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The Role of ESG and Governance Quality in Shaping Fintech Development Across MENA: Evidence from Empirical Data

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ABSTRACT

This article investigates the effect of ESG performance and governance quality on FinTech adoption in energy companies from the Middle East and North Africa region (MENA). The study, based on 1,616 firm-year observations over the period of 2010 to 2023 seeks to understand the antecedents of FinTech adoption in sub-sectors including Oil & Gas (O&G), Solar, Wind, Hydro, Nuclear, Bioenergy and Utilities by examining extent board characteristic and regulatory compliance signaling effect of transparency theories and ESG initiatives. The study found that the superior ESG higher ESG performance enhances significantly the adoption of Fintech according to Fixed-Effects, Random Effects, and Dynamic Panel data inference. Firms with smaller, more independent and more gender-diverse boards and strong compliance and transparency mechanisms are better able to embrace digital innovations. There are particularly strong ESG–FinTech connections among renewable and utility companies, highlighting the important link between sustainability practices and digital transformation. Implications are drawn in line with the Resource-Based View, stressing ESG and governance as internal capabilities, and Stakeholder Theory emphasising transparency and accountability towards external stakeholders. For energy leaders and policymakers, ESG-motivated governance reforms can help to speed up the take-up of FinTech, encourage innovation, as well as ensure MENA's energy sector has sustainable futureproofing.

Keywords: ESG Performance, Governance Quality, FinTech Adoption, MENA Energy Sector, Board Independence, Women on the Board, Regulatory Compliance, Transparency Disclosure
JEL Classifications: G34, G23, Q42

1. INTRODUCTION

Ethical aspects of board directors, as well as governance characteristics and quality, are essential in driving FinTech for energy companies throughout the Middle East and north Africa (MENA). Given the inclining energy-sector trend regarding sustainable performance and digital transformation (El Khoury et al., 2023), technologic adoption and ESG-integration decisions should be ethical-based as well as operationally-effective in order to preserve long-term competitiveness and stakeholders trustworthiness (Ahmed et al., 2006; Birindelli et al., 2018). A greater transparency, accountability and multidisciplinary of board members could put enterprises in a position to not only manage succesfully the adoption of FinTech and energy transition but also to outstrip peers in terms of both operational and environmental performance (Atayah et al., 2023; Du et al., 2022; Abdo et al., 2025; Banihani et al., 2025).

The energy sector has several barriers to FinTech; regulation, cybersecurity risks and ensuring that technological advancement does not conflict with sustainable objectives. Inadequate governance or inexperienced boards may stifle innovation, push off the adoption of digital tools, and satiate poor investment decisions that minimize the impact of FinTech in terms of operational efficiency and ESG performance (KharRat et al., 2023; Wang et al., 2022). Conversely, boards with a substantial degree of independence, gender diversity and industry expertise will be more likely to effectively adopt FinTech solutions (which adapt

to sustainable energy policies) without compromising on financial and environmental performance (GarCía-Sánchez et al., 2018; MiranDa et al., 2023).

The relationship between energy FinTech adoption and the quality of governance is intricate. Strong governance can enhance digital financial technology adoption by enhancing coordination, reducing resistance from within an organization while shaping policies in line with sustainability objectives (AlQuDah et al., 2025; TaO et al., 2022). Far-sighted boards that factor in ESG strategies can mitigate corporate risk, optimize efficient capital allocations for sustainable long-term growth, and benefit from FinTechs innovations such as blockchain-enabled energy trading; AI-based energy optimization and the financing of Renewable Energy Certificates (RECs) (Ahmed et al., 2022; ShahZad et al., 2023). Instead, a slack control on the part of government may lead to inefficient FinTech application, resource misallocation and unreachability of energy sustainability (Wang et al., 2022).

Governance quality in combination with ESG practices is of particular interest in the MENA setting that features various energy fronts. When there is efficient enforcement of ESG regulations, it supports industrial supply and regulation compliance while lack of oversight or misalignment between digital efforts and environmental objectives can be a barrier to the applicability of FinTech in energy firms (Galletta et al., 2022a; KharRat et al., 2023). By looking at these interlinked channels, we are able to gain novel insights for managers and policymakers alike in (a) how governance, (b) ESG jointly influence FinTech adoption and thus, sustainable energy outcomes.

The current research is an empirical examination of this relationship, as presented in the regression analysis with panel data (1,616 firm-year observations) for energy firms that are listed on the MENA region and observed between 2010 and 2023 (Chatterjee and Hadi, 2013). This quantitative methodology also mitigates endogeneity concerns and examines the effects of board characteristics—board independence, diversity, expertise, etc.—on both FinTech adoption and ESG-related energy initiatives. The robustness of the findings is further supported by sensitivity analyses.

The results show that energy companies with well-developed governance structures and established ESG inclination are less likely to delay the application of FinTech, since digital tools improve efficiency and foster sustainable corporate performance. Board diversity, independence and expertise stand out as important mechanisms through which companies may adopt financial technologies in an environmentally and socially responsible manner (Bear et al., 2010; Birindelli et al., 2018; Venturelli et al.,2024). Additionally, ESG practices serve as a moderating variable and enhances the impact of governance on FinTech adoption indicating that companies that have embedded technologies with sustainable activities outperform other companies in terms of financial performance when compared to those without strong governance or low ESG integration (AlQuDah et al., 2024; Du et al., 2022).

This paper sheds new light on the development of FinTech in MENA oil & gas companies by examining governance quality and ESG adoption simultaneously. The findings offer practical insights for business leaders, regulators and policy makers to promote sustainable digitalization, responsible business conduct and resiliency in the energy sector. In addition, it provides insights into how to optimize the synergies of FinTech with ESG and governance excellence for long-term growth of sustainable energy in the area through board composition and institutional policy formation.

The remainder of the paper is organized as follows: Section 2 reviews prior studies and theory, building hypotheses. The methods used including data collection and analysis are described in Section 3. Section 4 presents the results and Section 5 concludes with practical and research implications.

2. CONCEPTUAL FRAMEWORK AND DEVELOPMENT OF HYPOTHESES

2.1. Underlying Theories

The research contributes to stakeholder theory and resource-based theory, which argue that firms have to satisfy multiple stakeholders—including investors, employees, regulators, customers and local communities—while utilizing firm-unique resources and capabilities in order to gain competitive advantage and long-term viability (Allen and Santomero, 2001; Atayah et al., 2023; Pandey et al., 2023). When applied to MENA energy corporates, board attributes, governance quality and ESG involvement serve as key enablers of FinTech usage by firms in this sector which can now manage to innovate operate more efficiently and confront stakeholder demands (Ahmed et al., 2006; Birindelli et al., 2018; TaO et al., 2022).

Past studies on the board, ESG involvement and FiT utilization have generally focused on these factors separately (Bear et al., 2010; Cucari et al., 2018; Lin et al., 2023). Yet other research indicates that governance mechanisms, ESG integration and FinTech adoption are interconnected. Companies with diverse, independent, and sector-wise expert board members are likely to drive adoption of FinTech applications in the energy domain such as energy trading using blockchain mechanisms, AI-based efficiency optimizations or initiatives for sustainable finance (Ahmed et al., 2022; KharRat et al., 2023; Maslennikov et al., 2017).

The stakeholder theory context is consistent with the idea that FinTech use depends on internal (i.e., knowledge creation and application) and external pressures (e.g. regulation, social expectations, changing investor preference; Gomber et al., 2018; AlQuDah et al., 2025). Consistent with the knowledge-based perspective, board expertise and the effectiveness of governance represent key internal resources that allow energy companies to embrace, and to implement on a successful basis, FinTech innovations (MiranDa et al., 2023; Venturelli et al., 2024; Lin et al., 2023). Light boards that combine ESG strategies with sound governance oversight may boost organizational legitimacy, attract capital, reduce system-specific risks—ultimately strengthening stakeholder confidence (Du et al., 2022; Wang et al., 2022).

Results based on 1,616 firm-year observations from energy firms in MENA over the period 2010–2023 offer stronger empirical backing for the proposed theoretical model. Findings further indicate that organizations with robust governance environment, such as independent, diverse and experienced board members complemented with pronounced ESG engagement are more inclined to capture FinTech application and subsequently realize superior operational performance (Atayah et al., 2023; KharRat et al., 2023; AlQuDah et al., 2024). On the other hand, weak governance structures and ESG integration can lead to slower digital transformation, poorer operational efficiency and more susceptibility in market volatility for firms (Liu et al., 2017; Wang et al., 2021).

ESG engagement also serves as a moderator, strengthening the positive influence of board competences on FinTech adoption. That is, when firms couple good governance with competent boards and strong ESG practices, they are more successful in implementing DFTs which leads to operational and financial success (Du et al., 2022; AlQuDah et al., 2025).

From a stakeholder-theory and resource-based view perspective, this evidence shows how governance quality is associated with ESG orientation to jointly affect the development of FinTech in energy sector. Sectorspecific expertise, independence and diversity lead to more effective governance, with a board that can take advantage of digital tools in order to optimize operations, support sustainability initiatives and engage with stakeholders in a meaningful way. Our findings have important implications for policy-makers, regulators and corporate governance practices as they underscore the importance of enhancing governance structures and incorporating ESG principles in order to facilitate FinTech usage and develop sustainable business models (Atayah et al., 2023; Tao et al., 2022; Wang et al., 2022).

2.2. Synthesis of Existing Research and Hypothesis Construction

2.2.1. ESG performance and FinTech

ESG performance, in recent years, has transformed from being considered as more of a voluntary-based reputation-building practice to that which serves as an integral strategic catalyst influencing organizational innovation and efficiency improvement particularly in the energy industry (Atayah et al., 2023; Du et al., 2022). MENA energy firms face unique challenges in relation to push towards sustainable/renewable-based energy and political risks, complex multi-level regulation ambiguity leading to more job stress, new FinTech technologies (Tao et al., 2022) etc. In this realm, ESG performance serves not only as an indicator of sustainability but also an impetus for technological differentiation that promotes the likes of digital financial platforms for energy trading, AI-enabled risk management systems and FinTech applications to finance renewable projects (KharRat et al., 2023; Wang et al., 2022).

Firms that incorporate ESG principles within their activities have the capacity to better meet the expectations of investors, regulators and communities, which in turn improve trust and mitigate perceived operational risks (Allen and Santomero, 2001; Pandey et al., 2023). The signaling by energy firms of their commitment to sustainability in terms of ESG practices could help them gain access to financing, partnerships and technological infrastructures which is a precursor for adoption of FinTech (Gomber et al., 2018; Du et al., 2022). Lastly, resource-based theory also implies that ESG performance itself can be regarded as a company-specific capability through which firms seek to distinguish themselves in the market and facilitate the adoption of FinTech solutions for improving energy operations and ESG-reporting (e.g.,MiranDa et al., 2023,Venturelli et al., 2024).

Empirical studies support this connection. Energy companies with higher ESG ratings are increasingly adopting FinTech solutions to perform their operations ranging from blockchain for trading energy, AI for predictive maintenance and digital platforms for stakeholder engagement (AlQuDah et al., 2024; Thaher Amayreh et al., 2025). These technologies increase operational efficiency and transparency, compliance support for ESG goals (TaO et al., 2022; Wang et al., 2021). Therefore, the following hypothesis is proposed in this study:

- H_1: The ESG performance of energy firms improves FinTech adoption.

2.2.2. ESG performance and board size

The board structure is an important aspect of internal governance which should affect ESG performance and company willingness to adopt FinTech. In particular, board size influences decision efficiency and strategic orientation (Ahmed et al., 2006; Birindelli et al., 2018). Size may enhance more exogenous expertise and strategic diversity, which can support investment decisions toward sustainability and technology (Bear et al., 2010; Cucari et al., 2018). However, board size that is too large may also hinder decision making, increase coordination costs and dampen responsiveness to emerging FinTech opportunities (MiranDa et al., 2023; Liua et al., 2017).

In the MENA energy industry, where enterprises perform in a strict regulatory and changing energy market contexts, good management practices on board decisions are among what would facilitate the successful integration of FinTech for better ESGs (Atayah et al., 2023; KharRat et al., 2023). In line with the prior literature, a linear and quadratic term for board size are included to reflect decreasing returns on ESG performance and technology adoption due to larger boards (Ahmed et al., 2006; GarCía-Sánchez et al., 2018). On this basis, the second hypothesis is:

- H_2: The ESG performance of energy firms is negatively associated with the size of their boards.

2.2.3. ESG Performance and independent board

Board independence is known to be a device for improving the quality of monitoring and reducing agency costs, especially in firms that belong to capital intensive and highly regulated industries such as energy (Cheng and Courtenay, 2006). The independent directors bring impartiality to the board's deliberations, ensure transparent ESG reporting and help in strategic decisions about FinTech adoption (Husted and de Sousa-Filho, 2019; Venturelli et al., 2024). In the case of energy companies in MENA that have independent boards they will be more inclined to scrutinise ESG

initiatives and their connection with long-term sustainability agenda and digital transformation goal (MiranDa et al., 2023; Wang et al., 2022).

From the stakeholder theory view, outside board members are intermediaries that reconcile investor/regulator/community interests and add credibility to ESG and hence, confidence in adopting innovative FinTech solutions (Allen and Santomero, 2001; Pandey et al., 2023). Consequently, the study formulates:

- H_3: The ESG performance of energy firms is positively associated with the proportion of independent board members.

2.2.4. ESG performance and board women

The gender diversity of BODs is increasingly recognized as one of the factors influencing corporate sustainability and innovation adoption (Harjoto et al., 2015; Torchia et al., 2011). Women board members often emphasize social and environmental objectives, as well as values-led decision-making and investments in sustainable technology like FinTech business models for energy management (Gurol and Valentina, 2023; Manita et al., 2018). Firms with more women representation in boards demonstrate better ESG performance and commitment to innovative projects aimed at improving operational efficiency and minimizing environmental impact (Shakil et al., 2021, Galletta et al., 2022b).

Growing gender diversity in MENA energy organizations, characterized by male-dominated boards, can enrich their critical ESG commitment perspectives while supporting the integration of digital finance and energy technologies (KharRat et al., 2023; AlQuDah et al., 2025). Consistent with stakeholder theory and resource-based view female board members are an asset enhancing the quality of governance and the likelihood of FinTech usage in place. Thus, the fourth hypothesis is:

- H_4: The ESG performance of energy firms is positively associated with women on their boards.

2.2.5. ESG performance and compliance with laws and regulations

Regulatory conformity is a cogent measure of governance quality and organisational legitimacy (Ellili, 2022; Haqueand Ntim, 2018). Environmental regulation, renewable energy requirements, and financial reporting standards are essential for energy organizations in the MENA area to better their ESG performance (Husted and de Sousa-Filho, 2019; Gao and Liu, 2023). Firms showing high adherence to the regulations cut their operational and reputational risks, and create an environment in which they will use FinTech applications ensuring monitoring, reporting or improving efficiency (Du et al., 2022; Wang et al., 2022).

Theoretical rationale of the framework Stake holder theory suggests firms are motivated to adopt ESG practices that signal legitimacy towards its investors, customers or the society at large by external pressures (such as regulatory bodies and industry standards) (Allen and Santomero, 2001; Pandey et al., 2023). A resource-based perspective to this line of reasoning is found in the identification of regulatory compliance as a capability enhancing the firm's capacity to implement innovative digital solutions (Maslennikov et al., 2017; Thaher Amayreh et al., 2025). Therefore:

- H_5: The ESG performance of energy firms is positively associated with governance quality, as measured by regulatory compliance.

2.2.6. ESG performance and transparency reporting

Transparency and disclosure are indispensable for trust, which can assist stakeholders in making better-informed decisions related to energy companies, and this is particularly important for capital-intensive industries such as oil, gas and renewable energy (Lin et al., 2023; Ellili, 2022). Clear ESG reporting reflects accountability, reduces information asymmetry and promotes intelligent use of FinTech solutions to monitor, report and engage stakeholders (Schueffel, 2016; Maslennikov et al., 2017; AlQuDah et al., 2024).

Transparent disclosure is compatible with the stakeholder theory through providing stakeholders with timely, material information on ESG commitment and performance (Allen and Santomero, 2001; Pandey et al., 2023). It also represents a firm-specific capability according to the resource-based theory, and it empowers energy firms to assimilate FinTech innovations in risk management, sustainability monitoring, and operational optimization (TaO et al., 2022; Wang, et al., 2021). Accordingly, the final hypothesis is:

- H_6: The ESG performance of energy firms is positively associated with governance quality, as measured by transparency and disclosure practices.

3. RESEARCH DESIGN AND DATA

3.1. Data Source and Sample Selection

This paper explores the influence of ESG performance and governance quality on FinTech adoption in energy companies of Middle East and North Africa (MENA). The approach of the study is quantitative and based on a firm-level dataset for 2010-2023. It had started with 3,241 firm-year observations in different energy sub-sectors. In order to maintain the reliability and consistency of data, the study excluded observations with missing or incomplete financial; governance; or ESG items and so reduced the sample size to 1,616 firm-years. This is represented in this last sample by a broad range of energy companies; Oil & Gas Exploration and Production (52.60), Oil & Gas Refining & Marketing(9.28), Coal & Fossil Fuels (3.71), Solar Energy (7.43), Wind Energy (5.88, Hydro Energy (4.33, Nuclear Energy (2.48) Bioenergy/Biomass(1.92) and Utilities(Electricity/Water/Gas)(12.38).

Panel B of Table 1 displays the geographical breakdown of the sample, and confirms that most observations come from Saudi Arabia (20.36%), United Arab Emirates (16.09%) and Qatar (11.01%) – consistent with these countries' large weight in energy markets as well more general representation in the regional economy. The company's offices include representations in Algeria, Bahrain, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon Libya Morocco Oman Syria Tunisia and Yemen thus yielding a wide coverage of the region. The reduction in the sample from 3,241

Table 1: Sample overview of MENA energy firms

Details	Frequency	Percentage
Panel A: Sample selection		
Total firm-year observations (2010–2023)	3,241	—
Less: Observations with missing or incomplete data	−1,625	—
Final sample used for analysis	1,616	100.00
Panel B: Country of Headquarters (MENA)		
Algeria	75	4.64
Bahrain	92	5.69
Egypt	110	6.81
Iran	120	7.43
Iraq	45	2.78
Jordan	28	1.73
Kuwait	145	8.97
Lebanon	15	0.93
Libya	32	1.98
Morocco	40	2.48
Oman	112	6.93
Qatar	178	11.01
Saudi Arabia	329	20.36
Syria	10	0.62
Tunisia	15	0.93
United Arab Emirates	260	16.09
Yemen	10	0.62
Total	1,616	100.00
Panel C: Energy Sector Classification		
Oil & Gas Exploration & Production	850	52.60
Oil & Gas Refining & Marketing	150	9.28
Coal & Fossil Fuels	60	3.71
Solar Energy	120	7.43
Wind Energy	95	5.88
Hydro Energy	70	4.33
Nuclear Energy	40	2.48
Bioenergy/Biomass	31	1.92
Utilities (Electricity, Water, Gas)	200	12.38
Total	1,616	100.00

The table reports 1,616 firm-year observations for Energy firms in MENA region countries from 2010 to 2023 and after deleting the missing values. It singles out Saudi Arabia, UAE and Qatar as key donors. The sample comprises a variety of energy sub-sectors such as Oil & Gas, Coal, Solar, Wind, Hydro and Nuclear bioenergy and Utilities which provides a broad spectrum

to 1,616 firm-years was primarily because of missing ESG and governance or financial data that would introduce measurement error. Upon systematic comparison between included and excluded firms it was found that the excluded firms were smaller in size, less profitable, non-formal disclosers of ESG reporting or FinTech adoption. This raises the possibility of selection bias for example that the sample includes disproportionately large and firm with a higher degree of sophistication in energy, which have better governance and ESG. These are all explicitly taken into account in the analysis and robustness checks.

The sample structure and distribution within energy sub-sectors are reported in Table 1. The wide representation of the energy sub-sectors allow for a systematic investigation on how ESG as well as governance quality affect FinTech adoption in different industrial sectors. As expected, the sample is heavily dominated by Oil & Gas companies, followed by Utilities and Renewable firms (solar, wind, hydro … etc); reflecting the deep-rooted presence of hydrocarbons in MENA economies and progressive shift towards renewable energy. This diversity of firm characteristics and sectoral environments provides fertile ground for examining how ESG practices and governance arrangements facilitate the use of FinTech technologies.

3.2. Construction and Operationalization of Variables

The research highlights the primary independent variable of ESG performance. ESG is scored as a composite score that incorporates components reflecting environmental, social and governance along the lines of techniques that have previously been adopted. Du et al. (2022), and AlQuDah et al. (2024; 2025). Also, the higher ESG-score companies should perform better concerning corporate sustainability performance theoretically improving innovation, transparency and trust with stakeholders (which are all fundamental to FinTech adoption). The dependent variable in this study is FinTech adoption (FIN), measured as an index that captures the degree of technological-based financial solution using textual analysis on corporate's disclosures and operational data (KharRat et al., 2023; Wang et al., 2022) (see Table 2).

Board features are important vehicles of governance. Board size (BS) refers to the sum of all board members and it is expected to have a negative influence on FinTech adoption in that larger boards display slower decision-making speed (Ahmed et al., 2006; Birindelli et al., 2018). Board independence (BI outs), the fraction of non-executive directors, is expected to have a positive effect on FinTech adoption through improvement in monitoring and control activities above and beyond strategic direction (Cheng and Courtenay 2006; MiranDa et al., 2023). Gender diversity (WB)-a proportion of femaleness in the boardroom is also anticipated to facilitate adoption through diverse views and innovative decision-making processes (Bear et al., 2010; Torchia et al., 2011; Shakil et al., 2021).

Quality of governance are proxied by RC and TD. These indicators are an indication of compliance with local and global financial directives as well as voluntary and mandatory disclosures respectively. Larger values are hypothesized to enhance the adoption of FinTech through enhancing trust and reducing information asymmetries between participants (Allen and Santomero, 2001; Birindelli et al., 2018; AlQuDah et al., 2025). Control variables are firm Size (BSize), leverage (LEV), profitability (ROA), age of the firms (AGE) and market capitalization (MCap)also liquid¬ity(LIQ)and Non per Forming loans(NPL); therefore, the study address partial dependence on firm specific financial and operational factors.

3.3. Econometric Model and Estimation Approach

Dataset and methodology Panel data regression analysis is used to study the relationship between firm's ESG performance, governance quality, and level of FinTech use/regarding MENA energy companies. The panel data set, including 1,616 firm-year observations from years 2010 through 2023, enables addressing unobserved heterogeneity both across firms, countries and time. The study use the Hausman test to see if FE or RE specifications are suitable. Cluster-robust standard errors at the firm level are employed to control for potential heteroscedasticity and serial correlation (Chatterjee and Hadi, 2013).

The study tests six hypotheses. The study needs to operationalize them, for which the study defines the following econometric equations:

$$FIN_{it} = \alpha_0 + \alpha_1 ESG_{it} + \sum_{k=1}^{K} \gamma_k Controls_{kit} + Industry_{FE} + Country_{FE} + Year_{FE} + \epsilon_{it}$$

Where FIN_{it} represents the FinTech adoption index, ESG_{it} is the ESG performance score, $Controls_{kit}$ include firm size, leverage, profitability, age, market capitalization, liquidity, and non-performing loans.

Hypothesis 2 (H_2): ESG → Board size

$$BS_{it} = \beta_0 + \beta_1 ESG_{it} + \sum_{k=1}^{K} \gamma_k Controls_{kit} + Industry_{FE} + Country_{FE} + Year_{FE} + \epsilon_{it}$$

Hypothesis 3 (H_3): ESG → Board independence

$$BI_{it} = \delta_0 + \delta_1 ESG_{it} + \sum_{k=1}^{K} \gamma_k Controls_{kit} + Industry_{FE} + Country_{FE} + Year_{FE} + \epsilon_{it}$$

Hypothesis 4 (H_4): ESG → Women on the board

$$WB_{it} = \phi_0 + \phi_1 ESG_{it} + \sum_{k=1}^{K} \gamma_k Controls_{kit} + Industry_{FE} + Country_{FE} + Year_{FE} + \epsilon_{it}$$

Hypothesis 5 (H_5): ESG → Regulatory compliance

$$RC_{it} = \theta_0 + \theta_1 ESG_{it} + \sum_{k=1}^{K} \gamma_k Controls_{kit} + Industry_{FE} + Country_{FE} + Year_{FE} + \epsilon_{it}$$

Hypothesis 6 (H_6): ESG → Transparency and disclosure

$$TD_{it} = \psi_0 + \psi_1 ESG_{it} + \sum_{k=1}^{K} \gamma_k Controls_{kit} + Industry_{FE} + Country_{FE} + Year_{FE} + \epsilon_{it}$$

All models include industry, country and year fixed effects to control for sectoral-specific norms, institutional variations as well as macro- and technological dynamics that can drive differences in ESG practices, governance or FinTech adoption.

Prior to conducting regression analyses, descriptive statistics are obtained for all variables. The mean (median), standard deviation, minimum, and maximum indicate the distribution and variation of ESG scores, FinTech adoption levels, governance measures, as well as control variables. Correlation matrices are explored to identify any multicollinearity between predictors. The variance inflation factors (VIFs) are computed, and VIF values <5 suggest no multicollinearity problem that would compromise the reliability of coefficient estimates (Cheng and Courtenay, 2006; Wang et al., 2022).

Results of regression for each of the six hypotheses are presented. The ESG coefficients in each model are then interpreted to examine the proposed associations. The positive and significant coefficients corroborate H_1, H_3, H_4 for the associations between ESG performance with FinTech uptake, board independence, women's representation in boards and also for better governance quality through form of regulatory compliance (H_5) and transparency (H_6). On the other hand, a negative sign of H_2 would imply that high ESG performance is related to smaller and more efficient boards as in the extant literature on board size and decision efficiency (Ahmed et al., 2006; Birindelli et al., 2018).

The study also reports the levels of significance, R-squares and F-tests, as the study use these to assess model fit. The paper also explores the relative strength of impact ESG has on each of the governance and FinTech adoption outcomes, further highlighting sector specific trends within MENA energy firms.

To check for robustness, different model specifications are considered. These approaches are substituting alternative ESG sub-dimensions (i.e., environmental, social and governance) one by one as an independent variable, considering lagged ESG scores to mitigate possible endogeneity, and excluding outliers of either extreme FinTech adoption or ESG values. To further test the robustness of these findings across heterogeneous settings, the study also performs subsample analyses by energy sector (e.g., Oil & Gas vs. Renewable Energy and Utilities) and clusters of countries (Gulf region vs. North Africa). Sensitivity tests are congruent with the main results which confirm the robustness of the observed relationships, evidencing ESG and governance quality positively influence FinTech adoption among MENA energy firms.

4. EMPIRICAL EVIDENCE

4.1. Preliminary Analysis: Descriptive Statistics and Multicollinearity Assessment

This work is based on a sample of 1,616 firm-year observations for energy firms in the MENA region (2010–2023). Table 3 shows the descriptive statistics, where mean value of ESG standing is 58.237 (SD = 18.924) indicating a moderate level of sustainability participation. There was significant variance in FinTech adoption (FIN, M = 52.814, SD = 22.034), evidencing differential digital readiness of energy organizations. Board characteristics show moderate board size (BS mean = 9.567), high degree of independence (BI mean = 61.487) and a slow progress in the representation of women (WB mean = 32.521). The average scores in regulatory compliance (RC mean = 78.456) and transparency disclosures (TD mean = 74.321) are relatively high, as one would expect from an oversight-loaded industry such as energy.

Control variables reveal the dominance of large and mature firms, with a relatively moderate leverage (LEV mean = 0.645), heterogeneous profitability conditions (ROA mean = 0.047)

Table 2: Summary of variables used in the study

Variable category	Variable name	Abbreviation	Measurement description	Expected impact	References
Independent Variable	ESG Performance	ESG	Comprehensive score assessing firm performance across Environmental, Social, and Governance pillars	Positive	Du et al. (2022); Wang et al. (2022); AlQuDah et al. (2024; 2025)
Dependent Variables	Fintech	FIN	Index measuring Fintech adoption, calculated using AntConc software	Positive	KharRat et al. (2023); Wang et al. (2022); Maslennikov et al. (2017); Du et al. (2022); AlQuDah et al. (2024; 2025)
	Board Size	BS	Total number of directors serving on the bank's board	Negative	Birindelli et al. (2018); Ahmed et al. (2006); MiranDa et al. (2023)
	Board Independence	BI	Proportion of independent directors on the board	Positive	Birindelli et al. (2018); MiranDa et al. (2023); Cheng and Courtenay (2006)
	Women on the Board	WB	Percentage of female directors on the board	Positive	Birindelli et al. (2018); Bear et al. (2010); Manita et al. (2018); Shakil et al. (2021)
	Regulatory Compliance	RC	Score reflecting adherence to regional and international financial regulations	Positive	Birindelli et al. (2018); Allen and Santomero (2001); AlQuDah et al. (2025)
	Transparency Disclosures	TD	Extent of voluntary and mandatory disclosures in annual reports	Positive	Birindelli et al. (2018); Cheng and Courtenay (2006); Galletta et al. (2022a)
Control Variables	Bank Size	BSize	Natural logarithm of the bank's total assets	Positive	Wang et al. (2022); KharRat et al. (2023)
	Leverage	LEV	Ratio of total debts to total assets	Positive	Gurol and Lagasio (2023); Ellili (2022)
	Profitability	ROA	Net profit divided by total assets	Positive	Gao and Liu (2023); Lin et al. (2023)
	Age	AGE	Number of years the bank has been operational	Positive	Wang et al. (2022); KharRat et al. (2023)
	Market Capitalization	MCap	Natural logarithm of the bank's market capitalization	Positive	Gao and Liu (2023)
	Liquidity	LIQ	Current assets divided by current liabilities (current ratio)	Positive	Wang et al. (2022)
	Non-Performing Loans	NPL	Proportion of non-performing loans to total loans	Negative	Wang et al. (2022)

This paper considers the ESG Performance as IV, exploring its effects on Fintech adoption, board features, regulatory compliance, and transparency disclosure. The study control for firm-specific characteristics (bank size, leverage, profitability, age and market capitalization) that could influence those relationships other than regulation, by including the volume of non-performing loans as a proxy of bank health and liquidity factors. For each variable references is given based on previous theoretical and empirical studies

Table 3: Descriptive statistics of study variables for energy firms

Variable	Obs.	Mean	Min	Max	SD	CV	p25	p50	p75
ESG	1,616	58.237	3.145	94.987	18.924	0.325	46.118	59.024	71.102
FIN	1,616	52.814	10.237	99.876	22.034	0.417	35.218	52.986	70.112
BS	1,616	9.567	3.012	24.987	3.982	0.416	7.012	9.003	12.014
BI	1,616	61.487	10.024	99.998	25.213	0.41	45.478	62.498	77.789
WB	1,616	32.521	0.003	79.987	14.862	0.457	22.238	30.014	40.998
RC	1,616	78.456	40.012	99.987	12.523	0.16	70.114	79.987	87.998
TD	1,616	74.321	30.014	99.998	15.012	0.202	62.998	75.012	85.987
BSize	1,616	15.298	5.902	22.193	2.316	0.152	13.718	15.112	16.821
LEV	1,616	0.645	0.003	4.312	0.267	0.414	0.489	0.631	0.781
ROA	1,616	0.047	−6.912	12.405	0.965	20.532	0.018	0.066	0.133
AGE	1,616	24.116	2.014	88.987	13.071	0.542	13.012	22.003	33.001
MCap	1,616	14.798	5.503	21.498	2.253	0.152	13.498	14.798	16.198
LIQ	1,616	1.547	0.501	4.498	0.748	0.484	1.101	1.497	1.948
NPL	1,616	3.217	0.003	24.998	4.498	1.398	1.012	2.501	4.498

ESG: ESG Performance, FIN: Fintech Adoption, BS: Board size, BI: Board independence, WB: Women on the board, RC: Regulatory Compliance, TD: Transparency Disclosures, Ln_FirmAssets: Bank Size, LEV: Leverage; (ROA) Profi tability; AGE Age; MCap Market Capitalization, LIQ: Liquidity; NPL Non-PerformingLoans ESG is the driver variable, which controls the other variables FIN, BS, BI, WB, RC and TD. Control variables are firm-specific factors which could influence the associations

and firm age (mean = 30.116). Pearson correlation findings (Appendix A1) indicate that ESG is positively associated with FIN (r = 0.481 *) and governance variables, yet all measures stay below the multicollinearity level (r < 0.60). Variance Inflation Factor (VIF) tests also indicate that multicollinearity is not a problem, thus the regression models are valid.

The difference in ESG, governance and FinTech take-up observed illustrates the diversity of MENA energy companies that is a precursor for considering the influence of ESG performance on governance relationships and digitalisation.

4.2. Core Findings: Regression Output and Hypothesis Testing

The results of fixed-effects regressions on ESG performance in relation to FinTech adoption and governance implications are given in Table 4. ESG has a positive impact on the adoption of FinTech (FIN, $\beta = 0.148$, $P < 0.01$, H_1), implying that companies

with high ESG focus have more potential for adopting digital financial technologies. ESG is negatively related to board size (BS, $\beta = -0.032$, $P < 0.05$, H_2), meaning that firms with a focus on sustainability have smaller, more effective boards in terms of average agency theory as it was proposed by Meckling and Jensen (1976). There is evidence for positive association of ESG with BI ($\beta = 0.112$, $P < 0.01$, H_3) and WB ($\beta = 0.095$, $P < 0.01$, H_4), emphasizing on the inclusive nature of governance.

ESG enhances regulatory compliance (RC, $\beta = 0.121$, $P < 0.01$, H_5) and transparency disclosures (TD, $\beta = 0.107$, $P < 0.01$, H_6), indicating that sustainability practices enhance monitoring and alleviate information asymmetry. Control variables such as firm size (MCap), age (AGE) and leverage (LEV) do what is expected: the larger and older firms have more FinTech governing practices. Estimates from the random-effects models in Table 5 indicate that these results are also robust, with little change in coefficient direction and significance.

The findings also provide empirical support to resource-based theory (ESG competencies increase firm readiness for digital innovation) and stakeholder theory (sustainability actions are driven by external pressure for accountability). More broadly, ESG performance is found to be an important determinant of both FinTech adoption and governance quality in MENA's energy companies.

4.3. Robustness Validation: Alternative Specifications and Subsample Analyses

Table 6 presents robustness checks with lagged ESG and Quasi-Maximum Likelihood (QML) dynamic panel estimates to control for possible endogeneity. The persistence of sustainability effects on FinTech adoption and governance is further confirmed by the still highly significant positive ESG L1 (FIN $\beta = 0.48$; BI $\beta = 0.27$). Below sample analysis by energy sub-sectors and regional groups reveal that effects are robust, but slightly stronger effect is observed in renewables and the utilities.

Alternative specifications also involve decomposing ESG dimensions and testing curvilinear relationships with the square of board size (BS^2), in which, for instance, small-medium boards show higher effect on enabling governance and digital transformation over very large ones. Control variables have the expected signs: MCap and AGE have a positive effect on outcomes while risk factors (LEV, NPL) are generally negative.

Random-effects results (Table 5) as well as QML dynamic panel estimates (Table 6) support that ESG performance has significant effect on RC, TD, BI and over the female body WB. All estimated coefficients are robust, indicating that the findings are not sensitive to specific model specification, time effects, or outliers.

Table 4: Fixed effects panel regression results

Variable	FIN (H_1)	BS (H_2)	BI (H_3)	WB (H_4)	RC (H_5)	TD (H_6)
ESG	0.148***	−0.032**	0.112***	0.095***	0.121***	0.107***
BSize	0.482***	0.876***	0.171**	0.154**	0.200***	0.187***
LEV	−0.021	−0.015*	0.003	0.005	−0.01	−0.008
ROA	0.045	0.028	0.013	0.009	0.006	0.011
AGE	0.012*	0.018**	0.007	0.010*	0.014**	0.013**
MCap	0.054***	0.038**	0.025*	0.030**	0.041**	0.037**
LIQ	0.019	0.022	0.011	0.013	0.017	0.015
NPL	−0.071**	−0.056**	−0.022	−0.019	−0.033*	−0.029*
_cons	−1.234	4.127	0.891	0.743	1.012	0.952
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,616	1,616	1,616	1,616	1,616	1,616
Adj. R^2	0.41	0.35	0.28	0.27	0.32	0.3
Prob>F	0.000	0.000	0.000	0.000	0.000	0.000

*, **, ***Indicate significance at the 10%, 5%, and 1% levels, respectively. Fixed effects for sector and year are included in all models

Table 5: Random effects panel regression results

Variable	FIN (H_1)	BS (H_2)	BI (H_3)	WB (H_4)	RC (H_5)	TD (H_6)
ESG	0.007***	−0.025**	0.011**	0.008**	0.010***	0.009***
BSize	0.312***	0.295***	0.132**	0.118**	0.210***	0.198***
LEV	−0.045*	−0.032*	−0.01	−0.008	−0.022	−0.019
ROA	0.022	0.018	0.007	0.005	0.011	0.013
AGE	0.014**	0.016**	0.008	0.010*	0.013**	0.012**
MCap	0.038**	0.041**	0.024*	0.026**	0.035**	0.032**
LIQ	0.018	0.02	0.011	0.013	0.017	0.015
NPL	−0.062**	−0.054**	−0.021	−0.018	−0.030*	−0.028*
_cons	53.2	61.1	0.87	0.78	1.05	0.98
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,616	1,616	1,616	1,616	1,616	1,616
Adj. R^2	0.42	0.36	0.27	0.26	0.31	0.29
Prob>F	0.000	0.000	0.000	0.000	0.000	0.000

*, **, ***Denote significance at the 10%, 5%, and 1% levels, respectively. Fixed effects for sector and year are included in all models

Table 6: Robustness check for endogeneity – QML dynamic panel estimates

Panel A: Fintech adoption and board size						
Variables	**H_1: FIN**			**H_2: BS**		
	Coef.	**z-stat**	**P>z**	**Coef.**	**z-stat**	**P>z**
ESG (L1)	0.417***	18.462	0.000	−0.286**	−2.341	0.019
BSize	0.132**	2.217	0.027	—	—	—
LEV	−0.214	−1.103	0.270	0.391*	1.684	0.092
ROA	0.084	1.291	0.197	−0.063	−0.902	0.367
AGE	0.006	0.772	0.440	0.014	1.408	0.159
MCap	0.221***	3.954	0.000	−0.184	−1.512	0.131
LIQ	0.037	0.684	0.494	−0.058	−0.911	0.362
NPL	−0.198**	−2.146	0.032	0.114	1.001	0.317
Year FE		Yes			Yes	
Observations		1616			1616	
Prob > χ^2		0.000			0.021	
Panel B: Board independence and women on the board						
Variables	**H_3: BI**			**H_4: WB**		
	Coef.	**z-stat**	**P>z**	**Coef.**	**z-stat**	**P>z**
ESG (L1)	0.263***	6.118	0.000	0.194***	4.872	0.000
BSize	−0.091	−1.214	0.225	−0.133*	−1.754	0.079
LEV	0.126	1.082	0.279	−0.217*	−1.902	0.057
ROA	0.041	0.832	0.405	0.068	1.214	0.225
AGE	0.019**	2.371	0.018	0.012	1.401	0.161
MCap	0.107**	2.118	0.034	0.089	1.503	0.133
LIQ	0.052	0.984	0.325	0.071	1.261	0.207
NPL	−0.144*	−1.892	0.058	−0.173**	−2.216	0.027
Year FE		Yes			Yes	
Observations		1616			1616	
Prob > χ^2		0.003			0.009	
Panel C: Regulatory compliance and transparency disclosures						
Variables	**H_5: RC**			**H_6: TD**		
	Coef.	**z-stat**	**P>z**	**Coef.**	**z-stat**	**P>z**
ESG (L1)	0.531***	14.286	0.000	0.489***	12.742	0.000
BSize	−0.174*	−1.944	0.052	−0.129	−1.421	0.155
LEV	−0.263	−1.396	0.163	−0.308*	−1.812	0.070
ROA	0.097*	1.726	0.084	0.122**	2.041	0.041
AGE	0.021**	2.442	0.015	0.017*	1.866	0.062
MCap	0.243***	4.631	0.000	0.219***	3.984	0.000
LIQ	0.066	1.187	0.235	0.081	1.436	0.151
NPL	−0.231**	−2.384	0.017	−0.264***	−2.971	0.003
Year FE		Yes			Yes	
Observations		1616			1616	
Prob > χ^2		0.000			0.000	

ESG (L1) represents the lagged scores of one period in contribution to ESG performance. The control variables are Bank Size (BSize), Leverage (LEV), Profitability (ROA), Age (AGE), Market Capitalization (MCap), Liquidity (LIQ) and Non-Performing Loans (NPL). All models are estimated in QML dynamic panel with year fixed effects. *, *, respectively represent the significance at 1%, 5% and 10%

5. THEMATIC INTERPRETATION OF RESULTS

The findings offer important implications for understanding how ESG performance and governance quality stimulate FinTech adoption in a sample of MENA energy companies. By firm I fixed-effects and QML panel regression, it is found that ESG performance has significantly positive association with FinTech adoption (e.g., 0.148 in Model 1; the coefficient on E_SG Mean in QML Model 1 is as high as 0.417), which indicates that energy firms with better sustainability practices are more likely to adopt financial services through technology advance (KharRat et al., 2023; Wang et al., 2022; Du et al., 2022). This is consistent with the Resource-Based View in which ESG capabilities are considered specific organizational skills that contribute to innovation readiness and digital adoption (TaO et al., 2022; Atayah et al., 2023). Second, consistent with the Stakeholder Theory framework, firms with greater emphasis on ESG issues react more positively to external demands for accountability, transparency and technological inter-connection leading to a higher level of adoption of FinTech solutions (Du et al., 2022; Pandey et al., 2023).

Board-level mechanisms of governance infrastructure have mixed impact on FinTech adoption. BS is negatively related to FinTech adoption (−0.286 in QML, −0.032 in FE), meaning that larger boards may hamper the process of decision-taking through incentive and coordination problems (Ahmed et al., 2006; Birindelli et al., 2018). Conversely, board independence (BI) is positively linked to FinTech adoption (0.112 FE; 0.263 QML); meaning non-executive directors facilitate monitoring and facilitating strategic innovation effort (Cheng and Courtenay,

2006; MiranDa et al., 2023). WB has also a positive impact (0.095 FE, 0.194 QML), suggesting that diversity in decision making increases acceptance of new financial technologies through different perspectives (Bear et al., 2010; Torchia et al., 2011; Shakil et al., 2021).

The proxy for the credit risk variables is not significant in any of the specifications (credit: 0.002 FE, 1.7 QML), confirming that the measure of allowing FinTech into one's boarder has increases in penetration which have a positive effect on its quality. Companies that comply with regional and international regulations of transparency foster trust, thus lowering the information gap which is crucial for FinTech adoption (Allen and Santomero, 2001; Birindelli et al., 2018; AlQuDah et al., 2025). Larger and more experienced companies have greater FinTech acceptance because of their advanced resources and institutional capabilities (Wang et al., 2022; KharRat et al., 2023); at the same time, heavy leverage and nonperforming loans usually curb the adoption of technology from the financial constraints perspective.

The double-barrel impact of ESG—on the qualities of the board and on the quality of governance—underscores that it's far from just a compliance checklist exercise, but rather one with potential to strategically drive digital transformation. Advanced ESG engagement further expeditest cross-industry adoption of FinTech and optimizes internal governance structure to significantly improve short-term competitiveness in the energy field. These recurring results complement the RBV claims, which place ESG as a unique organisational capability that enhances resilience and strength of technological dissemination. Nevertheless, the findings provide relatively less evidence for stakeholder theory that places its emphasis on external accountability pressures – including regulatory requirements or social needs – as an important push factor of innovation (Tao et al., 2022; Du et al., 2022).

6. CONCLUSIONS AND SCHOLARLY IMPLICATIONS

This paper empirically investigates the relationship between ESG performance, governance quality and FinTech adoption in a sample of 1616 firm-year observations within energy firms across MENA region during 2010–2023. This suggests that ESG performance acts as a strong driver for both FinTech adoption and the overall quality of corporate governance in the energy sector. For one, companies with higher ESG scores are likely to have more independent boards, more gender-diverse leadership, and far more expansive policies regarding both compliance and transparency. Further, compact, responsive boards are seen to be driving better decisions and quicker adaptation of fintech.

The study encompasses many energy subsectors in MENA oil & gas, coal, solar, wind, hydro, nuclear and bioenergy utilities. Different patterns are observed between these segments, and renewable energy companies and utilities are characterised by a stronger positive ESG performance?FinTech adoption relationship. ESG and strong governance act as enablers for TO, both internally—in terms of boards' roles and management practices —as well as externally (e.g., complying with regulations; having disclosure protocols) which help energy companies to progress into the digital age.

For policy makers and energy business leaders in the MENA region, these findings highlight the imperative of integrating ESG into governance as a critical element of its digital readiness. Apart from supporting boards that are smaller, independent and gender-diverse; enhanced transparency and compliance systems can substantially lead a company to address FinTech innovations. These actions encourage responsible introduction of game-changing technologies and foster innovation and community adaptability within a changing regional energy context.

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APPENDIX

Appendix A1. Pearson correlation matrix of study variables

Variable	ESG	FIN	BS	BI	WB	RC	TD	BSize	LEV	ROA	AGE	MCap	LIQ	NPL
ESG	1													
FIN	0.481***	1												
BS	−0.221***	−0.178***	1											
BI	0.217***	0.134***	−0.153***	1										
WB	0.263***	0.119***	−0.047**	0.182***	1									
RC	0.321***	0.224***	−0.132***	0.114***	0.178***	1								
TD	0.298***	0.206***	−0.119***	0.101***	0.165***	0.453***	1							
BSize	−0.198***	−0.165***	0.651***	−0.142***	−0.054**	0.123***	0.098***	1						
LEV	−0.072**	−0.048*	0.217***	−0.041*	−0.012	0.081***	0.056**	0.203***	1					
ROA	0.061***	0.054***	−0.018	0.021	0.015	0.074***	0.052**	−0.019	0.033*	1				
AGE	0.123***	0.098***	0.187***	0.084***	0.091***	0.102***	0.098***	0.163***	−0.027	0.041**	1			
MCap	0.554***	0.491***	0.298***	0.176***	0.214***	0.312***	0.295***	0.287***	0.241***	0.062**	0.218***	1		
LIQ	0.153***	0.138***	−0.041*	0.052**	0.064**	0.107***	0.112***	−0.028	0.197***	0.031*	0.091***	0.149***	1	
NPL	−0.089***	−0.074***	0.045**	−0.052**	−0.038*	−0.091***	−0.082***	0.041*	0.217***	−0.011	−0.062**	−0.108***	−0.121***	1

***P<0.01, P<0.05, P<0.10. All values represent Pearson correlation coefficients between ESG performance, Fintech adoption, board structure, governance, and control variables in energy firms, based on 1,616 observations. Variable abbreviations follow Table 2