short-term changes in sustainability performance capture dynamics not mechanically tied to structural characteristics.

The descriptive time-series patterns depicted in Figure 1 reveal substantial and systematic differences across country groups in sustainability performance, carbon outcomes, and institutional quality. Advanced economies consistently display positive average sustainability gap and relatively stable sustainability momentum over time, indicating earlier and more sustained progress in the transition. By contrast, emerging markets exhibit negative sustainability gaps, accompanied by larger volatility in momentum, suggesting a more uneven adjustment process.

Clear heterogeneity also arises in carbon indicators. Advanced economies maintain the lowest levels of CO_2 emissions per 10,000 USD of GDP (CO_2/GDP) as well as lower CO_2 emissions per capita. Emerging economies, MENA, and particularly resource-rich MENA countries show substantially higher CO_2/GDP ratios and per capita emissions, with more limited reductions over time. These patterns reflect their greater dependence on carbon-intensive production structures and slower advances in decarbonization.

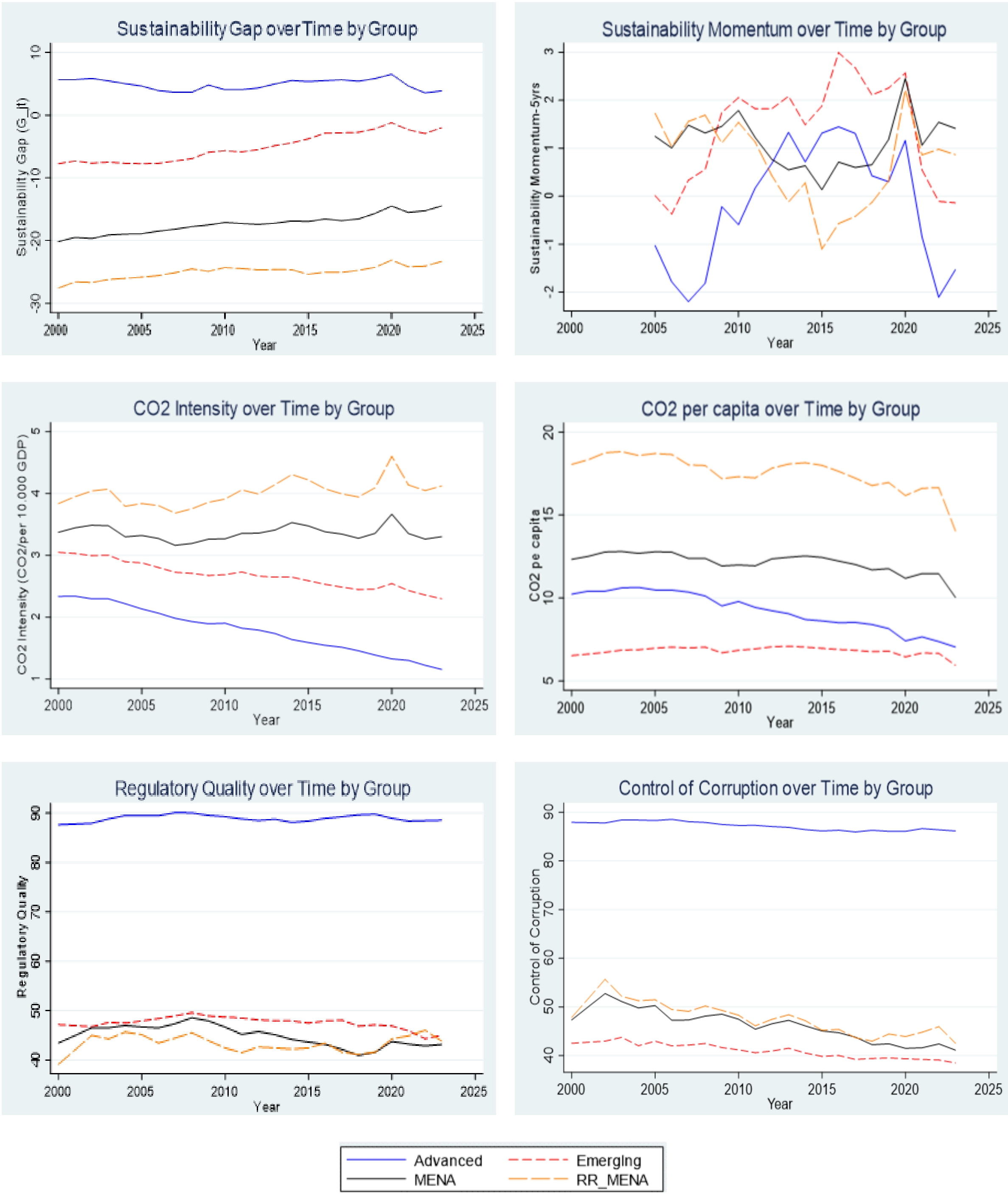
Institutional indicators further reinforce these differences. Advanced economies score consistently higher on regulatory quality and control of corruption, while MENA and resource-rich MENA countries demonstrate weaker institutional capacity and greater volatility. The alignment between institutional gaps and slower improvements in sustainability and carbon indicators suggests that institutional quality may play a critical role in shaping sustainability trajectories.

In addition, two supplementary figures are presented in the Appendix C to further illustrate cross-country heterogeneity. The first appendix figure depicts the joint distribution of fossil CO_2 emissions per capita and fossil CO_2 emissions per 10,000 USD of GDP (CO_2/GDP) for 2023. The scatter plot highlights that several resource-rich MENA economies, such as Kuwait, Qatar, Bahrain, and the United Arab Emirates, stand out with exceptionally high levels on both dimensions, reflecting carbon-intensive production structures and high domestic energy use. In contrast, advanced economies generally cluster at the lower end of the CO_2/GDP axis despite higher income levels, indicating greater energy efficiency and progress in decarbonization.

The second appendix figure plots actual GDPpc against ESG performance (measured as the gap to ESG-implied GDPpc) for 2023. The distribution reveals substantial dispersion around the zero-gap benchmark. Many advanced economies—including Denmark, Switzerland, the Netherlands, and Ireland—lie above the benchmark, indicating ESG performance exceeding what would be expected given their income levels. By contrast, several MENA and emerging economies (e.g., Saudi Arabia, Oman, Bahrain, Kuwait, and Libya) fall markedly below the benchmark, signaling significant sustainability underperformance relative to their economic capacity. This additional visual evidence further supports the presence of systematic structural gaps across income groups and regions.

Overall, the descriptive evidence highlights pronounced structural divergences across country groups and provides strong motivation for the subsequent empirical analysis.

Figure 1. Variables over Time by Country Groups



5 Methodology

5.1 Rationale and endogeneity

The ESG-adjusted GDPpc performance gap G_{jt} is derived from a sustainability-consistent income level $\hat{Y}_{jt,g}^{(ESG)}$ constructed with environmental (E) and governance (G) indicators. Because variables related to CO_2 emissions, energy efficiency, and financial transparency are among hundreds of variables used in that construction, any regression of G_{jt} on carbon intensity or financial transparency may suffer from *reflection bias*: part of the correlation arises mechanically from the LSEG methodology rather than from genuine behavioral effects.

To isolate causal mechanisms, we use three complementary identification devices:

1. Temporal separation: all explanatory variables enter with a one-year lag ($t - 1$), ensuring that information used to compute G_{jt} cannot include contemporaneous regressors.
2. Fixed effects: country fixed effects μ_j absorb time-invariant heterogeneity (including group-specific PLS weights $w_{i,g}^{(q)}$); year effects τ_t capture global shocks and any method revisions common to all countries.
3. Instrumental variables (IV): exogenous financial transparency reforms and energy-market shocks provide external variation orthogonal to contemporaneous LSEG calculations.

This design allows the coefficients on emissions and financial transparency to reflect behavioral impacts on sustainability-aligned performance rather than mechanical overlap in the index construction.

5.2 Static specification

The baseline static model relates the sustainability gap G_{jt} defined in (4.2) to lagged emissions, financial transparency, and their interaction:

$$G_{jt} = \beta_0 + \beta_1 C_{j,t-1} + \beta_2 T_{j,t-1} + \beta_3 \left(C_{j,t-1} \times T_{j,t-1}\right) + \mu_j + \tau_t + \varepsilon_{jt} \qquad (5.1)$$

To examine whether financial transparency's moderating effect differs for different country groups, we estimate the following specification:

$$G_{jt} = \beta_0 + \beta_1 C_{j,t-1} + \beta_2 T_{j,t-1} + \beta_3 \left(C_{j,t-1} \times T_{j,t-1}\right) + \beta_4 \left(C_{j,t-1} \times D_j\right) + \beta_5 \left(T_{j,t-1} \times D_j\right) + \beta_6 \left(C_{j,t-1} \times T_{j,t-1} \times D_j\right) + \mu_j + \tau_t + \varepsilon_{jt} \qquad (5.2)$$

Equation (5.1) relates the sustainability performance gap to lagged carbon intensity, financial transparency, and their interaction. A negative and statistically significant β_1 indicates that higher carbon intensity imposes a sustainability penalty. Because emissions depress the ESG-consistent benchmark $\hat{Y}_{jt}^{ESG}$ more than they reduce realized income, the performance gap becomes more negative, increasing the penalty associated with carbon intensity. A positive and significant β_2 implies that financial transparency delivers a sustainability reward. Greater financial transparency strengthens the credibility, availability, and effectiveness of governance processes, raising the ESG-consistent benchmark and shifting the performance gap upward toward or above zero. The interaction coefficient β_3 captures whether financial transparency moderates the penalty imposed by carbon intensity. A positive β_3 indicates that financial transparency cushions the emissions penalty, reducing the deterioration in the gap that results from higher carbon intensity. Conversely, a negative β_3 would imply that financial transparency amplifies the emissions penalty, worsening sustainability alignment under high carbon intensity.

Equation (5.2) allows the penalty–reward dynamics to vary across country groups, denoted by D_j. These groups distinguish emerging economies, MENA economies, and resource-rich MENA economies. A significant β_4 shows that the sustainability penalty imposed by carbon intensity differs systematically across groups. A negative β_4 for a particular group indicates that emissions generate a sharper sustainability penalty in that group relative to the baseline, while a positive β_4 implies a weaker penalty. A significant β_5 indicates that the sustainability reward from financial transparency varies across country groups. A positive β_5 means financial transparency delivers a stronger reward in that group, raising the ESG-consistent benchmark more than in the baseline; a negative β_5 signals a weaker transparency-driven reward. The triple-interaction coefficient β_6 determines whether financial transparency cushions or amplifies the emissions penalty differently across groups. A positive β_6 suggests that financial transparency more effectively offsets the emissions penalty within group D_j, strengthening the resilience of ESG fundamentals to carbon intensity. A negative β_6 indicates that financial transparency is less effective in cushioning the penalty in that group, possibly reflecting institutional constraints or structural weaknesses.

5.3 Five-year momentum specification

To capture the direction and speed of sustainability alignment, we estimate analogous models with the five-year momentum defined in (4.3) as the dependent variable:

$$\Delta^5 G_{jt} = \theta_0 + \theta_1 C_{j,t-1} + \theta_2 T_{j,t-1} + \theta_3 \left(C_{j,t-1} \times T_{j,t-1}\right) + \mu_j + \tau_t + u_{jt} \tag{5.3}$$

and its extended heterogeneous version,

$$\begin{aligned}\Delta^5 G_{jt} = \theta_0 + \theta_1 C_{j,t-1} + \theta_2 T_{j,t-1} + \theta_3 \left(C_{j,t-1} \times T_{j,t-1}\right) + \theta_4 \left(C_{j,t-1} \times D_j\right) \\ + \theta_5 \left(T_{j,t-1} \times D_j\right) + \theta_6 \left(C_{j,t-1} \times T_{j,t-1} \times D_j\right) + \mu_j + \tau_t + u_{jt}\end{aligned} \tag{5.4}$$

The momentum specification examines the direction and speed of sustainability alignment by modeling five-year changes in the performance gap, ΔG_{jt}. This captures whether countries are reducing a sustainability penalty, building a sustainability reward, or experiencing no meaningful convergence toward the ESG-consistent income benchmark.

A negative and statistically significant θ_1 indicates that higher carbon intensity imposes a dynamic sustainability penalty. Elevated emissions slow or reverse improvements in the performance gap because carbon-intensive production structures depress the ESG-consistent benchmark more quickly than countries can adjust their realized income. As a result, carbon intensity hinders convergence toward ESG-aligned development paths. A positive θ_2 implies that financial transparency delivers a dynamic sustainability reward. Improvements in financial transparency elevate the ESG-consistent benchmark $\hat{Y}_{jt}^{ESG}$, enabling faster reductions in the misalignment between fundamentals and realized income. Transparent, rule-based institutions therefore accelerate sustainability-enhancing adjustment processes, such as cleaner production, stronger regulatory enforcement, and more credible long-term policy frameworks. The interaction coefficient θ_3 captures whether financial transparency cushions or amplifies the dynamic emissions penalty. A positive θ_3 indicates that financial transparency softens the adverse dynamic effects of carbon intensity, mitigating the deterioration in sustainability momentum caused by emissions. A negative θ_3 would imply that weak financial transparency amplifies the dynamic penalty, limiting the ability of governance improvements to generate sustainability gains. The extended momentum specification allows these dynamic penalty–reward mechanisms to vary across structural country groups, denoted by D_j. A significant θ_4 or θ_5 indicates that the direct dynamic effects of carbon intensity or financial transparency differ systematically across emerging economies, MENA economies, or resource-rich MENA economies. The triple-interaction coefficient θ_6 determines whether financial transparency moderates the emissions penalty more or less effectively within a particular group. A positive θ_6 suggests that governance improvements in that group more effectively offset the emissions-related dynamic penalty, leading to faster convergence toward the ESG-consistent benchmark. A negative θ_6 indicates that financial transparency is less effective at cushioning emissions-related pressures or reveals deeper underlying carbon inefficiencies within the group, thereby amplifying the dynamic penalty.

5.4 Instrumental-variable strategy

Although the lag structure and fixed effects in (5.1)–(5.4) mitigate immediate simultaneity concerns, carbon intensity and institutional quality may still respond endogenously to underlying economic and policy dynamics that also influence sustainability performance. To address this concern, we estimate an instrumental-variables version of the static specification using two-stage least squares (2SLS), treating both the carbon-intensity regressor $C_{j,t-1}$, the institutional-quality measure $T_{j,t-1}$, and their interaction as potentially endogenous.

Our instrument set combines plausibly exogenous institutional and energy-related shocks. For the institutional-quality indicator $T_{j,t-1}$, we use discrete governance reforms such as the timing of Extractive Industries Transparency Initiative (EITI) accession, the first IMF Fiscal Transparency Evaluation (FTE), and the initial enactment of freedom-of-information (FOI) legislation. For carbon intensity $C_{j,t-1}$, we use shocks that shift emissions independently of contemporaneous sustainability outcomes: global fossil-fuel price changes interacted with a country's energy-import dependence, exogenous variation in renewable-resource potential (for example, hydrological inflows or wind anomalies), and exposure to the EU CBAM through the carbon content of exports. These shocks influence emissions or financial transparency, but conditional on country and year fixed effects, they are plausibly orthogonal to the LSEG sustainability-adjusted GDP benchmark $\hat{Y}_{jt}^{ESG}$. Because LSEG's adjusted income measures are constructed solely from contemporaneous ESG indicators, they do not embed information on the timing of these reforms or external energy shocks, supporting the exclusion restriction.

In the second stage, the potentially endogenous regressors are replaced by their fitted values from the first stage, yielding the IV analogue of the baseline static specification:

$$G_{jt} = \beta_0 + \beta_1 \hat{C}_{j,t-1} + \beta_2 \hat{T}_{j,t-1} + \beta_3 (\hat{C}_{j,t-1} \times \hat{T}_{j,t-1}) + \mu_j + \tau_t + \varepsilon_{jt} \quad (5.5)$$

An analogous IV formulation is estimated for the momentum outcome ΔG_{jt}, with $\hat{C}_{j,t-1}$, $\hat{T}_{j,t-1}$, and $\hat{C}_{j,t-1} \times \hat{T}_{j,t-1}$ entering exactly as in (5.3). IV versions of the heterogeneity models in (5.2) and (5.4) are also estimated. In these specifications, all interaction and triple-interaction terms involving $C_{j,t-1}$ and $T_{j,t-1}$ are replaced by their fitted counterparts from the first stage. Because the structure of these specifications follows directly from (5.2)–(5.4), they are not written out explicitly.

Instrument strength is assessed using the Kleibergen–Paap rk F-statistic, and over-identifying restrictions are evaluated using the Hansen J statistic. These diagnostics allow us to verify that the instruments are relevant and satisfy the exclusion restriction within this empirical framework.

5.5 Estimation procedure and interpretation

All models are estimated using within-country fixed-effects regressions with country-clustered robust standard errors. Step 1 constructs G_{jt} and ΔG_{jt} directly from the LSEG dataset; Step 2 lags all explanatory variables by one year; Step 3 estimates specifications (5.1)-(5.4); and Step 4 implements IV–2SLS using the instruments described above.

Interpretation focuses on the marginal effect of carbon intensity at different levels of institutional quality and across structural groups. For a generic group indicator D_j, the static marginal effect of carbon intensity is:

$$\frac{\partial G_{jt}}{\partial C_{j,t-1}} = \beta_1 + \beta_3 T_{j,t-1} + \beta_4 D_j + \beta_6 (T_{j,t-1} \times D_j),$$

evaluated at representative institutional-quality quantiles. A negative β_1 indicates that carbon intensity imposes a sustainability penalty by lowering the ESG-consistent benchmark relative to realized income. Positive coefficients β_2, β_3, and θ_2, θ_3 in the momentum model show that institutional quality delivers a sustainability reward and mitigates the emissions-related penalty. The triple-interaction terms β_6 and θ_6 capture how these moderating effects vary across structural groups (emerging economies, MENA, and resource-rich MENA).

Robustness checks include alternative measures of institutional quality (Regulatory Quality, Control of Corruption), alternative measures of carbon intensity (CO_2/GDP and CO_2 per capita), and placebo tests using future values of $C_{j,t}$ and $T_{j,t}$. All results are reported with 95 percent confidence intervals and standardized effect sizes to facilitate comparability across specifications.

6 Results and Discussion

Table 2 presents the static fixed-effects estimates using CO_2 emissions per USD 10,000 of GDP as the baseline measure of carbon intensity. Column (1) reports the specification without interaction terms, including only lagged carbon intensity and regulatory quality. Column (2) adds the emissions– financial transparency interaction. Column (3) incorporates heterogeneity for emerging markets, and Columns (4) and (5) extend the heterogeneity analysis to MENA and resource-rich MENA economies. All specifications include country and year fixed effects and use the one-year lag structure described in Section 5.

6.1 Static Effects: CO_2 Intensity per GDP

In Columns (1) and (2), the coefficient on carbon intensity becomes negative and statistically significant once the interaction with regulatory quality is included, indicating a measurable sustainability penalty associated with higher CO_2 intensity. In Column (2), the coefficient of -3.13 implies that a one standard deviation increase in CO_2 intensity equivalent to 1.35 additional tons of CO_2 per 10,000 USD of GDP) reduces the sustainability gap by about 4.2 percentage points, which corresponds to roughly one third of a standard deviation of the dependent variable. Regulatory quality enters positively, and the interaction coefficient of 0.071 indicates that financial transparency mitigates this penalty. Evaluated at the mean level of regulatory quality (64.47), the implied marginal effect of carbon intensity is -3.13 + 0.071 × 64.47 = 1.45, while at one standard deviation below the mean it remains negative at -0.47. These estimates show that the emissions penalty is sizable in low financial transparency environments and is substantially reduced, and can even reverse in sign, when regulatory quality is high.

Table 2. Static Performance Gap with $C_{j,t} \equiv$ CO2/GDP$^{(10k)}_{j,t}$ and $T_{j,t} \equiv$ Regulatory Quality$_{j,t}$

	(1)	(2)	(3)	(4)	(5)
$C_{j,t-1}$	0.123	-3.127***	4.703**	-4.837***	-5.068***
	[0.246]	[0.566]	[1.874]	[0.397]	[0.385]
$T_{j,t-1}$	0.079***	-0.101***	-0.020	-0.114***	-0.145***
	[0.016]	[0.025]	[0.048]	[0.023]	[0.020]
$C_{j,t-1} \times T_{j,t-1}$		0.071***	-0.001	0.096***	0.099***
		[0.008]	[0.021]	[0.006]	[0.006]
$C_{j,t-1} \times EMR_j$			-7.197***		
			[1.925]		
$T_{j,t-1} \times EMR_j$			0.005		
			[0.056]		
$C_{j,t-1} \times T_{j,t-1} \times EMR_j$			0.044*		
			[0.023]		
$C_{j,t-1} \times MENA_j$				3.311***	
				[0.563]	
$T_{j,t-1} \times MENA_j$				0.051	
				[0.036]	
$C_{j,t-1} \times T_{j,t-1} \times MENA_j$				-0.079***	
				[0.010]	
$C_{j,t-1} \times \text{RR MENA}_j$					3.764***
					[0.551]
$T_{j,t-1} \times \text{RR MENA}_j$					0.098**
					[0.043]
$C_{j,t-1} \times T_{j,t-1} \times \text{RR MENA}_j$					-0.081***
					[0.010]
Constant	-6.320***	3.051	-2.373	3.898***	5.718***
	[1.209]	[1.865]	[1.963]	[1.363]	[1.302]
Observations	1,670	1,670	1,670	1,670	1,670
Adjusted R-squared	0.9591	0.9653	0.9676	0.9677	0.9674
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
F	12.86	48.47	50.64	58.02	58.38

Notes: The dependent variable is the static sustainability performance gap $G_{j,t}$, expressed as a percent deviation from the ESG-implied sustainability gap (equations (4.1) and (4.2). All explanatory variables enter with a one-year lag. $C_{j,t-1}$ denotes CO_2 emissions per unit of output (tons per USD 10,000 of GDP), and $T_{j,t-1}$ denotes Regulatory Quality. Group indicators ADV_j, EMR_j, $MENA_j$, and RR MENA$_j$ are defined in Appendix B. All models include country and year fixed effects; standard errors clustered at the country level are reported in brackets. Positive coefficients indicate sustainability rewards (higher gap), while negative coefficients indicate sustainability penalties (lower gap). *** p<0.01, ** p<0.05, * p<0.10.

Column (3) introduces heterogeneity for emerging markets. The baseline marginal effect of carbon intensity is 4.703 for advanced economies, which corresponds to an increase of about 6.4 percentage points in the sustainability gap for a one standard deviation increase in CO_2 intensity. The interaction with the emerging-market indicator is -7.197, which yields a marginal effect of 4.703 - 7.197 = -2.494 for emerging economies. This reversal in sign indicates that emerging markets face a measurable sustainability penalty from higher carbon intensity, whereas non-emerging economies experience a positive association over the same range of variation.[1] The interaction between regulatory quality and the emerging indicator is small, while the triple interaction is positive and statistically significant, indicating that financial transparency reduces the emissions penalty more effectively in emerging markets than in the baseline group. Overall, the estimates reveal a clear asymmetry across development levels, with carbon intensity associated with a sustainability reward in non-emerging economies but a penalty in emerging ones.

Column (4) introduces heterogeneity for MENA economies. The baseline marginal effect of carbon intensity is -4.837, which implies a reduction of about 6.5 percentage points in the sustainability gap for a one standard deviation increase in CO_2 intensity. The interaction with the MENA indicator is 3.311, so the implied marginal effect for MENA economies is -4.837 + 3.311 = -1.526. This indicates that the emissions penalty is negative for both MENA and non-MENA economies but smaller in magnitude within MENA. The interaction between regulatory quality and the MENA indicator is small and statistically insignificant, and the triple interaction is negative and significant, which indicates that improvements in regulatory quality mitigate the emissions penalty less effectively in MENA. Taken together, the results suggest that although MENA economies face a weaker emissions penalty than the baseline group, they also exhibit weaker responsiveness to financial transparency.

Column (5) reports the heterogeneity specification for resource-rich MENA economies. The baseline marginal effect of carbon intensity is -5.068, which implies a reduction of about 6.8 percentage points in the sustainability gap for a one standard deviation increase in CO_2 intensity, equivalent to 1.35 additional tons of CO_2 per 10,000 USD of GDP. The interaction with the resource-rich indicator is 3.764, which yields a marginal effect of -5.068 + 3.764 = -1.304 for the group. This is close to the marginal effect estimated for the full MENA sample and indicates that the emissions penalty is smaller in resource-rich MENA than in non-MENA economies. The interaction between regulatory quality and the group indicator is positive and statistically significant, while the triple interaction is negative and significant, which implies that financial transparency does not meaningfully moderate the emissions penalty in resource-rich MENA. Overall, the results show that although the emissions penalty is weaker in resource-rich MENA relative to the baseline group, the region does not exhibit the transparency-based mitigation observed outside MENA.

6.2 Static Effects: CO_2 Emissions per Capita

A complementary set of estimates replaces emissions per GDP with emissions per capita in Table 3, which provides a population-scaled measure of carbon intensity and serves as a robustness check against alternative normalizations of CO_2. Unlike CO_2 per unit of output, which varies substantially with production structure and technological efficiency, CO_2 per capita evolves slowly within countries and reflects longer-run features such as energy mix, climate conditions, and consumption patterns. Because these year-to-year movements are closely tied to changes in income and aggregate energy use, the per-capita specification captures a different source of variation and can produce marginal effects that differ in sign from those in the CO_2 per GDP results. This difference in underlying variation is immediately visible in the estimates, which show markedly smaller coefficients and weaker institutional interactions.

[1] In the EMR specification, the coefficient on carbon intensity reflects the marginal effect for advanced economies because the emerging-market indicator enters only through interaction terms. The positive baseline estimate therefore corresponds to advanced economies and does not represent the effect for emerging markets.

Table 3. Static Performance Gap with $C_{j,t} \equiv$ CO2 per capita$_{j,t}$ and $T_{j,t} \equiv$ Regulatory Quality$_{j,t}$

	(1)	(2)	(3)	(4)	(5)
$C_{j,t-1}$	0.337***	0.397***	2.754***	1.009***	0.781***
	[0.058]	[0.126]	[0.546]	[0.239]	[0.235]
$T_{j,t-1}$	0.079***	0.085***	0.074	0.146***	0.098***
	[0.015]	[0.019]	[0.054]	[0.025]	[0.022]
$C_{j,t-1} \times T_{j,t-1}$		-0.001	-0.022***	-0.006**	-0.003
		[0.002]	[0.006]	[0.003]	[0.003]
$C_{j,t-1} \times EMR_j$			-2.351***		
			[0.560]		
$T_{j,t-1} \times EMR_j$			0.065		
			[0.058]		
$C_{j,t-1} \times T_{j,t-1} \times EMR_j$			0.018***		
			[0.006]		
$C_{j,t-1} \times MENA_j$				-0.867***	
				[0.279]	
$T_{j,t-1} \times MENA_j$				-0.141***	
				[0.035]	
$C_{j,t-1} \times T_{j,t-1} \times MENA_j$				0.004	
				[0.004]	
$C_{j,t-1} \times \text{RR MENA}_j$					-0.430
					[0.289]
$T_{j,t-1} \times \text{RR MENA}_j$					0.011
					[0.046]
$C_{j,t-1} \times T_{j,t-1} \times \text{RR MENA}_j$					-0.002
					[0.004]
Constant	-8.628***	-8.998***	-10.92***	-11.92***	-10.40***
	[1.094]	[1.316]	[2.109]	[1.421]	[1.403]
Observations	1,670	1,670	1,670	1,670	1,670
Adjusted R-squared	0.9603	0.9603	0.9620	0.9615	0.9609
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
F	29.12	19.62	19.01	17.77	14.60

Notes: The dependent variable is the static sustainability performance gap $G_{j,t}$, expressed as a percent deviation from the ESG-implied sustainability gap (equations (4.1) and (4.2)). All explanatory variables enter with a one-year lag. $C_{j,t-1}$ denotes tons of CO_2 emissions per capita per year, and $T_{j,t-1}$ denotes Regulatory Quality. Group indicators EMR_j, $MENA_j$, and RR MENA$_j$ are defined in Appendix B. All models include country and year fixed effects; standard errors clustered at the country level are reported in brackets. Positive coefficients indicate sustainability rewards (higher gap), while negative coefficients indicate sustainability penalties (lower gap). *** p<0.01, ** p<0.05, * p<0.10.

In Columns (1) and (2), the coefficient on per capita emissions is positive but small, which contrasts with the negative effects obtained using CO_2 per GDP. This pattern follows directly from the construction of the sustainability gap measure in Appendix A: the gap increases when actual GDPpc rises faster than ESG-implied GDPpc. Year-to-year changes in CO_2 per capita tend to coincide with periods of income growth and higher aggregate energy use rather than with shifts in carbon efficiency. For example, when a country experiences a temporary output expansion, households consume more electricity and fuel, raising CO_2 per capita slightly while actual GDPpc rises more sharply, which increases the gap. Quantitatively, a one standard deviation increase in CO_2 per capita (7.30 additional tons of CO_2 per person) raises the gap by about 2.9 percentage points in Table 3, compared with the

4.2 to 6.8 percentage point responses observed for CO_2 intensity in Table 2. The interaction between per capita emissions and regulatory quality is close to zero, consistent with the fact that per capita emissions evolve slowly and do not respond meaningfully to short-run institutional conditions.

The heterogeneity results in Columns (3) to (5) show that group-specific marginal effects under the per capita specification are uniformly small and positive, with limited variation across emerging, MENA, and resource-rich MENA economies. The implied effects range from about 0.14 to 0.40 for a one unit change in per capita emissions, which corresponds to increases of roughly 1.0 to 2.9 percentage points in the sustainability gap for a one standard deviation movement. These magnitudes are substantially smaller than those obtained with CO_2 per GDP and confirm that the per capita measure carries much weaker within-country variation. The interaction terms with regulatory quality are close to zero and mostly statistically insignificant, indicating that financial transparency does not play a systematic moderating role in this specification. This stands in contrast to the CO_2 per GDP results, where both the level effects and the financial transparency interactions varied meaningfully across country groups. Under the per capita measure, population-scaled emissions move too slowly and too uniformly across country clusters to generate strong heterogeneity patterns.

A key difference between the two emissions measures in Tables 2 and 3 is the scale and dispersion of the underlying data. CO_2 per GDP has a standard deviation of 1.35 tons per 10,000 USD of output, which reflects the relatively slow evolution of production-based carbon efficiency within countries. CO_2 per capita, by contrast, has a standard deviation of 7.30 tons per person because population-scaled emissions differ widely across countries. For example, per capita emissions exceed 25 tons in Qatar, Kuwait, and the United Arab Emirates, average about 15 to 17 tons in the United States, range between 5 and 8 tons across many EU economies, fall to 2 to 5 tons in middle-income emerging economies, and drop below 1 ton in low-income countries. This wide dispersion, combined with limited year-to-year movement within countries, explains why the marginal effects in Table 3 are smaller in magnitude and why the institutional interactions are weaker than in the CO_2 per GDP specification. The per capita measure captures a broader cross-sectional distribution driven by structural energy use and consumption patterns rather than by short-run changes in production efficiency.

6.3 Dynamic Effects: Five-Year Momentum of the Gap

The estimates in Table 4 examine whether emissions and regulatory quality predict medium-term changes in sustainability performance by replacing the level of the gap with its five-year momentum. The dependent variable is $\Delta^5 G_{jt} = G_{jt} - G_{j,t-5}$, which measures how the sustainability gap has evolved over the preceding five years. A positive value of $\Delta^5 G_{jt}$ indicates convergence toward the ESG-implied benchmark, while a negative value indicates deterioration. As reported in Table 1, the dispersion of the momentum measure is substantially smaller than that of the static gap (the standard deviation of $\Delta^5 G_{jt}$ is 2.99, compared with 12.71 for G_{jt}), reflecting the fact that countries typically adjust their sustainability position only gradually over five-year intervals. The coefficients in Table 4 therefore capture effects on the direction and speed of convergence rather than on the long-run level of the sustainability gap.

In Columns (1) and (2), the coefficient on carbon intensity is positive and statistically significant, indicating that increases in CO_2 per unit of GDP are associated with improvements in the five-year momentum of the sustainability gap. A one standard deviation increase in carbon intensity, equal to 1.35 additional tons of CO_2 per 10,000 USD of GDP, raises $\Delta^5 G_{jt}$ by about 1.1 to 2.2 percentage points. Although these effects are modest relative to the static gap estimates, they represent meaningful medium-term adjustments, given that the standard deviation of $\Delta^5 G_{jt}$ is only 2.99. Regulatory quality enters negatively in Column (1), implying that higher financial transparency is associated with slightly slower convergence when carbon intensity is not interacted, but the interaction term in Column (2) is small and statistically insignificant. Overall, the baseline estimates suggest that variations in carbon intensity have detectable but moderate effects on the pace of convergence, while financial transparency plays a limited role in shaping medium-term dynamics at the aggregate level.

Table 4. Momentum of the Gap with $C_{j,t} \equiv$ CO2/GDP$^{(10k)}_{j,t}$ and $T_{j,t} \equiv$ Regulatory Quality$_{j,t}$

	(1)	(2)	(3)	(4)	(5)
$C_{j,t-1}$	0.810***	1.607***	-0.599	1.106***	1.021**
	[0.244]	[0.405]	[1.787]	[0.419]	[0.425]
$T_{j,t-1}$	-0.030**	0.014	-0.064	0.012	-0.003
	[0.015]	[0.022]	[0.064]	[0.024]	[0.022]
$C_{j,t-1} \times T_{j,t-1}$		-0.017**	0.004	-0.012*	-0.012*
		[0.007]	[0.022]	[0.007]	[0.007]
$C_{j,t-1} \times EMR_j$			2.160		
			[1.839]		
$T_{j,t-1} \times EMR_j$			0.075		
			[0.069]		
$C_{j,t-1} \times T_{j,t-1} \times EMR_j$			-0.016		
			[0.023]		
$C_{j,t-1} \times MENA_j$				0.978	
				[0.803]	
$T_{j,t-1} \times MENA_j$				-0.016	
				[0.053]	
$C_{j,t-1} \times T_{j,t-1} \times MENA_j$				-0.004	
				[0.015]	
$C_{j,t-1} \times \text{RR MENA}_j$					1.465*
					[0.850]
$T_{j,t-1} \times \text{RR MENA}_j$					0.048
					[0.068]
$C_{j,t-1} \times T_{j,t-1} \times \text{RR MENA}_j$					-0.006
					[0.016]
Constant	0.930	-1.414	1.537	-1.146	-0.491
	[1.142]	[1.417]	[2.395]	[1.370]	[1.327]
Observations	1,290	1,290	1,290	1,290	1,290
Adjusted R-squared	0.3584	0.3623	0.3630	0.3631	0.3642
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
F	8.152	7.183	4.426	4.092	4.365

The dependent variable is the five-year momentum of the sustainability performance gap $\Delta^5 G_{j,t}$, which measures the change in the gap over the preceding five years (equation (4.3)). All explanatory variables enter with a one-year lag. $C_{j,t-1}$ denotes tons of CO_2 emissions per capita per year, and $T_{j,t-1}$ denotes Regulatory Quality. Group indicators EMR_j, $MENA_j$, and $RR\, MENA_j$ are defined in Appendix B. All models include country and year fixed effects; standard errors clustered at the country level are reported in brackets. Positive coefficients indicate improvements in sustainability momentum (faster convergence toward the ESG-implied benchmark), while negative coefficients indicate deterioration. *** p<0.01, ** p<0.05, * p<0.10.

The heterogeneity results in Columns (3) to (5) show that group-specific effects on the five-year momentum are small and exhibit limited systematic variation across emerging, MENA, and resource-rich MENA economies. The implied marginal effects of carbon intensity range from about 0.15 to 0.30 for a one unit increase in CO_2 intensity, which corresponds to changes of roughly 0.2 to 0.4 percentage points in $\Delta^5 G_{jt}$ for a one standard deviation movement. These effects are considerably smaller than those in the static specification and reflect the lower volatility of the momentum measure. The interaction terms with regulatory quality are small and mostly insignificant, indicating that financial transparency exerts little influence on medium-term convergence dynamics within any of the regional groups. Unlike the static results, where heterogeneity across development levels and regions was pronounced, the momentum specification reveals broadly similar adjustment patterns across country groups, with limited evidence that institutional differences shape the medium-term evolution of the sustainability gap.

A comparison of Tables 2 and 4 shows that the factors associated with the level of the sustainability gap are not the same as those that shape its medium-term evolution. The static specification captures persistent cross-country differences in sustainability performance, and financial transparency plays an important role in explaining these structural gaps. In contrast, year-to-year movements in regulatory quality are too small to generate systematic variation in the five-year momentum measure. The dispersion of $\Delta^5 G_{jt}$ is also much narrower than that of G_{jt}, which limits the scope for institutional variables to influence the estimated dynamics. As a result, the medium-term adjustment captured by $\Delta^5 G_{jt}$ is driven primarily by broader economic and structural forces, including growth cycles, external shocks, and technological shifts, rather than by incremental changes in institutional quality. The momentum specification therefore complements the static results by showing that financial transparency shapes persistent differences in sustainability performance but is not a strong predictor of the pace at which countries move toward or away from their ESG-implied benchmark in the medium run.

6.4 Dynamic Effects: Five-Year Momentum of CO_2 Emissions per Capita

The estimates in Table 5 examine how per-capita emissions relate to medium-term changes in sustainability performance by replacing CO_2 per GDP with CO_2 per capita in the momentum specification. As before, the dependent variable is $\Delta^5 G_{jt} = G_{jt} - G_{j,t-5}$, which measures the change in the sustainability gap over the preceding five years. Since per-capita emissions evolve slowly and display limited year-to-year variation, the coefficients in this specification capture how population-scaled energy use correlates with the direction and speed of convergence rather than with long-run structural differences. The results therefore complement those in Table 3 by examining whether per-capita emissions contain any additional information about the medium-term trajectory of sustainability performance.

In Columns (1) and (2), the coefficients on per capita emissions are small and only weakly significant, consistent with the limited within-country variation in this variable. A one standard deviation increase in CO_2 per capita, equal to 7.30 additional tons per person, raises the five-year momentum by less than one percentage point, which is modest relative to the dispersion of $\Delta^5 G_{jt}$. The interaction with regulatory quality is near zero and statistically insignificant, reflecting the fact that changes in population-scaled emissions are only loosely connected to institutional conditions. Overall, the baseline results indicate that per-capita emissions provide little information about medium-term adjustments in sustainability performance.

The heterogeneity results in Columns (3) to (5) show similarly muted patterns. The group-specific coefficients for emerging, MENA, and resource-rich MENA economies are small, statistically insignificant, and close to one another, indicating that per-capita emissions do not generate differentiated medium-term dynamics across country groups. The interactions with regulatory quality are likewise negligible. These findings parallel those in the static per-capita specification and reflect the fact that population-scaled emissions change only slowly over time, leaving little scope for regional or institutional characteristics to shape the five-year momentum of the sustainability gap.

Table 5. Momentum of the Gap with $C_{j,t} \equiv$ CO2 per capita$_{j,t}$ and $T_{j,t} \equiv$ Regulatory Quality$_{j,t}$

	(1)	(2)	(3)	(4)	(5)
$C_{j,t-1}$	0.236***	0.376**	-0.271	0.380	0.335
	[0.067]	[0.157]	[0.658]	[0.261]	[0.259]
$T_{j,t-1}$	-0.044***	-0.027	-0.077	-0.009	-0.026
	[0.015]	[0.018]	[0.070]	[0.022]	[0.019]
$C_{j,t-1} \times T_{j,t-1}$		-0.002	0.003	-0.003	-0.003
		[0.002]	[0.007]	[0.003]	[0.003]
$C_{j,t-1} \times EMR_j$			0.634		
			[0.681]		
$T_{j,t-1} \times EMR_j$			0.042		
			[0.072]		
$C_{j,t-1} \times T_{j,t-1} \times EMR_j$			-0.003		
			[0.007]		
$C_{j,t-1} \times MENA_j$				-0.067	
				[0.327]	
$T_{j,t-1} \times MENA_j$				-0.060	
				[0.042]	
$C_{j,t-1} \times T_{j,t-1} \times MENA_j$				0.003	
				[0.004]	
$C_{j,t-1} \times \text{RR MENA}_j$					0.033
					[0.338]
$T_{j,t-1} \times \text{RR MENA}_j$					-0.012
					[0.060]
$C_{j,t-1} \times T_{j,t-1} \times \text{RR MENA}_j$					0.002
					[0.004]
Constant	1.844*	0.926	3.297	0.594	1.140
	[0.981]	[1.241]	[2.730]	[1.348]	[1.325]
Observations	1,290	1,290	1,290	1,290	1,290
Adjusted R-squared	0.3596	0.3602	0.3614	0.3606	0.3597
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
F	8.964	6.599	4.128	3.843	3.589

The dependent variable is the five-year momentum of the sustainability performance gap $\Delta^5 G_{j,t}$, which measures the change in the gap over the preceding five years (equation (4.3)). All explanatory variables enter with a one-year lag. $C_{j,t-1}$ denotes tons of CO_2 emissions per capita per year, and $T_{j,t-1}$ denotes Regulatory Quality. Group indicators EMR_j, $MENA_j$, and $RR\,MENA_j$ are defined in Appendix B. All models include country and year fixed effects; standard errors clustered at the country level are reported in brackets. Positive coefficients indicate improvements in sustainability momentum (faster convergence toward the ESG-implied benchmark), while negative coefficients indicate deterioration. *** p<0.01, ** p<0.05, * p<0.10.

As a robustness check, we re-estimated all static and dynamic specifications by replacing Regulatory Quality with Control of Corruption as the institutional variable. This alternative financial transparency measure exhibits similar persistence and dispersion and yields coefficient patterns that closely parallel those reported in Tables 2 to 5. In particular, the sign and significance of the emissions coefficients are nearly identical, and the institutional interactions are qualitatively unchanged. These results indicate that the main conclusions are not sensitive to the choice of governance indicator. Full tables are reported in Appendix C.

6.5 Instrumental Variable Extension

The instrumental variable extension is currently under development. The final draft will incorporate an external instrument for carbon intensity and institutional quality to address potential endogeneity concerns. These results will be added in a subsequent version of the paper.

6.6 Regional Counterfactual Analysis: The Case of MENA

The regional patterns documented above raise a natural question: how much of MENA's weaker sustainability performance reflects its institutional environment and how much stems from deeper structural conditions. To address this, we rely on the static production-based specification in Table 2, because it captures persistent cross-country differences in sustainability performance and exhibits the only economically meaningful interaction between carbon intensity and financial transparency. In this specification, each heterogeneity column identifies the marginal effect of carbon intensity for a particular subset of countries relative to the rest of the world: emerging economies in Column (3), all MENA economies in Column (4), and resource-rich MENA economies in Column (5). The sample remains constant across columns, but the baseline against which each group is compared shifts accordingly. This setup allows us to construct counterfactual simulations that quantify how the sustainability performance of MENA and resource-rich MENA would change under alternative institutional or structural conditions observed elsewhere in the global sample.

6.6.1 Design of Counterfactuals.

The counterfactual analysis proceeds in three steps. First, we construct the marginal effects implied by the static specification in equation (5.2). The impact of carbon intensity on the sustainability gap is

$$ME_j^{(C)} = \beta_1 + \beta_3 T_j + \beta_4 D_j + \beta_6 T_j D_j,$$

while the impact of regulatory quality is

$$ME_j^{(T)} = \beta_2 + \beta_3 C_j + \beta_5 D_j + \beta_6 C_j D_j,$$

where D_j denotes the relevant group indicator. Because the sample remains constant across columns in Table 2, the "baseline" marginal effect always corresponds to non-group countries, and group-specific effects are obtained by adding the interaction coefficients.

Second, we evaluate two sets of counterfactuals. For the financial transparency channel, we hold carbon intensity fixed and replace T_j with higher transparency benchmarks drawn from the global distribution (the global mean and the advanced-country mean). The implied change in the gap is

$$\Delta G_j^{(T)} = (T_{cf} - T_j)\, ME_j^{(T)}.$$

For the structural channel, we hold regulatory quality fixed and replace C_j with the global or advanced-country mean, which yields

$$\Delta G_j^{(C)} = (C_{cf} - C_j)\, ME_j^{(C)}.$$

Third, we aggregate these changes to obtain predicted adjustments in the sustainability performance gap at the group level (MENA and resource-rich MENA) and at the individual-country level for all MENA economies. This two-channel framework decomposes MENA's sustainability performance into its institutional and structural components and quantifies the potential gains from transparency reforms and from reductions in production-based carbon intensity.

6.6.2 Institutional Counterfactuals

Table 6 reports how the sustainability gap would change if MENA countries matched two external financial transparency benchmarks. Both MENA and RR-MENA begin from low institutional quality, average transparency levels are around 44.9 and 43.4, well below the global mean of 64.5 and far from the advanced-economy level of about 88.9. Despite similar starting points, the two groups respond differently to higher financial transparency. The marginal effect of financial transparency is essentially zero for MENA (-0.0059) but meaningfully positive for RR-MENA (+0.0252), reflecting the stronger interaction between financial transparency and carbon intensity in resource-rich economies.

These elasticities determine the size of the predicted changes. MENA's average sustainability gap is -17.37 percentage points, and moving financial transparency to the global benchmark improves it by -0.12 points. The advanced benchmark yields a slightly larger improvement of -0.26 points. These effects are very small, less than 2 percent of the average MENA gap, and indicate that transparency reform, by itself, has limited ability to shift sustainability performance in non-resource-rich countries.

RR-MENA shows a somewhat larger response. The group's baseline gap is deeper (-25.06 points), and raising transparency to the global benchmark improves it by +0.53 points. Moving all the way to the advanced-country benchmark increases the gain to +1.15 points, about 5 percent of the group's baseline deficit. These adjustments remain modest in absolute size but are clearly larger than those for the rest of the region, consistent with the stronger marginal effect estimated for RR-MENA.

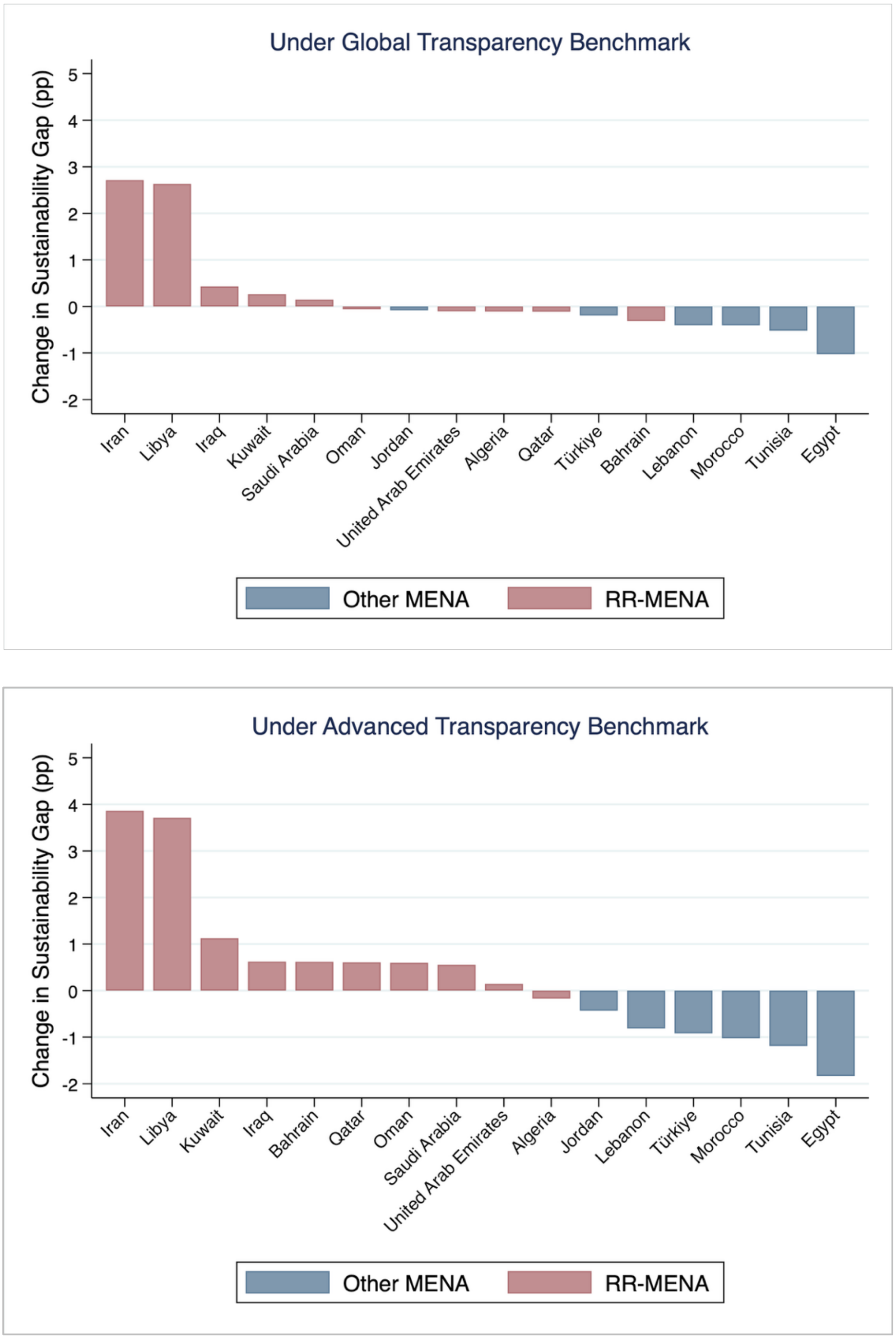
Table 6. Institutional Counterfactuals for MENA and RR-MENA

(Benchmark financial *transparency levels: Global = 64.47, Advanced = 88.98)*

	MENA	RR-MENA
Mean financial transparency $\bar{T}$	44.88	43.35
Mean carbon intensity $\bar{C}$	3.36	4.01
Marginal effect $ME^{(T)}$	–0.0059	0.0252
Baseline sustainability gap $\bar{G}$ (pp)	–17.37	–25.06
Predicted change under global benchmark $\Delta G_{\text{global}}^{(T)}$ (pp)	–0.12	+0.53
Predicted change under advanced benchmark $\Delta G_{\text{adv}}^{(T)}$ (pp)	–0.26	+1.15

Figure 2 shows how these group-level patterns translate into country-level adjustments under the global and advanced benchmarks. RR-MENA economies with both low financial transparency and higher carbon intensity record the largest predicted improvements, consistent with their marginal effect of 0.0252. Several countries in this group show positive changes under both benchmarks, with values that align closely with the group-level adjustments. In contrast, most non–RR MENA economies exhibit very small or negative predicted changes. Their marginal effect of financial transparency is −0.0059, and many already begin near the global benchmark, so raising financial transparency produces little improvement. For those starting above the benchmark, the model implies a small negative adjustment. These negative values do not represent a deterioration in sustainability fundamentals; they simply reflect alignment to a common benchmark when the estimated elasticity is close to zero. The same pattern holds under the advanced benchmark: RR-MENA shows somewhat larger gains, while predicted changes for the rest of the region remain close to zero or slightly negative.

Figure 2. Improvements under Different Financial Transparency Benchmarks



The pattern of results can also be understood through the lens of the penalty–reward interpretation of the sustainability gap. Financial transparency reforms generate only a small "reward" for most MENA economies because their estimated marginal effect is close to zero, so even large movements toward the benchmark translate into minimal changes in the gap. In RR-MENA, the marginal effect is higher, so aligning financial transparency with external benchmarks produces a somewhat larger reward, although still small relative to the depth of the initial sustainability penalty faced by the group.

6.6.3 Structural Counterfactuals

The structural counterfactuals focus on production-based carbon intensity, measured in tons of CO_2 emitted per USD 10,000 of GDP (Table 7). This metric captures how carbon-intensive a country's production structure is, rather than how much it consumes. In the MENA region, average carbon intensity is 3.36 tons per USD 10,000 of GDP for MENA and 4.01 tons for RR-MENA, compared with 2.32 for the global benchmark and 1.79 for the advanced-economy benchmark. These gaps indicate that several economies in the region produce far more CO_2 per unit of economic output than the international standards used for comparison.

The marginal effect of carbon intensity on the sustainability gap, evaluated at group-mean transparency, is −0.7631 for MENA and −0.5236 for RR-MENA. This means that a one-ton reduction in CO_2 emissions per USD 10,000 of GDP improves the sustainability gap by roughly half to three-quarters of a percentage point. Given the distance from the benchmarks, these elasticities produce moderate adjustments at the group mean. Aligning with the global benchmark improves the gap by 0.80 percentage points for MENA and 0.89 points for RR-MENA. The advanced-economy benchmark yields somewhat larger changes of 1.20 and 1.16 points. These values are larger than those in the transparency counterfactuals but remain small relative to the baseline gaps of −17.37 and −25.06 percentage points.

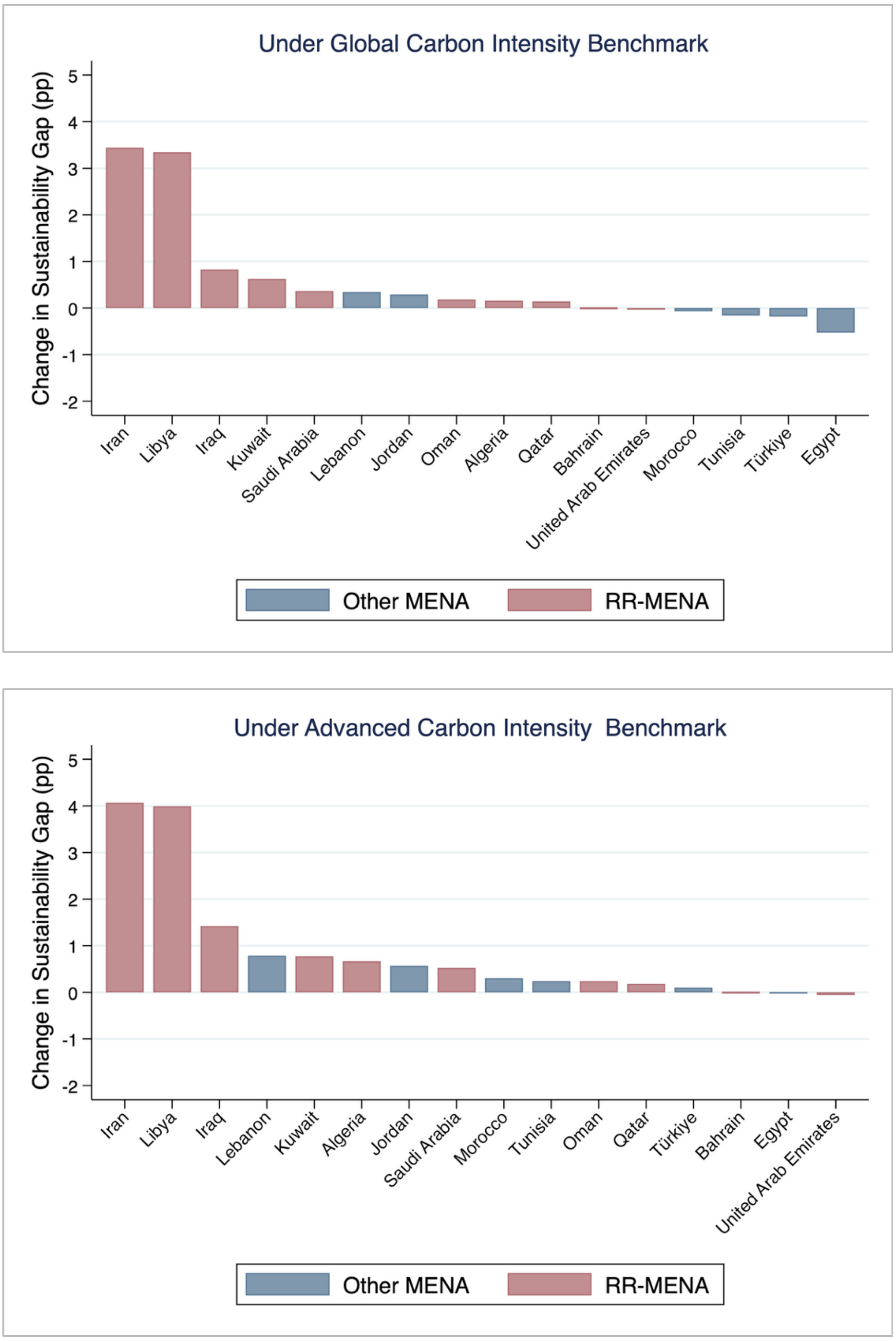
Table 7. Structural Counterfactuals for MENA and RR-MENA

(Benchmark carbon-intensity levels: Global = 2.32, Advanced = 1.79)

	MENA	RR-MENA
Mean carbon intensity $\bar{C}$	3.36	4.01
Mean financial transparency $\bar{T}$	44.88	43.35
Marginal effect $ME^{(C)}$	–0.7631	–0.5236
Baseline sustainability gap $\bar{G}$ (pp)	–17.37	–25.06
Predicted change under global benchmark $\Delta G^{(C)}_{\text{global}}$ (pp)	+0.80	+0.89
Predicted change under advanced benchmark $\Delta G^{(C)}_{\text{adv}}$ (pp)	+1.20	+1.16

The country-level patterns in Figure 3 provide a clearer view of where structural constraints are most acute. Several RR-MENA economies produce far more CO_2 per unit of output than both benchmarks and therefore exhibit the largest improvements. Iran and Libya, for example, emit more than 5 tons of CO_2 per USD 10,000 of GDP, which is more than double the global benchmark and nearly three times the advanced-economy level. For these countries, even partial convergence toward benchmark intensities produces improvements of roughly 3 to 4 percentage points in the sustainability gap. Kuwait and Iraq, with intensities above 4 tons per USD 10,000 of GDP, also show sizable improvements. These results reflect the fact that countries with very carbon-intensive production structures face the steepest sustainability penalties and therefore gain the most when intensity is reduced.

Figure 3. Improvements under Different Carbon Intensity Benchmarks



In contrast, the non–RR MENA economies lie closer to international norms. Countries such as Tunisia, Morocco, Jordan, or Turkey produce between 1.8 and 2.3 tons of CO_2 per USD 10,000 of GDP, levels already close to the global benchmark. As a result, their predicted improvements remain modest, generally below one percentage point, and often close to zero. In these cases, large reductions in the sustainability gap require structural changes beyond emissions intensity alone, such as shifts in sectoral composition, investment in cleaner technologies, or improvements in overall production efficiency.

Viewed together, the structural counterfactuals highlight an uneven distribution of sustainability penalties across the region. At the group level, the improvements from aligning carbon intensity with international benchmarks are moderate because the estimated marginal effect is limited and because group averages mask substantial heterogeneity. At the country level, however, the gains can be large, especially for economies with the highest emissions intensity. In the language of penalties and rewards, the RR-MENA economies carry the largest carbon-related penalties and therefore receive the largest potential rewards from structural decarbonization. For the rest of the region, the structural penalty is smaller, and the associated rewards from convergence toward benchmark intensities are correspondingly more limited.

7 Conclusion and Policy Implications

This paper assessed the sustainability performance of MENA economies using the sustainability gap—the deviation between actual and ESG-implied, sustainability-consistent income, which is constructed from LSEG Sovereign Sustainability Solutions. By combining production-based and consumption-adjusted CO_2 measures, institutional indicators of financial transparency, and a five-year momentum metric, the analysis provides a comprehensive evaluation of both the static level and dynamic trajectory of sustainability alignment in the region. The empirical results indicate that MENA economies carry structurally large sustainability penalties, driven overwhelmingly by high production-based carbon intensity and only weakly mitigated by existing levels of financial transparency.

A central contribution of the paper is distinguishing between production-based and per-capita (consumption-scaled) emissions. Production-based CO_2 intensity (tons of CO_2 per USD 10,000 of GDP) emerges as the key determinant of the static sustainability gap. Higher production-based intensity systematically depresses sustainability-adjusted performance, and this effect varies sharply across country groups. In non-MENA and advanced economies, transparency meaningfully cushions the emissions penalty. In contrast, in MENA, and especially in resource-rich MENA, the transparency–emissions interaction is weak: transparency does not significantly moderate the penalty, and the structural production system dominates the sustainability outcome. Per-capita emissions, by contrast, show only small effects in level regressions and virtually no relevance in dynamic specifications, reflecting their slow evolution and closer ties to income rather than to carbon efficiency. This confirms that the sustainability gap responds primarily to production-side carbon inefficiency rather than to household or consumption-based emissions.

The five-year momentum analysis offers complementary insights. Contrary to the static specification, where both emissions and transparency display strong heterogeneity, the medium-term adjustment of the sustainability gap shows limited responsiveness to institutional variables. Carbon intensity influences the direction of adjustment, but its effects are modest. Transparency provides little predictive power for the pace of sustainability convergence. The dynamics therefore reflect slow-moving structural and macroeconomic forces rather than year-to-year changes in governance. Together, these findings indicate that transparency shapes the long-run level of sustainability performance but is not a reliable predictor of short-run adjustment speed.

The counterfactuals reinforce this interpretation. Institutional counterfactuals show that aligning MENA and resource-rich MENA economies with global or advanced-country transparency benchmarks yields only minor improvements, typically below one percentage point for MENA and one to one-and-a-half points for resource-rich MENA. These gains are small relative to the baseline gaps of -17 to -25 percentage points, and confirm that transparency reform, while valuable, is not a high-elasticity lever in the region. Structural counterfactuals, in contrast, reveal substantial heterogeneity: although group-level improvements remain modest, several resource-rich economies with exceptionally high production-based carbon intensities would gain 3–4 percentage points in sustainability performance from convergence toward global benchmarks. These country-level improvements highlight the sharply nonlinear nature of structural penalties and rewards in carbon-intensive production systems.

Taken together, the findings generate three policy implications.

First, financial transparency reforms are necessary but not powerful enough to materially reduce the region's sustainability penalty on their own. They improve credibility, reduce information frictions, and facilitate access to ESG-linked financing, but their direct influence on sustainability-aligned income remains weak in MENA and nearly absent in resource-rich MENA. Transparency therefore functions as an enabling condition rather than a transformative lever.

Second, meaningful reductions in sustainability penalties require structural transformation of the region's production systems. Reducing carbon intensity (through energy-efficiency upgrades, subsidy reform, modernization of electricity generation, expanded renewable capacity, and diversification away from hydrocarbon-based production) is the only channel with high elasticity in MENA. For the most carbon-intensive producers, structural reform yields much larger returns than governance reform.

Third, the momentum analysis highlights the slow pace of sustainability adjustment. Emissions-intensive production structures and institutional inertia generate gradual convergence toward ESG-consistent income rather than rapid shifts. This underscores the importance of sustained policy commitment, consistent regulatory frameworks, and long-term investment horizons in decarbonization and institutional modernization.

Overall, the region's sustainability trajectory depends on the interaction of governance quality and structural transformation, but these two channels operate at different strengths. Governance reforms enhance the credibility and feasibility of transition policies, while structural reforms determine the magnitude of achievable sustainability rewards. For MENA economies—and especially for resource-rich ones—the central policy priority is therefore to align financial transparency improvements with decisive reforms that directly reduce production-based carbon intensity.

Finally, the empirical results open several avenues for future research. The institutional contingency of emissions penalties suggests potential implications for sovereign risk pricing through bond spreads and CDS markets. The growing reach of carbon border adjustment mechanisms may amplify the joint effects of high emissions and weak transparency on trade-related carbon costs. At the micro level, linking national governance and emissions patterns to firm-level transition risk would deepen understanding of how structural and institutional factors jointly influence sustainability performance and climate-economy dynamics.

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Appendix A. Formal Reconstruction of the LSEG *ESG Factor-In* Methodology

This appendix presents a systematic reconstruction of the methodology developed by LSEG Sovereign Sustainability Solutions (2025). While the original technical documentation offers a comprehensive overview, the exposition relies on descriptive rather than formal notation. For clarity and replicability, we restate the main equations and assumptions in standard economic notation and sequence. This reconstruction does not modify or reinterpret the original methodology but systematically presents its logic as a multi-step empirical framework linking ESG indicators to GDPpc through income-group–specific partial least squares (PLS) regressions, non-parametric expectations, and global normalization. The goal is to assist researchers in applying, comparing, and extending the approach in cross-country sustainability analysis.

A.1. Framework and notation

Let j denote a country, t a year, i an ESG indicator, $q \in \{E, S, G\}$ a sustainability pillar, and g an income-group classification (low, lower-middle, upper-middle, high non-OECD, high OECD). All variables are expressed in per-capita terms, and income (GDPpc) is measured in PPP-adjusted U.S. dollars.

$$\begin{aligned} Y_{jt} &= \text{actual GDPpc (PPP)}, \\ X_{ijt} &= \text{value of ESG indicator } i \text{ for country } j \text{ in year } t. \end{aligned} \quad \text{(A.1)}$$

The methodology constructs, for each country, a sustainability-consistent level of income, denoted $\hat{Y}_{jt,g}^{(q)}$, and two composite outcomes: (1) a normalized ESG score, and (2) a performance gap relative to peers at comparable income levels.

A.2. Income-group–specific estimation

Because the relationship between income and ESG indicators is non-linear, countries are partitioned into income groups g. Within each group, a PLS regression is estimated separately for each pillar q:

$$\hat{Y}_{jt,g}^{(q)} = \alpha_{g,q} + \sum_{i \in q} w_{i,g}^{(q)} X_{ijt}, \quad \text{(A.2)}$$

where $w_{i,g}^{(q)}$ are *materiality weights* indicating the contribution of indicator i to explaining cross-country variation in GDPpc within group g. Low-income groups exhibit high weights for infrastructure and health indicators (e.g., access to electricity, infant mortality); middle-income groups for education and digital access; and high-income groups for innovation, energy efficiency, and governance. The PLS stage is predictive rather than causal and identifies which ESG variables co-vary with income among peers.

A.3. Expected indicator values and performance

To benchmark each indicator against income, a *locally weighted regression* (LOESS) of each X_{ijt} on GDPpc Y_{jt} is estimated:

$$\tilde{X}_i^{\text{exp}}(Y_{jt}) = f_i(Y_{jt}), \quad \text{(A.3)}$$

where $f_i(\cdot)$ is a non-parametric function describing the expected level of indicator i at income Y_{jt}.

For indicators displaying an inverted-U pattern (e.g., *Voice and Accountability*), the curve is flattened beyond its turning point $Y^*_{i,\max}$ to avoid predicting declines in performance at very high incomes:

$$\tilde{X}_i^{\text{exp}}(Y_{jt}) = \begin{cases} f_i(Y_{jt}), & Y_{jt} \leq Y^*_{i,\max}, \\ f_i(Y^*_{i,\max}), & Y_{jt} > Y^*_{i,\max}. \end{cases} \qquad \text{(A.4)}$$

Monotonic indicators such as energy efficiency retain the unadjusted LOESS function. The indicator-level deviation from expectation is computed as:

$$\text{Perf}^{(i)}_{ijt} = \frac{X_{ijt} - \tilde{X}_i^{\text{exp}}(Y_{jt})}{\tilde{X}_i^{\text{exp}}(Y_{jt})}. \qquad \text{(A.5)}$$

Positive values denote above-expected performance relative to peers; negative values indicate under-performance.

A.4. Construction of sustainable GDPpc

The income level statistically consistent with a country's ESG profile is reconstructed using the PLS coefficients from (A.1):

$$\hat{Y}^{(q)}_{jt,g} = \alpha_{g,q} + \sum_{i \in q} w^{(q)}_{i,g} X_{ijt}, \qquad \text{(A.6)}$$

and combined across pillars to obtain the composite ESG value:

$$\hat{Y}^{(ESG)}_{jt,g} = \frac{1}{3}\left(\hat{Y}^{(E)}_{jt,g} + \hat{Y}^{(S)}_{jt,g} + \hat{Y}^{(G)}_{jt,g}\right). \qquad \text{(A.7)}$$

Both quantities are expressed in PPP-adjusted U.S. dollars per capita, matching the scale of Y_{jt}. Economically, $\hat{Y}^{(ESG)}_{jt,g}$ represents the level of income implied by the country's ESG structure, conditional on the within-group relationship between ESG indicators and income.

A.5. Performance accentuation

An optional performance accentuation allows stronger weighting of relative over- or under-performance. Let ρ denote the exogenous exponent ($\rho = 0$ yields no amplification, $\rho = 1$ proportional adjustment, and $\rho > 1$ accentuates deviations), distinct from the income-group index g:

$$\hat{Y}^{\text{adj}}_{jt,q} = \hat{Y}^{(q)}_{jt,g} \, (1 + \text{Perf}^{(q)}_{jt})^{\rho}. \qquad \text{(A.8)}$$

A.6. Global normalization of scores

For each pillar q, adjusted sustainable incomes are globally normalized on a 0–100 scale:

$$\text{Score}_{j,q} = \frac{\log(\hat{Y}^{\text{adj}}_{j,q}) - \min_p[\log(\hat{Y}^{\text{adj}}_{p,q})]}{\max_p[\log(\hat{Y}^{\text{adj}}_{p,q})] - \min_p[\log(\hat{Y}^{\text{adj}}_{p,q})]} \times 100. \qquad \text{(A.9)}$$

The minimum and maximum are taken across all countries p, ensuring that the highest adjusted GDPpc corresponds to 100 and the lowest to 0 for each pillar. The logarithmic transformation reduces skewness and compresses extreme income differences. While normalization is global, each $\hat{Y}_{j,q}^{\text{adj}}$ originates from a group-specific regression (A.1)–(A.6). Scores are therefore comparable numerically across countries, but their underlying indicator weights differ by income group.

A useful intuition may help clarify the distinction between the *score* and the *performance gap*. One can think of the score as analogous to a runner's predicted marathon finishing time based on training fundamentals and physiological capacity; it reflects an absolute level of sustainability-adjusted development relative to all other countries. The performance gap introduced in the next section then captures whether a country runs faster or slower than that predicted time. Countries with positive gaps have ESG fundamentals that exceed what is reflected in their realized income ("ahead of peers"), whereas negative gaps indicate realized outcomes above ESG-implied fundamentals ("behind peers").

A.7. Performance gap

The performance gap measures the percentage difference between sustainable and actual income:

$$\text{Perf}_{jt}^{(ESG)} = \frac{\hat{Y}_{jt}^{(ESG)} - Y_{jt}}{Y_{jt}}. \qquad \text{(A.10)}$$

It can be interpreted naturally through a penalty–reward lens. The benchmark $\hat{Y}_{jt}^{ESG}$ represents the level of income that would be statistically consistent with a country's ESG fundamentals. The gap therefore summarizes whether realized income is above or below this sustainability-consistent benchmark.

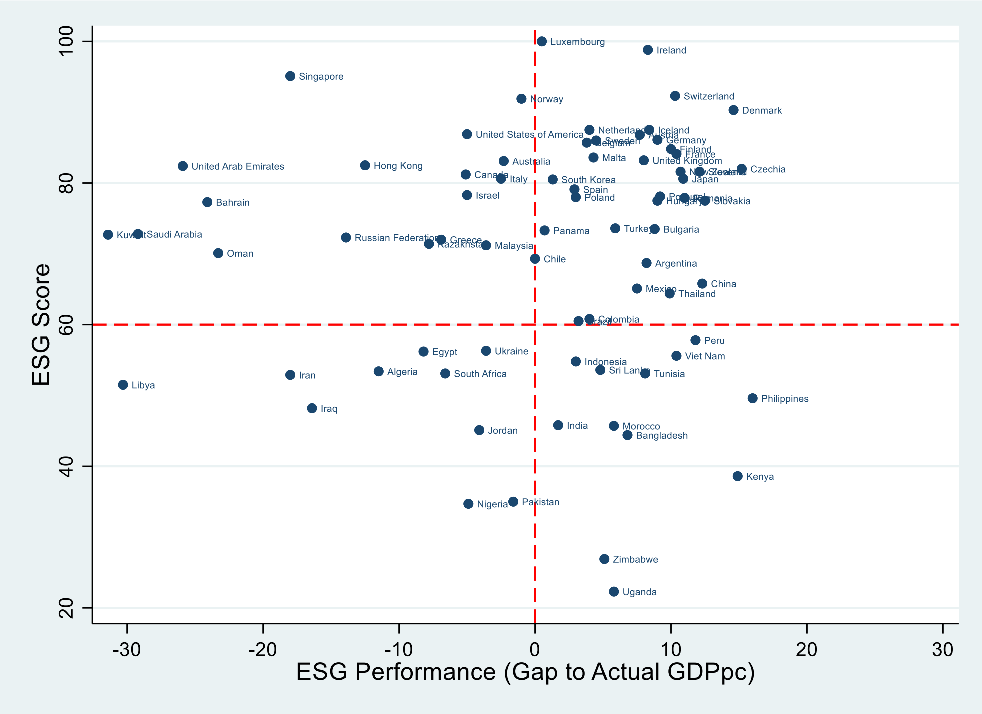
A **sustainability reward** corresponds to a positive gap $\left(\text{Perf}_{jt}^{(ESG)} > 0\right)$. In this case, ESG fundamentals exceed what is reflected in realized income: the country possesses unused ESG capacity and is "ahead of peers" in fundamentals relative to economic outcomes. A larger positive gap indicates a stronger reward.

A **sustainability penalty** corresponds to a negative gap $\left(\text{Perf}_{jt}^{(ESG)} < 0\right)$, indicating that realized income exceeds ESG-implied fundamentals. The country is "behind peers," relying on income levels that are not supported by its ESG foundations. A more negative gap reflects a larger penalty.

Determinants that raise $\hat{Y}_{jt}^{ESG}$ (e.g., transparency) deliver a sustainability reward; determinants that reduce $\hat{Y}_{jt}^{ESG}$ (e.g., carbon intensity) impose a sustainability penalty. Interaction terms capture whether one determinant cushions or amplifies the penalty imposed by another.

This penalty–reward interpretation aligns naturally with the two-dimensional sustainability space in Figure A.1, which plots the ESG Score against the sustainability performance gap. The resulting quadrants offer an intuitive diagnostic of countries' sustainability positions. Countries with a high Score and high performance gap receive both an absolute sustainability reward (a high level of ESG-implied income) and a relative reward (unused ESG capacity), reflecting ESG leaders. High-Score but low-gap countries are high-income economies with weaker ESG momentum, consistent with "complacent developed" profiles. Low-Score but high-gap countries represent emerging reformers whose ESG fundamentals exceed what is reflected in their current income, placing them in the "catch-up performer" category. Finally, low-Score, low-gap countries accumulate both an absolute and a relative sustainability penalty, indicative of laggards with weak ESG alignment. The quadrant structure therefore provides a coherent summary of how absolute sustainability levels and relative sustainability performance jointly position countries in the global ESG landscape.

Figure A.1 Relationship between ESG Score and Performance Gap



A.8. Comparability and interpretation

Both measures are dimensionless and allow cross-country analysis:

- *Score* (0–100)*:* globally normalized; comparable in scale but based on group-specific models.
- *Performance Gap (%):* directly comparable across countries; always interpreted relative to each country's own wealth level.

For empirical applications, global rankings can be complemented with within-group percentiles to account for differences in indicator materiality across income groups.

A.9. Summary of steps

1. Estimate income-group–specific PLS weights $w_{i,g}^{(q)}$ (A.1).
2. Compute expected indicator values via LOESS and deviations (A.2)-(A.4).
3. Derive sustainable GDPpc and composite ESG value (A.5)-(A.6).
4. Apply performance accentuation if desired (A.7).
5. Normalize globally to a 0–100 scale (A.8).
6. Compute the relative performance gap (A.9).

Appendix B. Variables

Table B.1. Definition of Variables

Variable Type& Name	Definition & Source
Dependent Variables	
Static sustainability performance gap	Global Sustainable GDP gap compared to reported GDP (%). This is an efficiency metric that makes countries comparable whatever their positioning in the development pathway. A positive (resp. Negative) figure means that the country has a better (resp. worse) than expected ESG level. (Source: LSEG-Sovereign Sustainability Data- https://www.lseg.com/en/data-analytics/sustainable-finance/sovereign-climate-data#overview)
Five-year momentum of the sustainability performance gap	Global Sustainable gap compared to reported GDP/5 years variation. It reflects the momentum in the country's efficiency.(Source: LSEG-Sovereign Sustainability Data (https://www.lseg.com/en/data-analytics/sustainable-finance/sovereign-climate-data#overview)
Carbon Intensity Variables	
$CO2/GDP_{j,t}^{(10k)}$	fossil_CO2_per_GDP_by_country values in GHG_per_GDP_by_country sheet are expressed in t CO2eq/kUSD/yr-Converted to CO2eq/10kUSD/yr for presentation purposes. (Source: EDGAR_2024_GHG_booklet_2024_fossilCO2only)
CO2 per capita	GHG emissions in the EDGAR Database include CO2 (fossil only), CH4, N2O and F-gases. They are aggregated using Global Warming Potential values from IPCC AR5 (GWP-100 AR5).Values in GHG_per_capita_by_country sheet are expressed in t CO2eq/cap/yr (Source: EDGAR-) EDGAR_2024_GHG_booklet_2024)
Financial Transparency / Institutional-Quality Variables	
Regulatory Quality	Regulatory Quality: Percentile Rank. Regulatory quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.(Source: WGI)
Control of Corruption	Control of Corruption: Percentile Rank. Control of corruption captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests. (Source: WGI)
Other Control Variables	
EMER	1 if country j is an emerging or developing economy, and 0 otherwise.
MENA	1 if country j belongs to the Middle East and North Africa region, and 0 otherwise.
RR MENA	1 if country j is a resource-rich MENA economy, and 0 otherwise.

Notes: Table describes the variables used in the study.

Table B.2. Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) sustainability performance gap	1.00					
(2) Five-year momentum of sustainability performance gap	0.02	1.00				
(3) CO_2 emissions per capita	-0.47	-0.11	1.00			
(4) CO_2 emissions per GDP	-0.51	0.02	0.47	1.00		
(5) Regulatory Quality	0.37	-0.26	0.32	-0.29	1.00	
(6) Control of Corruption	0.28	-0.27	0.39	-0.22	0.92	1.00

Table B.3. Countries by Development Level

Advanced Countries (31 Countries)		
Australia	Iceland	Portugal
Austria	Ireland	Singapore
Belgium	Israel	Slovakia
Canada	Italy	Slovenia
Czechia	Japan	South Korea
Denmark	Luxembourg	Spain
Finland	Malta	Sweden
France	Netherlands	Switzerland
Germany	New Zealand	United Kingdom
Greece	Norway	United States
Hong Kong		

Emerging Countries (45 Countries)		
Resource Rich MENA (10 Countries)	**Emerging Excl. MENA (29 Countries)**	
Algeria	Argentina	Pakistan
Bahrain	Bangladesh	Panama
Iran	Brazil	Peru
Iraq	Bulgaria	Philippines
Kuwait	Chile	Poland
Libya	China	Romania
Oman	Colombia	Russian Federation
Qatar	Hungary	South Africa
Saudi Arabia	India	Sri Lanka
United Arab Emirates	Indonesia	Thailand
	Kazakhstan	Uganda
Other MENA	Kenya	Ukraine
Egypt	Malaysia	Viet Nam
Jordan	Mexico	Zimbabwe
Lebanon	Nigeria	
Morocco		
Tunisia		
Turkey		

Note: Table presents countries by country group. We identify the advanced countries based on IMF classification[2].

[2] https://www.imf.org/en/Publications/WEO/weo-database/2023/April/groups-and-aggregates#ae

Appendix C. Additional Descriptive Figures

Figure C.1. Per Capita Carbon Emissions and Carbon Intensity of GDP (2023)

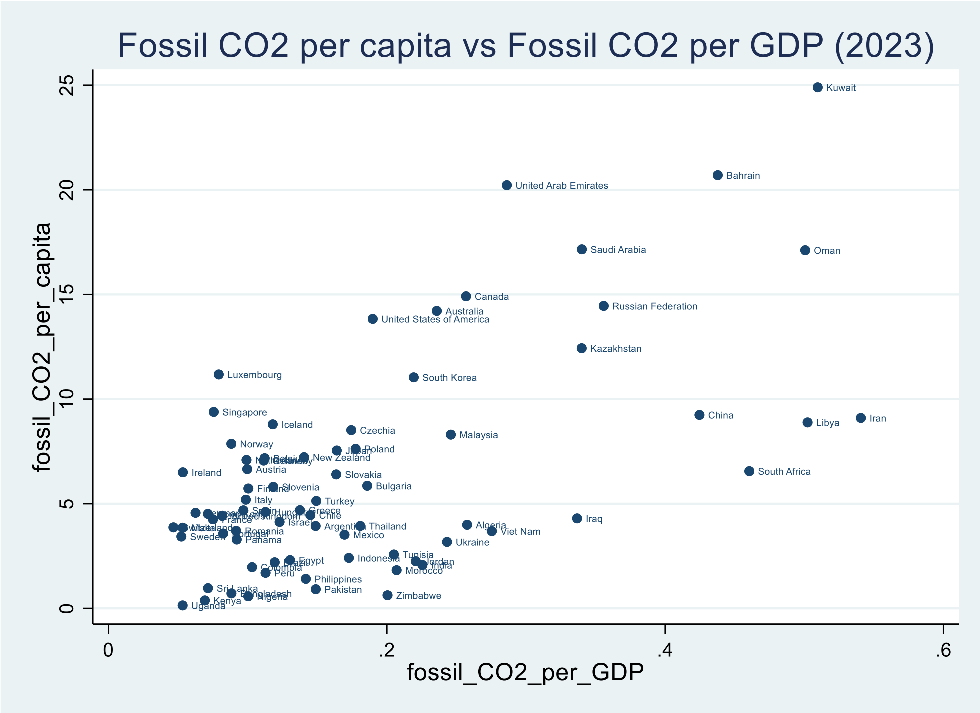
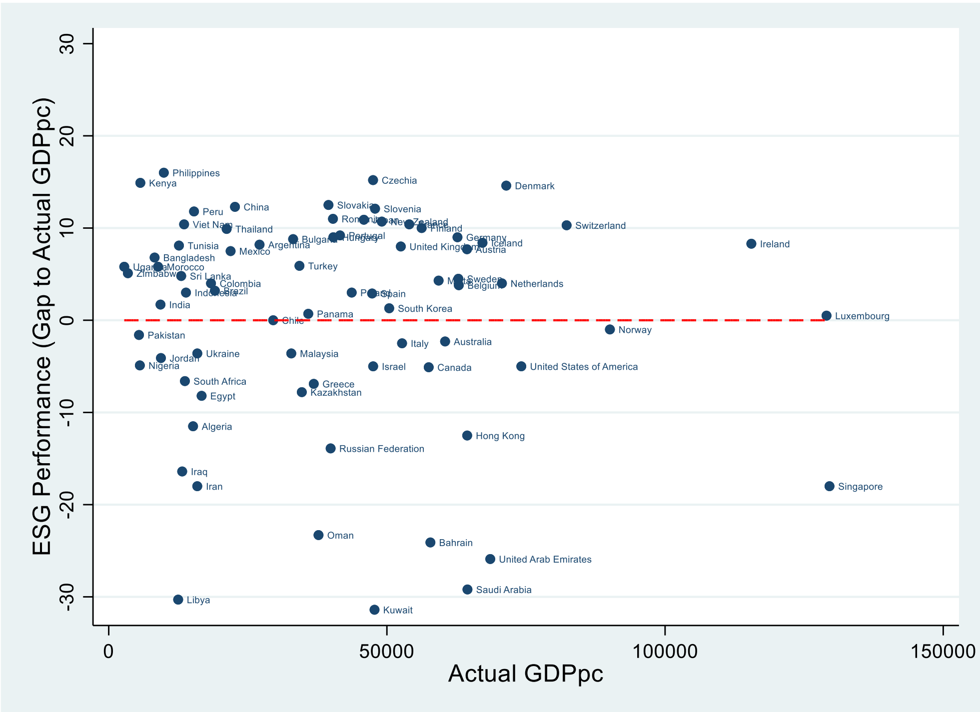


Figure C.2. ESG Performance vs. Actual GDPpc (2023)



Appendix D. Robustness

Table D.1. Robustness-Static Performance Gap with $C_{j,t} \equiv$ CO2/GDP$^{(10k)}_{j,t}$ and $T_{j,t} \equiv$ Control of Corruption$_{j,t}$

	(1)	(2)	(3)	(4)	(5)
$C_{j,t-1}$	0.322	-2.023***	5.099***	-2.626***	-2.786***
	[0.243]	[0.260]	[1.464]	[0.226]	[0.223]
$T_{j,t-1}$	0.113***	-0.072***	0.073**	-0.069***	-0.089***
	[0.014]	[0.017]	[0.036]	[0.019]	[0.017]
$C_{j,t-1} \times T_{j,t-1}$		0.065***	-0.004	0.082***	0.083***
		[0.004]	[0.017]	[0.004]	[0.004]
$C_{j,t-1} \times EMR_j$			-7.076***		
			[1.483]		
$T_{j,t-1} \times EMR_j$			-0.101**		
			[0.042]		
$C_{j,t-1} \times T_{j,t-1} \times EMR_j$			0.050***		
			[0.018]		
$C_{j,t-1} \times MENA_j$				1.220***	
				[0.445]	
$T_{j,t-1} \times MENA_j$				0.067*	
				[0.037]	
$C_{j,t-1} \times T_{j,t-1} \times MENA_j$				-0.063***	
				[0.008]	
$C_{j,t-1} \times \text{RR MENA}_j$					1.666***
					[0.468]
$T_{j,t-1} \times \text{RR MENA}_j$					0.109**
					[0.046]
$C_{j,t-1} \times T_{j,t-1} \times \text{RR MENA}_j$					-0.066***
					[0.009]
Constant	-8.388***	-0.386	-6.311***	-0.800	0.126
	[1.076]	[1.134]	[1.405]	[1.011]	[0.991]
Observations	1,670	1,670	1,670	1,670	1,670
Adjusted R-squared	0.9603	0.9668	0.9687	0.9690	0.9685
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
F	33.28	100	78.54	102.5	103.6

Notes: The dependent variable is the static sustainability performance gap $G_{j,t}$, expressed as a percent deviation from the ESG-implied sustainability gap (equations (4.1) and (4.2). All explanatory variables enter with a one-year lag. $C_{j,t-1}$ denotes CO_2 emissions per unit of output (tons per USD 10,000 of GDP), and $T_{j,t-1}$ denotes Control of Corruption. Group indicators ADV_j, EMR_j, $MENA_j$, and RR MENA$_j$ are defined in Appendix B. All models include country and year fixed effects; standard errors clustered at the country level are reported in brackets. Positive coefficients indicate sustainability rewards (higher gap), while negative coefficients indicate sustainability penalties (lower gap). *** p<0.01, ** p<0.05, * p<0.10.

Table D.2. Robustness-Static Performance Gap with $C_{j,t}$ ≡ CO2 per capita$_{j,t}$ and $T_{j,t}$ ≡ Control of Corruption$_{j,t}$

	(1)	(2)	(3)	(4)	(5)
$C_{j,t-1}$	0.334***	0.174	1.604***	0.209	0.102
	[0.055]	[0.121]	[0.507]	[0.203]	[0.201]
$T_{j,t-1}$	0.107***	0.091***	0.187***	0.114***	0.088***
	[0.013]	[0.017]	[0.049]	[0.020]	[0.018]
$C_{j,t-1} \times T_{j,t-1}$		0.002	-0.011**	0.004*	0.006**
		[0.001]	[0.005]	[0.002]	[0.002]
$C_{j,t-1} \times EMR_j$			-1.505***		
			[0.522]		
$T_{j,t-1} \times EMR_j$			-0.086*		
			[0.052]		
$C_{j,t-1} \times T_{j,t-1} \times EMR_j$			0.012**		
			[0.006]		
$C_{j,t-1} \times MENA_j$				-0.350	
				[0.251]	
$T_{j,t-1} \times MENA_j$				-0.102***	
				[0.035]	
$C_{j,t-1} \times T_{j,t-1} \times MENA_j$				-0.001	
				[0.003]	
$C_{j,t-1} \times \text{RR MENA}_j$					-0.025
					[0.282]
$T_{j,t-1} \times \text{RR MENA}_j$					-0.006
					[0.052]
$C_{j,t-1} \times T_{j,t-1} \times \text{RR MENA}_j$					-0.005
					[0.004]
Constant	-9.948***	-8.981***	-12.958***	-9.651***	-9.200***
	[0.912]	[1.124]	[1.881]	[1.120]	[1.142]
Observations	1,670	1,670	1,670	1,670	1,670
Adjusted R-squared	0.9614	0.9614	0.9619	0.9624	0.9621
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
F	50.59	33.50	19.87	23.23	21.60

Notes: The dependent variable is the static sustainability performance gap $G_{j,t}$, expressed as a percent deviation from the ESG-implied sustainability gap (equations (4.1) and (4.2)). All explanatory variables enter with a one-year lag. $C_{j,t-1}$ denotes tons of CO_2 emissions per capita per year, and $T_{j,t-1}$ denotes Control of Corruption. Group indicators EMR_j, $MENA_j$, and RR MENA$_j$ are defined in Appendix B. All models include country and year fixed effects; standard errors clustered at the country level are reported in brackets. Positive coefficients indicate sustainability rewards (higher gap), while negative coefficients indicate sustainability penalties (lower gap). *** p<0.01, ** p<0.05, * p<0.10.

Table D.3. Robustness- Momentum of the Gap with $C_{j,t} \equiv \text{CO2/GDP}^{(10k)}_{j,t}$ and $T_{j,t} \equiv \text{Control of Corruption}_{j,t}$

	(1)	(2)	(3)	(4)	(5)
$C_{j,t-1}$	0.790***	1.272***	-0.388	1.115***	1.075***
	[0.244]	[0.312]	[1.225]	[0.300]	[0.301]
$T_{j,t-1}$	-0.033**	0.002	-0.039	0.023	0.020
	[0.015]	[0.020]	[0.050]	[0.020]	[0.019]
$C_{j,t-1} \times T_{j,t-1}$		-0.013**	0.002	-0.017***	-0.018***
		[0.005]	[0.016]	[0.005]	[0.005]
$C_{j,t-1} \times EMR_j$			1.645		
			[1.270]		
$T_{j,t-1} \times EMR_j$			0.030		
			[0.057]		
$C_{j,t-1} \times T_{j,t-1} \times EMR_j$			-0.009		
			[0.017]		
$C_{j,t-1} \times MENA_j$				0.207	
				[0.836]	
$T_{j,t-1} \times MENA_j$				-0.100*	
				[0.058]	
$C_{j,t-1} \times T_{j,t-1} \times MENA_j$				0.022	
				[0.014]	
$C_{j,t-1} \times \text{RR MENA}_j$					0.227
					[0.946]
$T_{j,t-1} \times \text{RR MENA}_j$					-0.127*
					[0.075]
$C_{j,t-1} \times T_{j,t-1} \times \text{RR MENA}_j$					0.029*
					[0.016]
Constant	1.009	-0.547	1.213	-0.663	-0.424
	[1.157]	[1.271]	[1.854]	[1.219]	[1.207]
Observations	1,290	1,290	1,290	1,290	1,290
Adjusted R-squared	0.3590	0.3619	0.3625	0.3661	0.3682
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
F	9.010	7.676	4.571	5.675	6.034

The dependent variable is the five-year momentum of the sustainability performance gap $\Delta^5 G_{j,t}$, which measures the change in the gap over the preceding five years (equation (4.3)). All explanatory variables enter with a one-year lag. $C_{j,t-1}$ denotes tons of CO_2 emissions per capita per year, and $T_{j,t-1}$ denotes Control of Corruption. Group indicators EMR_j, $MENA_j$, and $RR\ MENA_j$ are defined in Appendix B. All models include country and year fixed effects; standard errors clustered at the country level are reported in brackets. Positive coefficients indicate improvements in sustainability momentum (faster convergence toward the ESG-implied benchmark), while negative coefficients indicate deterioration. *** p<0.01, ** p<0.05, * p<0.10.

Table D.4. Robustness-Momentum of the Gap with $C_{j,t} \equiv$ CO2 per capita$_{j,t}$ and $T_{j,t} \equiv$ Control of Corruption$_{j,t}$

	(1)	(2)	(3)	(4)	(5)
$C_{j,t-1}$	0.222***	0.406***	0.250	0.550**	0.553**
	[0.066]	[0.134]	[0.594]	[0.227]	[0.225]
$T_{j,t-1}$	-0.042***	-0.021	-0.028	-0.000	-0.003
	[0.015]	[0.017]	[0.062]	[0.018]	[0.018]
$C_{j,t-1} \times T_{j,t-1}$		-0.003	-0.003	-0.006**	-0.006**
		[0.002]	[0.007]	[0.003]	[0.003]
$C_{j,t-1} \times EMR_j$			0.170		
			[0.609]		
$T_{j,t-1} \times EMR_j$			-0.002		
			[0.065]		
$C_{j,t-1} \times T_{j,t-1} \times EMR_j$			0.002		
			[0.007]		
$C_{j,t-1} \times MENA_j$				-0.284	
				[0.297]	
$T_{j,t-1} \times MENA_j$				-0.080*	
				[0.047]	
$C_{j,t-1} \times T_{j,t-1} \times MENA_j$				0.007*	
				[0.004]	
$C_{j,t-1} \times \text{RR MENA}_j$					-0.417
					[0.330]
$T_{j,t-1} \times \text{RR MENA}_j$					-0.128*
					[0.069]
$C_{j,t-1} \times T_{j,t-1} \times \text{RR MENA}_j$					0.009**
					[0.004]
Constant	1.661	0.551	1.375	0.458	0.680
	[1.032]	[1.166]	[2.347]	[1.134]	[1.169]
Observations	1,290	1,290	1,290	1,290	1,290
Adjusted R-squared	0.3596	0.3610	0.3626	0.3633	0.3644
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
F	9.876	7.312	4.594	4.592	4.806

The dependent variable is the five-year momentum of the sustainability performance gap $\Delta^5 G_{j,t}$, which measures the change in the gap over the preceding five years (equation (4.3)). All explanatory variables enter with a one-year lag. $C_{j,t-1}$ denotes tons of CO_2 emissions per capita per year, and $T_{j,t-1}$ denotes Control of Corruption. Group indicators EMR_j, $MENA_j$, and $RR\,MENA_j$ are defined in Appendix B. All models include country and year fixed effects; standard errors clustered at the country level are reported in brackets. Positive coefficients indicate improvements in sustainability momentum (faster convergence toward the ESG-implied benchmark), while negative coefficients indicate deterioration. *** p<0.01, ** p<0.05, * p<0.10.