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# The Nexus of Tech-Enabled Financial Disruptions, Internet Plus Policy, Business Climate Uncertainty, and ESG Performance in China: Evidence from a Sys-GMM Approach

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## ABSTRACT

Rapid integration of technology-driven solutions has transformed corporate strategies in the quest for effective sustainability frameworks. The study provides a robust theoretical foundation for understanding financial digitalization and ESG dynamics within policy frameworks and the complexities of the business environment using a panel dataset of listed financial institutions in China from 2012 to 2023, employing a two-step system-GMM approach. The results reveal a significant positive relationship between tech-enabled financial disruptions and ESG performance, implying that tech-enabled solutions in the financial sector enhance sustainability outcomes. Furthermore, the internet plus policy strengthens this relationship by fostering a supportive digital ecosystem, while business climate uncertainty negatively influences it, underscoring the detrimental effects of regulatory and economic unpredictability on ESG commitments. These insights hold important implications for policymakers and corporate executives in leveraging financial digitalization to optimize ESG performance, strengthen digital policies, and overall sustainability while balancing risk management to encourage long-term sustainable investments.

**Keywords:** Tech-enabled Financial Disruptions, ESG Performance, Internet Plus Policy; Business Climate Uncertainty; Sustainability.

## INTRODUCTION

The shift in technological progress and financial systems has led to the emergence of disruptions that have altered conventional financial systems and produced newer and better alternatives. Tech-enabled financial disruptions (TFD), emerging from financial technology, enhance operational efficiency, financial inclusion, accessibility, financial accountability, faster-informed decision-making, report transparency, and inclusive economic growth (F. Berg et al., 2022). Innovations such as mobile banking, e-payment systems, blockchain technology, and other FinTech platforms have revolutionized financial interactions (Arner et al., 2017; Gomber et al., 2018). Beyond their use as transactional tools in the financial sector, these technological advancements create opportunities to improve ESG performance (F. Berg et al., 2022). ESG is a multifaceted concept that evaluates an entity's pledge to environmental stewardship, society, and governance structures. ESG considerations are gaining attention among investors, policymakers, academics, and governments as vital indicators of corporate sustainability. Firms' ability to incorporate ESG strategies enables them to navigate societal and environmental expectations alongside core organizational activities, which is perceived as a competitive advantage (Friede et al., 2015). These technologies are capable of lowering transaction costs, improving access to financial resources, enhancing the transparency of transactions, and promoting sustainable business models, thereby aligning financial technology with broader sustainability goals (Demirguc-Kunt et al., 2018). Additionally, tech-enabled systems have reduced the reliance on physical transactions, lowering the carbon footprint of cash handling and transportation (S. K. Gupta et al., 2023; Sam et al., 2021).

Technological transformation does not occur in seclusion; business climate and internet policies can either amplify or undermine its effects. The internet plus initiative is a part of China's digital economic strategy to merge internet technologies with traditional industries, aiming to boost innovation, productivity, and sustainability (Hong, 2017; Hristov, 2017; M. Wang et al., 2023; Yijing, 2023). State-driven policies, such as

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the internet plus policy, often offer institutional support that enables firms to leverage TFD for ESG outcomes. As policies promote infrastructural development, it becomes more cost-effective for firms to digitalize their processes and activities. Although digitalization holds beneficial potential for all facets of ESG performance, the business environment is highly complex and often marked by uncertainties that adversely influence the operational and strategic choices of firms. These uncertainties can disrupt business operations, increase firms' risk aversion, and constrain the financial resources available for sustainability investments. Business climate uncertainty often arises from macroeconomic volatility, regulatory unpredictability, and geopolitical shifts, and often adversely affects firms (Baker et al., 2016; Trinh, 2024). Such uncertainty necessitates critical decision-making by firms; hence, they are confronted with a compromise between immediate survival and long-term sustainability objectives. To address immediate pressures during financial crises or economic downturns, firms might redirect resources from sustainability projects (Guan et al., 2021). This study explores the complex connection between technology, policy, and economic factors in shaping ESG performance to augment the literature and provide actionable insights into the interplay of these indicators (Lu et al., 2024).

Despite the growing emphasis on how technological transformation impacts ESG performance, the mechanisms by which tech-enabled financial disruption influences ESG have not been comprehensively explored. Research has concentrated on the direct influence of various aspects of technological advancement on the whole or some dimensions of ESG performance (Cui, 2022; Fang et al., 2023; Ren et al., 2023; Su et al., 2023; J. Wang et al., 2023; L. Wang & Hou, 2024; Wu & Li, 2023; Xue et al., 2023; P. Yang et al., 2024). Three key issues were explored in this study. First, the role of policy effects and business environment factors in moderating the relationship has been given little or no attention. Lu et al. (2024) suggested that the digital background and policy orientation may differ over time and thus impact ESG performance. Second, there is a need to examine how firms' ESG performance responds to the mechanisms of uncertainty and external risk (Lu et al., 2024). Hence, this research examines the moderating influences of the internet plus policy and business climate uncertainty. Third, there is a methodological gap in the application of robust econometric techniques. Hence, we employed the robust two-step system generalized method of moments (Sys-GMM) for data analysis to mitigate endogeneity, provide reliable empirical evidence, and achieve the objectives of examining how tech-enabled financial disruptions impact entities' ESG performance and the moderating influence of internet plus policy and business climate uncertainty. Internet plus policy aims to enhance tech-enabled financial disruptions' impact on ESG performance, while business climate uncertainty may adversely affect this relationship.

This paper theoretically examines the role of technological transformation and policy frameworks in driving ESG performance through foundational theories such as stakeholder, institutional, resource-based, diffusion of technology, trade-off, and agency theories. The paper aims to enrich the understanding of financial innovation, ESG performance, and institutional policies and their linkages with the United Nations SDGs of 2030 (Demirguc-Kunt et al., 2018; Manupati et al., 2020; L. Wang & Yang, 2024). This study offers significant insights into focused interventions and initiatives to enhance sustainable practices, financing, and responsible investing. The study findings are relevant for stakeholders aiming to align technological advancements with sustainability goals, as they expand the growing body of ESG literature and how technological advancements interact with institutional environments to shape sustainability outcomes (Fatemi et al., 2018; Khan et al., 2016). The remainder of the study is structured with the literature review in section two, methods in section three, resulting outcomes and discussion in section four, and section 5 captures the conclusion, policy and practical implications, and future research directions.

## LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

### Tech-Enabled Financial Disruption and ESG Performance

Advancements in technology introduce innovative transformations in the financial industry that reshape its business models, corporate functioning, and change the mode of financial transactions (Lu et al., 2024). These transformations are characterized by efficiency, speed, and a variety of new financial products and financial businesses experienced by financial institutions in their office processes and customer interfaces (Gomber et al., 2017). New technologies have disrupted the financial system, organizational structure, and corporate culture,

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offering inclusive, cost-efficient, and transparent solutions that have broadened financial inclusion (Arner et al., 2017; Gomber et al., 2018). Fintech has been utilized to empower previously unbanked and underprivileged groups, enabling them to participate in the formal financial system, which also enables SMEs to grow (L. Yang & Zhang, 2020). Digital technology potentially helps firms create unique products and services with fierce competition, expand their clientele share and customer base, and stimulate industry transformation that enhances the attainment of favorable ESG performance outcomes (L. Wang & Yang, 2024).

ESG performance, as a recognition of an organization's corporate sustainability development practices, has emerged as a critical measurement metric of an economic society (Y. Chen & Ren, 2025; Mu et al., 2023). ESG performance is the overall practices of an organization that relate to diminishing its operations' negative environmental impact, its responsibility to its stakeholders and society, and the standard of its business governance (Brogi & Lagasio, 2019; Liu et al., 2022). This points to the need for firms to balance economic profitability with sustainability and ethical practices by initiating development frameworks that support ESG considerations and disclosing progress to relevant stakeholders (Arun et al., 2022). The connection between TFD and ESG performance is supported by several theories. TFD, from a resource-based view, is a driver of the adoption of resource-efficient technologies that offer competitive advantages to a firm while meeting sustainability objectives (Hart, 1995). Technologies such as blockchain, big data, and artificial intelligence can be used by firms to promote change in their operational systems, track social metrics across supply chains, and expand their market size while ensuring that social responsibility standards are not compromised (Lu et al., 2024; Manupati et al., 2020). Stakeholder theory assumes that satisfying diverse interests is significant for a firm's success. Hence, these new technologies can help firms sustain ethical practices among relevant stakeholders (Freeman & Dmytriyev, 2017). The theory emphasizes meeting various stakeholders' expectations to remain in business, which aligns with the goal of financial technology with respect to sustainability (Freeman, 2010). Furthermore, institutional theory suggests that firms adopt innovative practices to align with institutional pressures in the business environment, such as regulatory compliance frameworks, stakeholders' expectations, and market norms (DiMaggio & Powell, 1983). Digital technology uptake and implementation reflect firms' responses to institutional pressures and demands, which can either facilitate or hinder it in the form of industry standards, government policies and regulations, or social norms seeking improved products and services, pledges to sustainable practices, and business responsibility (Yin et al., 2024).

TFD has reduced the need for physical branch networks, moving financial services to mobile/electronic devices, therefore enhancing resource allocation and promoting energy efficiency, which aligns with SDG 12, "Responsible production and consumption." Numerous mobile payment platforms have broadened financial inclusion, reduced inequality in access to financial resources, and improved economic growth (Jack & Suri, 2014; Zhang et al., 2024). Similarly, utilizing blockchain technology has assisted firms in tracking and verifying sustainable supply chains and promoting environmentally responsible sourcing/production processes (Manupati et al., 2020). This has also led to transparency and accountability that support ESG performance (Cui, 2022). Tech-enabled financial disruptions are beneficial for both firms and consumers in terms of reducing operational costs, enhancing accessibility and transparency, and promoting ethical governance practices (Radziwill, 2018). Advancing digital financial technologies contributes to improving an entity's overall ESG performance and achieving sustainable development goals. We put forth the first hypothesis in light of the discussion above:

*H1: Tech-enabled financial disruptions arising from technological advancements have a positive and significant impact on ESG performance.*

**The Role of China's Internet Plus Policy (IPP) as a Facilitating Mechanism**

The indispensable role of the government in supporting production and growth and improving economic activities has been featured in many studies (C.-L. Chen et al., 2021). Governments often formulate policies to initiate transformation, support initiatives, and implement changes. China has always had a strong government presence, not only in industry and commerce but in every aspect of the nation's economy, paying close attention to advancements and reforms (Hristov, 2017; Yijing, 2023). IPP is one such reform, an initiative to integrate the internet and digital technological innovations with traditional industries to transform into a

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modernized economy to boost productivity and sustainability (Mhlanga, 2022; Yijing, 2023; Z. Zhao et al., 2016). The policy is a broad national strategy in which several real industries were targeted by this policy, including finance, manufacturing, healthcare, and information services (Lee & Lee, 2015; Z. Zhao et al., 2016). IPP aims to provide an enabling institutional environment to encourage the adoption of digital tools, including the Internet of Things (IoT), mobile internet, cloud computing, artificial intelligence, and big data, for economic modernization and development (Hristov, 2017). The IPP caught the interest of many stakeholders who consider the initiative as a significant catalyst for economic expansion and sustainability (Hong, 2017; M. Wang et al., 2023; Zhu, 2022). IPP acts as a facilitating mechanism that promotes technological innovation in the sweeping digitalization of China's inclusive financial system (Z. Zhao et al., 2016).

The positive moderating role of the IPP can be contextualized within institutional theory, which posits that policies and regulatory frameworks serve as external institutional forces that shape corporate behavior (North, 1990; Scott, 2014). Such policies influence organizational behavior by establishing norms, incentives, and expectations, as policy frameworks provide guidance, resources, and legitimacy for such initiatives (DiMaggio & Powell, 1983). The IPP acts as a supportive framework, with the Chinese government investing heavily in established and emerging digital technologies that provide firms with the resources, infrastructure, and incentives necessary to adapt and innovate. Firms operating in cities and business environments where the internet plus has effectively developed and where internet technology is advancing tend to be better equipped to integrate digital technologies to provide new economic resources that support ESG strategies and sustainable practices (M. Wang et al., 2023).

Policies such as the IPP foster digital innovation by addressing the structural, infrastructural, and institutional challenges that hinder the diffusion of technology in emerging and developed economies (Rogers, 2003; M. Wang et al., 2023). The evolution of China's financial industry has been significantly impacted by the emergence of the internet plus policy. Following the quest for sustainability globally, the role of policy-driven digital innovation in improving ESG performance is attracting significant attention. IPP enables improved operational efficiency, cost, and seamless delivery, freeing up resources for ESG-related initiatives. The initiative encourages firms to adopt advanced technologies that facilitate greener practices and enhance social accountability. This helps create and foster a digital-friendly environment for learning. IPP ensures better stakeholder engagement and accountability through enhanced ESG disclosure by promoting the usage of digital reporting platforms.

IPP has been discussed in the context of China; however, similar initiatives exist globally. Two initiatives that stand out as examples are the European Union's Digital Single Market Strategy and Digital India Campaign, which were established in the same year as the IPP and have similar aims to integrate digital technologies across industries that foster innovation in various aspects (Eckert & Kovalevska, 2021; R. Gupta et al., 2020; Schmidt & Krimmer, 2022). These initiatives entail considerable government involvement and investment to drive their objectives and encourage adoption. The financial industry continues to utilize technological advancements and policy drives to improve financial inclusion and equitable access to financial resources, thereby supporting the UN Sustainable Development Goals (Y. Li et al., 2019; M. Wang et al., 2023; Zhu, 2022). Digital innovation policies promote financial inclusion, enhance social equity, and improve governance by increasing access to transparent financial systems (R. Gupta et al., 2020; Patil et al., 2017). These policies have massively promoted digital infrastructure development and created an enabling regulatory environment for digital disruption to drive improvements in ESG performance. Internet plus policy, as an institutional mechanism that facilitates the adoption of technological innovations, effectively interacts with technology-enabled financial disruptions to enhance ESG performance. Since the internet plus policy was implemented, there has been an accelerated digital transformation of the economy (W. He et al., 2020). After the discussion above, we put out the study's second hypothesis:

*H2: The internet plus policy strengthens the impact of tech-enabled financial disruption on ESG performance.*

**The Mechanism of Business Climate Uncertainty (BCU) as a Moderating Constraint**

Business climate impacts the operational decisions and directions of firms within and beyond the sphere; hence, the clamor for stability that will allow firms to thrive. Fluctuating market conditions, financial market volatility,

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macroeconomic shocks, economic instability, policy unpredictability, trade, and geopolitical tensions adversely impact firm behavior and performance (T. O. Berg, 2019; Gulen & Ion, 2015). Firms may face increased operational risks and reduced access to resources during uncertain times. This can lead firms to shift their commitments from long-term ESG investments to immediate survival. ESG investments are often characterized by high-risk premiums and short-term direct investment costs, with long-term benefits, which compel firms to reduce them in their strategic plans during uncertainty or policy changes after weighing the feasibility of such investments (Bin-Feng et al., 2024). These factors and other circumstances in the business environment that create constraints that weaken the ability of firms to utilize their full capacity are termed uncertainties.

Business climate uncertainty has an ambiguous long-run effect on firms' investment decision-making (Bloom et al., 2007). These uncertainties create ambiguity in the decision-making process of firms due to the challenges associated with planning, funding, and the direction of resources (Baker et al., 2016; Bloom, 2014). To ensure financial stability in the face of uncertainty, firms are likely to prioritize immediate operational needs over prolonged sustainability initiatives to secure their ongoing concerns (Flammer & Bansal, 2017). While ESG initiatives offer long-term benefits for firms and all stakeholders, business climate uncertainty heightens risk perception and investors' confidence, which often leads to treating ESG investment as discretionary expenditure during periods of uncertainty (Bansal & DesJardine, 2014). On the premise of trade-off theory, firms often weigh the cost-benefit analysis of an investment before allocating resources to it. Firms facing uncertainty in the business environment will favor investments that have a short pay-back period ahead of those like ESG initiatives with a long pay-back. Trade-off theory assumes that entities must offset the costs and benefits of allocating resources to optimize value (Myers, 1977). Investment in technologies and digital transformations is often capital-intensive and characterized by long-term returns, and business climate uncertainty triggers a trade-off by amplifying financial risk that compels the adoption of a more conservative investment strategy to maintain the capacity to navigate economic volatility.

ESG investments are usually not appealing in an uncertain business environment for firms that are financially constrained due to the perceived absence of immediate returns and the uncertainty of future returns (Bin-Feng et al., 2024). Similarly, investment in digitalization and tech-enabled financial platforms and the process of the innovations that come with the transformation not only disrupt business models but also carry a risk of uncertainty (Scholz et al., 2020). There is a consistent view that as uncertainty increases, the resultant effect is that corporate investments decrease and commitments are postponed until there are stable indices (Gulen & Ion, 2015). BCU typically discourages voluntary sustainability efforts and weakens firms' ability to adhere to ESG regulations due to the increased cost of compliance (Hoang et al., 2024). Conversely, some studies suggest that some firms may take a proactive strategic approach in uncertain times to increase ESG investment in environmental and social initiatives to gain competitive advantage (Orlitzky et al., 2011). Furthermore, firms in hazardous environmental industries may perceive such investment as a hedge against reputational threats or policy changes (Flammer, 2015). However, when viewed from either side, BCU comes with increased discouragement regarding the fickleness of outcomes and probabilities of commitments. This was obvious amid global catastrophes like the financial crisis of 2008 and the COVID-19 pandemic, where BCU increased globally, leading to reduced investments by firms as they prioritized operational survival (Al-Thaqeb et al., 2022; Ding et al., 2021; Shabir et al., 2021). Based on the above discussion, we put forth the study's third hypothesis:

*H3: Business climate uncertainty weakens the positive relationship between tech-enabled financial disruptions and ESG performance.*

# METHODOLOGY

## Data Sources and Sample

This study discusses how tech-enabled financial disruptions, internet plus policy, and business climate uncertainty affect the ESG performance of financial institutions in China. The study considers other firm-level and broader economic control variables, such as firm size, transaction magnitude, risk management, socioeconomic conditions, and macroeconomic conditions. The study utilizes quarterly observations of 122 A-

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listed financial institutions in China from 2012 to 2023. The longitudinal panel structure enables the application of sophisticated econometric methods, such as the Two-Step System GMM estimator, to address endogeneity concerns and dynamic relationships. The focus on financial institutions stems from their critical role in driving digital financial innovations and facilitating corporate ESG performance across multiple sectors, as businesses and financiers of other businesses are involved in sustainability practices (J. He & Su, 2022). Tech-enabled financial disruptions, a digital transaction index, are proxied by several digital transactions obtained from the WIND database and composed of principal component analysis (PCA).

Firm-level ESG performance scores were obtained from the Sino-Securities Index Information and accessed from the WIND database (Schmidthuber et al., 2020). These ESG scores capture firms' practices centered around sustainability and ethical aspects related to environmental, social, and governance dimensions, which are measured against established national and international standards. In our research, we classified these ratings into nine distinct grades, assigning weights to align with earlier research (Deng et al., 2023; Fang et al., 2023; L. Wang & Hou, 2024). In this study, the internet plus policy serves as an exogenous shock variable. Business climate uncertainty is represented by an index reflecting China's business environment factors.

We incorporated the internet plus policy and business climate uncertainty as moderating variables. The internet plus policy, initiated by the Chinese government in 2015, is a digital transformation strategy aimed at fostering innovation and facilitating sustainable economic transformation across various industries through strategic digital integration (Hristov, 2017; Yijing, 2023). The internet plus policy serves as an exogenous shock. Business climate uncertainty reflects China's business climate factors, captured as an index. The index represents the overall perception of the business environment, including economic volatility, investment risks, policy unpredictability, and political tension (Baker et al., 2016; Y. Li & Liu, 2024). The inclusion of the moderating variables of internet plus policy and business climate uncertainty ensures that the analysis captures the critical institutional and macroeconomic factors that could influence the relationship between TFD and ESG performance (Lu et al., 2024). This paper uses a variety of control factors to account for firm-level and macroeconomic elements that could influence ESG performance. Firm Size is measured as the logarithm of total assets. Transaction Magnitude, proxied by total revenue, represents the scale. Macroeconomic conditions (GDP) reflect economic growth patterns. Risk management captures financial sector leverage rates, reflecting firms' financial risks. Socioeconomic conditions (inflation) are derived from the World Bank's WDI database to capture a country's socioeconomic conditions. We further introduced total liabilities and risk-taking (Liabilities Leverage Rate) to assess the results' robustness.

**Table 1: Variable Measurement**

| Variable | Type | Measurement/Source |
|---|---|---|
| ESG Performance | Dependent | ESG ratings (WIND database) |
| Tech-enabled Financial Disruptions | Independent | Digital transaction volume/value (WIND database) |
| Internet Plus Policy | Moderator | Binary dummy: 0 (pre-2015), 1 (post-2015) |
| Business Climate Uncertainty | Moderator | China business climate index (WIND database) |
| Firm Size | Control | Log of total assets (WIND database) |
| Transaction Magnitude | Control | Total revenue (WIND database) |
| Macroeconomic conditions (GDP) | Control | National GDP (China Bureau of Statistics) |
| Socioeconomic Condition | Control | Inflation rate (World Development Indicators) |
| Risk Management | Control | Average leverage rate of financial sector (WIND database) |
| Total Liabilities | Control | Log of total liabilities (WIND database) |
| Risk Taking as Liabilities Leverage | Control | Leverage rate of financial sector (Liability Side) |

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## Econometric Methodology

This study applied the two-step sys-GMM estimator, a well-suited analytical method for addressing endogeneity concerns, unobserved heterogeneity, and dynamic relationships in panel data (Blundell & Bond, 1998), for analysis and robustness checks. The sys-GMM is a sophisticated estimator for estimating dynamic panel data models and is robust and proficient in overcoming severe issues. Specifically, the two-step sys-GMM approach controls for endogeneity arising from lagged dependent variables and other regressors. It accounts for firm-specific and time-invariant unobservable effects and ensures the efficiency and consistency of the estimators, particularly in the presence of heteroscedasticity and autocorrelation (Roodman, 2009). Sys-GMM thoroughly analyzes the distinctions and results of the study's panel dataset. It employs moment conditions based on parameters and data with an expectation of zero at the true value of the parameters. Sys-GMM is especially appropriate when the explained variable's distribution is unknown (Ben Bouheni, 2014). In sys-GMM, the lag value of the ESG rating is utilized to transform ESG performance into a dynamic model and prevent autocorrelation issues found in static regression models. This method produces better and more precise predictions by reducing the lagged impact of dependent variables (Ullah et al., 2024).

The AR test was used to check for the absence of autocorrelation in the first-differenced data; if the null hypothesis is not rejected, it means that the initial error term shows no serial correlation. If the p-value for AR (2) is greater than 0.05 and the p-value for AR (1) supports the null hypothesis, it confirms the selection of the instrument (Arellano & Bond, 1991; Roodman, 2009; Ullah et al., 2022, 2024). The robustness of the findings is further validated through the introduction of alternative variables, using appropriate instruments to address potential endogeneity issues and alternative methods using a mean group estimator (Pesaran & Smith, 1995). Figure 1 below captures the study's conceptual framework.

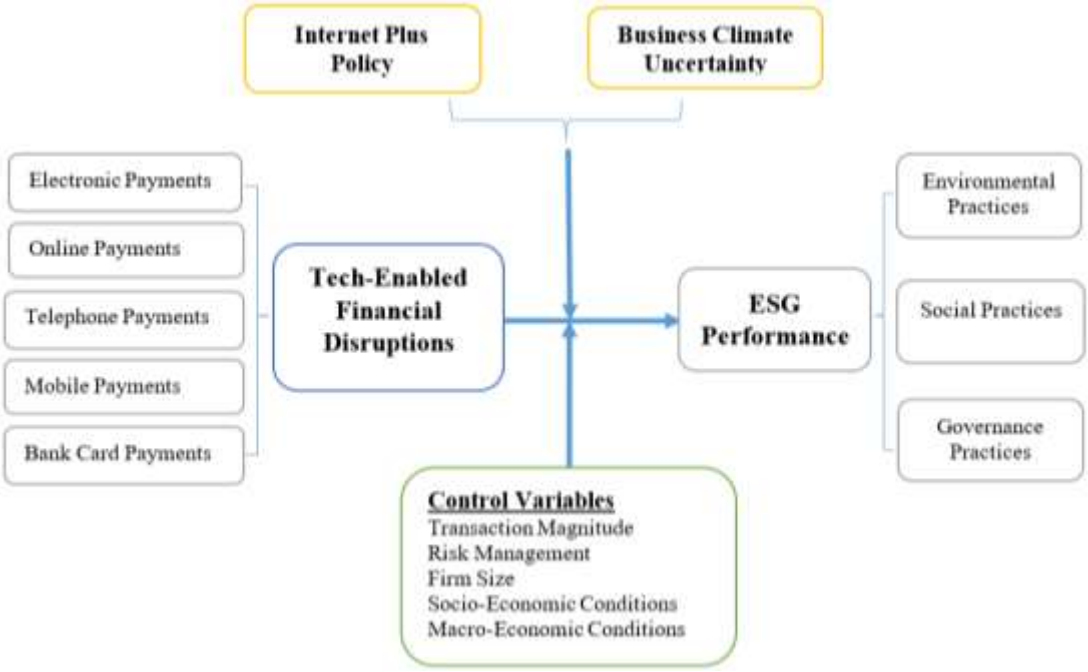


Figure 1: Conceptual Framework

## Econometrics Model

The theoretical basis is an expanded version of the traditional economic growth model, which includes the core Cobb-Douglas production function. The dynamic GMM econometric models are outlined as a two-step system:

$$ESG_{it}=\alpha+\beta_1 L.ESG_{it}+\beta_2 TFD_{it}+\beta_3 IPP_{it}+\beta_4 BCU_{it}+\beta_5(TFD\times IPP)_{it}+\beta_6(TFD\times BCU)_{it}+\beta_7 FS_{it}+\beta_8 TM_{it}+\beta_9 GDP_{it}+\varepsilon_{it} \quad (1)$$

$$ESG_{it}=\alpha+\beta_1 L.ESG_{it}+\beta_2 TFD_{it}+\beta_3 IPP_{it}+\beta_4 BCU_{it}+\beta_5(TFD\times IPP)_{it}+\beta_6(TFD\times BCU)_{it}+\beta_7 FS_{it}+\beta_8 TM_{it}+\beta_9 GDP_{t}+\beta_{10} RM_{it}+\varepsilon_{it} \quad (2)$$

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$ESG_{it}=\alpha+\beta_1 L.ESG_{it}+\beta_2 TFD_{it}+\beta_3 IPP_{it}+\beta_4 BCU_{it}+\beta_5(TFD\times IPP)_{it}+\beta_6(TFD\times BCU)_{it}+\beta_7 FS_{it}+\beta_8 TM_{it}+\beta_9 GDP_t+\beta_{10} RM_{it}+\beta_{11} SEC_{it}+\varepsilon_{it}$
(3)

$ESG_{it}=\alpha+\beta_1 L.ESG_{it}+\beta_2 TFD_{it}+\beta_3 IPP_{it}+\beta_4 BCU_{it}+\beta_5(TFD\times IPP)_{it}+\beta_6(TFD\times BCU)_{it}+\beta_7 FS_{it}+\beta_8 TM_{it}+\beta_9 GDP_t+\beta_{10} RM_{it}+\beta_{11} SEC_t+\beta_{12} TL_{it}+\varepsilon_{it}$
(4)

$ESG_{it}=\alpha+\beta_1 L.ESG_{it}+\beta_2 TFD_{it}+\beta_3 IPP_{it}+\beta_4 BCU_{it}+\beta_5(TFD\times IPP)_{it}+\beta_6(TFD\times BCU)_{it}+\beta_7 FS_{it}+\beta_8 TM_{it}+\beta_9 GDP_t+\beta_{10} RM_{it}+\beta_{11} SEC_{it}+\beta_{12} RT_{it}+\varepsilon_{it}$
(5)

Where ESG connotes environmental, social, and governance performance, TFD is tech-enabled financial disruptions. IPP is the internet plus policy. BCU is business climate uncertainty. FS is firm size. TM is transaction magnitude. GDP is macroeconomic conditions capturing China's GDP. RM is risk management. Error term, year, and fixed effects are included in all models. Robustness checks (Models 3–5) explore the inclusion of alternative control variables, such as socioeconomic conditions/inflation (SEC), total liabilities (TL), and risk-taking (RT) as leverage rates.

**Further Robustness Check**

We utilized the Mean Group (MG) estimator models based on Pesaran & Smith (1995) as an alternative analysis method to further check the robustness of the findings. The MG estimation allows for heterogeneity across groups (firms) by averaging the group-specific coefficients obtained from individual regressions. The Mean Group estimator assumes slope heterogeneity as coefficients vary across groups (firms); individual regressions produce unbiased estimates; hence, it takes a simple average of the group-specific coefficients. The group-specific estimates can be represented as

$$\hat{\beta}_{MG} = \frac{1}{N}\sum_{i=1}^{N}\hat{\beta}_i$$
(6)

Where $\hat{\beta}_i$ is the coefficient for group *i,* and *N* is the total number of firms

The Mean Group estimator for the models is as follows:

$ESG_{it}=\alpha_i+\beta_1 TFD_{it}+\beta_2 IPP_{it}+\beta_3 BCU_{it}+\beta_4(TFD_{it}*IPP_{it})+\beta_5(TFD_{it}*BCU_{it})+\beta_6 FS_{it}+\beta_7 TM_{it}+\beta_8 GDP_{it}+\epsilon_{it}$
(7)

$ESG_{it}=\alpha_i+\beta_1 TFD_{it}+\beta_2 IPP_{it}+\beta_3 BCU_{it}+\beta_4(TFD_{it}*IPP_{it})+\beta_5(TFD_{it}*BCU_{it})+\beta_6 FS_{it}+\beta_7 TM_{it}+\beta_8 GDP_{it}+\beta_9 TL_{it}+\epsilon_{it}$
(8)

## RESULTS AND DISCUSSION OF FINDINGS

**Diagnostic Test**

Several diagnostic tests were carried out to prevent autocorrelation and multi-collinearity, as captured in Table A in appendix. Furthermore, White heteroskedasticity and Pesaran CIPS Unit Root tests were performed. The test results for slope heterogeneity accept the alternative hypothesis that the slope coefficients differ across all the cross-sectional units. The Adjusted Delta statistics p-value is also below the 0.05 threshold. The Shapiro-Wilk W and Shapiro-Francia W test p-values for normality were below 0.05, rejecting the null hypothesis that invalidates the normality assumption in the model variables. The results of Breusch-Pagan and White's heteroskedasticity tests and Cameron and Trivedi's decomposition of the information matrix (IM) test provide strong evidence indicating the presence of heteroskedasticity in the model. Pesaran's, Friedman's, and Frees' cross-sectional dependence fixed effect tests in the model have p-values of 0.0000, suggesting a substantial

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cross-sectional dependency. Pesaran's CIPS second-generation unit root test results provide p-values that support the alternative hypothesis, indicating significant stationarity in the dataset.

**Descriptive Statistics and Correlation Analysis**

Table 2 displays the summary of variables in the study, providing a rundown of the dataset's behavioral patterns. The average ESG performance is 4.95 across the observations, with a range of 1 to 7 and a standard deviation of 1.075, showing minimal variation. The regression variables indicate low mean values, with tech-enabled financial disruptions at 0.000 and macroeconomic conditions at 12.264. Standard deviations are also low, in the range of 0.078 for business climate uncertainty and 1.075 for ESG performance, indicating minimal variability.

**Table 2: Variables Descriptive Statistics**

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| ESG Performance | 5856 | 4.95 | 1.075 | 1 | 7 |
| Tech-enabled Financial Disruptions | 5856 | 0 | 1 | -1.73 | 1.44 |
| Internet Plus Policy | 5856 | .75 | 0.433 | 0 | 1 |
| Business Climate Uncertainty | 5856 | 4.766 | 0.078 | 4.48 | 4.867 |
| Firm Size | 5856 | 11.109 | 1.053 | 7.778 | 13.65 |
| Transaction Magnitude | 5856 | 9.602 | 0.966 | 4.795 | 12.086 |
| Macroeconomic Conditions | 5856 | 12.264 | 0.287 | 11.673 | 12.76 |
| Risk Management | 5856 | 4.082 | 0.098 | 3.89 | 4.286 |
| Socioeconomic Conditions | 5856 | 2.064 | 0.778 | .235 | 4.82 |

Table 3 captures the correlation results and reveals a moderate correlation among the variables. The outcomes indicate minimal multi-collinearity issues, which improve the accuracy of the results (Ozili & Iorember, 2023; Ringim & Güngör, 2024). Studies involving multiple variables are often plagued with issues of multi-collinearity; hence, the use of a correlation matrix to examine the strength or otherwise of the connection between the variables to detect potential multi-collinearity problems. This is because the precision of research findings can be adversely affected by issues of multi-collinearity (Kashif et al., 2024). The pairwise correlation results reported in Table 4 reveal that while the independent variable tech-enabled financial is positively and significantly correlated with ESG performance, the moderating variables internet plus policy and business climate policy exhibited a negatively significant correlation. The control variables also exhibited mixed results, with firm size, transaction magnitude, and macroeconomic conditions depicting positive and significant correlations with ESG performance, while the results for risk management and socioeconomic conditions show that the variables are negative and strongly associated with ESG performance. The correlation values and significance levels reveal a moderate correlation between the variables, which indicates that the multi-collinearity issue is minimal and the accuracy of the results and analysis for decision-making is enhanced (Moudud-Ul-Huq & Akter, 2024; Ozili & Iorember, 2023). The variance inflation factor test was conducted to check for multi-collinearity problems in the dataset. The result of the variables' VIF test is displayed in Table 4 below. After concluding the VIF test, the outcomes revealed no problem of multi-collinearity, with all the values below the threshold of 5 for the variables in the dataset (Hashmi et al., 2022; Koapaha, 2023). Internet plus policy was at the upper limit with 4.76, business climate uncertainty had the lowest with 1.24, and the mean VIF for the whole dataset is 2.39, indicating no collinearity concerns.

**Table 3: Pairwise Correlations and Variance Inflation Factor Results**

| Variables | ESG | TFD | IPP | BCU | FS | TM | GDP | RM | SEC | VIF |
|---|---|---|---|---|---|---|---|---|---|---|
| ESG | 1.000 | | | | | | | | | - |
| TFD | 0.057** | 1.000 | | | | | | | | 1.63 |

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| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| IPP | -0.026*** | 0.787*** | 1.000 | | | | | | | 4.76 |
| BCU | -0.066*** | -0.413*** | -0.297*** | 1.000 | | | | | | 1.24 |
| FS | 0.517*** | 0.256*** | 0.229*** | -0.114*** | 1.000 | | | | | 2.07 |
| TM | 0.468*** | 0.162*** | 0.124*** | -0.049*** | 0.859*** | 1.000 | | | | 2.07 |
| GDP | 0.073*** | 0.976*** | 0.720*** | -0.398*** | 0.246*** | 0.191*** | 1.000 | | | 4.17 |
| RM | -0.080*** | 0.188*** | 0.637*** | -0.157*** | 0.095*** | 0.049*** | 0.162*** | 1.000 | | 1.33 |
| SEC | -0.074*** | -0.547*** | -0.577*** | 0.302*** | -0.164*** | -0.122*** | -0.602*** | -0.506*** | 1.000 | 1.87 |
| VIF | | | | | | | | | | 2.39 |

**Two-Step Sys-GMM Analysis Results**

The study examines the impact of tech-enabled financial disruptions on the ESG performance of financial institutions in China and the moderating effect of the internet plus policy and business climate uncertainty on the relationship. The regression results show model suitability, with a j-instrument (statistics) value of 106 and a Wald/Chi2 test p-value of 0.000. We also employed the Arellano-Bond (AR) test to identify the presence of autocorrelation in the first-differenced outcomes. The AR1 assessment results for Models 1 and 2 show coefficients of -8.416 and -8.409, respectively, and a *p*-value below 5% (AR1p = 0.000), revealing the presence of autocorrelation and serial correlation in the data. Nonetheless, the AR (2) test indicates a p-value exceeding 5% (0.448 and 0.422), meaning that there is no second-order correlation, and the null hypothesis cannot be rejected. Furthermore, the p-values of 0.133 and 0.121 from the Hansen test fall within the recommended specified range of 0.10 to 0.30 (Roodman, 2009), as the Hansen statistic suggests that the instruments used are valid and not over-identified.

A robustness check was conducted in Models 3, 4, and 5 to reinforce the validity of the results obtained in the primary models. The additional models incorporate unique variables to ensure that the association between core variables and ESG performance is consistent and robust. In Model 3, we introduce socioeconomic conditions (SEC). Total liabilities (TL) and risk-taking (RT) were introduced in Models 4 and 5, respectively, and were used to validate the earlier findings, employing a system GMM panel estimator. The model suitability, autocorrelation, and instrument validity results show that there is no fundamental change in the direction of the sign of the core explanatory, interaction, and control factors in Models 1 and 2 with the introduction of the additional control variables.

The results of Model 1 reveal that tech-enabled financial disruptions (TFD) positively and significantly influence ESG performance (1.624, $p < 0.01$), suggesting that access to technology-driven financial resources enhances a firm's ability to integrate sustainability initiatives into its operations. Internet plus policy (IPP) exerts a positive and significant effect on ESG performance (0.175, $p < 0.01$), highlighting the role of digital infrastructure and policy support in driving sustainable business practices. Business climate uncertainty (BCU) shows a positive and significant relationship with ESG performance (0.273, $p < 0.01$). A favorable business climate fosters ESG adoption, emphasizing the enabling role of stable business and institutional environments in achieving sustainability. The interaction between TFD and IPP enhances ESG performance (0.111, $p < 0.01$).

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The positive interaction suggests that TFD and policy-driven digital infrastructural transformation are complementary in fostering ESG adoption. The interaction between TFD and BCU negatively moderates the relationship with ESG performance (-0.401, $p < 0.01$). The negative interaction indicates that a highly favorable business climate may reduce firms' incentives to leverage TFD, possibly leading to complacency in ESG efforts. Firms operating in unstable business climates suffer from increased regulatory uncertainty, constraints on access to resources, and restrictions that discourage responsible and sustainable practices.

Firm Size (FS) has a positive and significant outcome (0.101, $p < 0.01$), indicating that larger firms exhibit better ESG performance, likely due to their greater resources, visibility, and stakeholder pressure. Larger firms have the capacity to make substantial investments in sustainability and are often subject to higher expectations from stakeholders, including investors, regulators, and the public. The coefficient of transaction magnitude (TM) is insignificant, suggesting that the scale of financial transactions alone does not influence ESG performance. Positive macroeconomic conditions (GDP) significantly improve ESG performance (0.338, $p < 0.01$), underscoring the role of economic stability in facilitating sustainable practices. Economic growth creates opportunities for firms to allocate resources to ESG initiatives without compromising profitability. Model 2 examined the same variables and incorporated an additional variable, risk management (RM). This expanded framework enables a more nuanced exploration of ESG performance, particularly by accounting for firms' risk management strategies alongside technological, institutional, and macroeconomic factors. The outcome of the analysis took the same direction as the results of Model 1, and the inclusion of risk management (RM) as a new variable revealed a significant adverse relationship with ESG performance.

Models 3, 4, and 5 were used as a robustness check for the earlier findings of the main models by introducing new control variables stepwise. There were no changes in the direction of the outputs for the variables. The significant negative coefficient of socioeconomic conditions across the models indicates that higher inflation rates are associated with poor ESG performance. It implies that economic volatility, as evidenced by inflation, creates financial pressures that hinder firms' ability to prioritize sustainability initiatives. The coefficient of total liabilities (TL) in Model 4 (-0.061) indicates that firms with higher total liabilities tend to underperform in terms of ESG outcomes, albeit at a lower level of significance ($p < 0.1$). This result highlights the potential burden of financial leverage on firms' capacity to fund sustainability projects. The inclusion of risk-taking as a liability leverage rate in Model 5 offers a more refined measure of firms' financial risk exposure. The significant negative coefficient (-0.009, $p < 0.01$) implies that entities with higher risk-taking behavior, as reflected in their leverage rates, exhibit poorer ESG performance. This result reinforces the adverse relationship between financial risk and sustainability.

**Table 4: The Role of Internet Plus Policy and Climate Business Uncertainty between the TFD and ESG**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | Two-Step System GMM | | | | |
| | Main Model-1 | Main Model-2 | Robustness through alternate variable | | |
| Variables | ESG | ESG | ESG | ESG | ESG |
| Lag. ESG | 0.810*** | 0.809*** | 0.808*** | 0.807*** | 0.808*** |
| | (0.007) | (0.007) | (0.008) | (0.008) | (0.008) |
| Tech-enabled Financial | 1.624*** | 1.897*** | 2.451*** | 2.395*** | 2.411*** |
| Disruptions (TFD) | (0.387) | (0.386) | (0.375) | (0.387) | (0.373) |
| Internet Plus Policy (IPP) | 0.175*** | 0.285*** | 0.302*** | 0.279*** | 0.378*** |
| | (0.051) | (0.056) | (0.057) | (0.064) | (0.058) |
| Business Climate Uncertainty | 0.273*** | 0.319*** | 0.358*** | 0.347*** | 0.357*** |
| (BCU) | (0.060) | (0.059) | (0.061) | (0.063) | (0.061) |
| TFD* IPP | 0.111*** | 0.117*** | 0.166*** | 0.157*** | 0.180*** |
| | (0.031) | (0.032) | (0.033) | (0.034) | (0.033) |
| TFD* BCU | -0.401*** | -0.472*** | -0.596*** | -0.580*** | -0.595*** |

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| | | | | | |
|---|---|---|---|---|---|
| | (0.079) | (0.079) | (0.077) | (0.081) | (0.077) |
| Firm Size (FS) | 0.101*** | 0.102*** | 0.101*** | 0.171*** | 0.101*** |
| | (0.010) | (0.010) | (0.010) | (0.042) | (0.010) |
| Transaction Magnitude (TM) | 0.007 | 0.007 | 0.008 | 0.005 | 0.008 |
| | (0.007) | (0.007) | (0.008) | (0.008) | (0.008) |
| Macroeconomic Conditions (GDP) | 0.338*** | 0.424*** | 0.380*** | 0.362*** | 0.480*** |
| | (0.061) | (0.064) | (0.066) | (0.073) | (0.068) |
| Risk Management (RM) | | -0.275*** | -0.280*** | -0.257*** | |
| | | (0.082) | (0.082) | (0.088) | |
| Socioeconomic Conditions (SEC) | | | -0.037*** | -0.037*** | -0.034*** |
| | | | (0.007) | (0.007) | (0.007) |
| Total Liabilities (TL) (Robust) | | | | -0.061* | |
| | | | | (0.035) | |
| Risk Taking as Liabilities Leverage Rate (RT) (Robust) | | | | | -0.009*** |
| | | | | | (0.002) |
| Constant | -5.992*** | -6.258*** | -5.856*** | -5.731*** | -7.743*** |
| | (0.763) | (0.782) | (0.825) | (0.881) | (0.856) |
| Year Effect | Yes | Yes | Yes | Yes | Yes |
| Fixed-Effects | Yes | Yes | Yes | Yes | Yes |
| Observations | 5,731 | 5,731 | 5,731 | 5,731 | 5,731 |
| AR1 | -8.416 | -8.409 | -8.423 | -8.421 | -8.420 |
| AR1(p-Value) | 0 | 0.000 | 0.000 | 0.000 | 0.000 |
| AR2 | -0.759 | -0.803 | -0.786 | -0.777 | -0.819 |
| AR2 (p-value) | 0.448 | 0.422 | 0.432 | 0.437 | 0.413 |
| Sargan Statistics | 232.1 | 230.9 | 227.5 | 226.9 | 224.5 |
| Hansen Statistics | 100.7 | 100.5 | 100.2 | 99.43 | 100.2 |
| Hansen (p-value) | 0.133 | 0.121 | 0.110 | 0.106 | 0.110 |
| J. Statistics / Instruments | 106 | 106 | 106 | 106 | 106 |
| Wald/CHI | 5.176 | 5.128 | 5.534 | 5.753 | 5.436 |
| Wald/CHI (p-value) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Number of Firms | 122 | 122 | 122 | 122 | 122 |

**Mean Group Estimator Analysis Results**

We conducted further robustness checks using the Mean Group estimator (Pesaran & Smith, 1995) to provide robust perspectives into the connection between tech-enabled financial disruptions (TFD), ESG performance, and the moderating roles of internet plus policy (IPP) and business climate uncertainty (BCU). Table 6, Column 1 displays the outcomes of Model 1, which aligns with and validates the results obtained from the two-step sys-GMM. The direction of the Model 2 results further validates the outcomes of Model 1 of the Mean Group estimator, with a favorably significant coefficient of TFD. The outcome of IPP is also favorably significant (0.593, $p < 0.05$), reflecting that the internet plus policy plays a crucial part in enhancing the positive impact of TFD on ESG performance. The interaction term (TFD * IPP) further confirms this moderating effect, demonstrating that institutional policies can act as catalysts for the digital transformation of financial systems to sustain sustainability. The coefficient of BCU is positive but weakly significant (0.355, $p < 0.10$), implying that business climate uncertainty has a limited positive impact on ESG performance. However, the interaction term (TFD * BCU) (-0.972, $p < 0.01$) is negative and highly significant, indicating that business climate uncertainty interacting with TFD weakens the favorable connection between TFD and ESG. This result highlights the adverse effect of economic volatility on corporate sustainability.

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**Table 5: Pesaran & Smith (1995) Mean Group Estimator**

| | (1) | (2) |
|---|---|---|
| | Mean Group estimator | |
| | Main Model | Main Model 2 |
| Variables | ESG | ESG |
| TFD | 3.324** | 2.383* |
| | (1.355) | (1.392) |
| Internet Plus Policy (IPP) | 0.614** | 0.593** |
| | (0.261) | (0.262) |
| Business Climate Uncertainty | 0.355* | 0.452** |
| (BCU) | (0.194) | (0.197) |
| TFD* IPP | 0.861*** | 0.815*** |
| | (0.195) | (0.201) |
| TFD* BCU | -0.972*** | -0.745*** |
| | (0.256) | (0.263) |
| Firm Size (FS) | 2.635*** | 1.918*** |
| | (0.439) | (0.406) |
| Transaction Magnitude (TM) | 0.100 | 0.028 |
| | (0.081) | (0.069) |
| Macroeconomic Conditions (GDP) | 0.718** | 0.721** |
| | (0.356) | (0.337) |
| Total Liabilities (TL) | | -0.031** |
| | | (0.014) |
| Constant | -38.913*** | -29.684*** |
| | (6.056) | (6.268) |
| Year Effect | Yes | Yes |
| Observations | 5,853 | 5,731 |
| Root Mean Squared Error | 0.5208 | 0.4959 |
| Wald/CHI | 113.6 | 94.90 |
| Wald/CHI (p-value) | 0.000 | 0.000 |
| Number of Firms | 122 | 122 |

## DISCUSSION OF RESULTS

This study measured the nexus of tech-enabled financial disruptions, internet plus policy, and business climate uncertainty and how it impacts the ESG performance of financial institutions in China using a two-step System Generalized Method of Moments (GMM) analysis. The post-diagnostic analysis suggests that the models are specified correctly and the estimated coefficients are unbiased, and the instruments are error-free. Hence, the discussion of the results is aligned with the empirical evidence and relevant foundational theories. TFD was found to positively and significantly impact ESG performance, which supports hypothesis one (H1) of this study. Tech-driven financial resources have the potential to revolutionize sustainable practices, as supported by the findings of (Kashif et al., 2024).

Tech-enabled transactions have expanded financial inclusion and accessibility to financial services while diminishing geographical barriers, carbon emissions, and the need for expanding more physical branch locations (Shang et al., 2023). These align with China's commitment to attain a carbon emissions peak by 2030 and sustain through to carbon neutrality by 2060. Firms invest in innovations such as clean energy, emissions reduction technologies, and enhanced governance systems to improve their sustainability practices. The outcome shows that financial and technological resources can be viewed as strategic assets and are theoreticall-

y aligned with resource-based theory. These strategic assets not only differentiate firms but also drive ESG outcomes (Barney, 1991). The result validates the findings of (L. Wang & Yang, 2024), in which digital

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technology innovations were found to significantly enhance enterprise ESG performance, leading to high-quality developments. Firms can, through their technological capabilities, achieve a sustainable competitive advantage (Hart, 1995). The outcome of this study also aligns with several empirical studies that emphasize the achievement of better ESG outcomes through financial and technological resources (Fang et al., 2023; Ren et al., 2023; X. Zhao & Cai, 2023). Enhancing tech-driven financial resources and platforms can boost ESG performance in both developing and emerging markets. Firms can establish sustainable business models by leveraging these resources and adopting industry best practices. Stakeholder theory also offers a theoretical perspective on the significant outcome between TFD and ESG performance. The demand from numerous stakeholders often forces firms to adjust, adopt, and prioritize ESG initiatives (Freeman & Dmytriyev, 2017). TFD has led to the emergence of several financial products and services that are digitally provided, with a visible trace of research, innovation, and the adoption of sustainable technologies. These include digital payments, P2P lending, the use of renewable energy to power service delivery, digital monitoring systems, and efficient resource management practices, which align with ESG goals (Allen et al., 2016).

The result of the interaction of TFD and internet plus policy on ESG performance revealed a positive and significant relationship, which supports the study's hypothesis two (H2) that the internet plus policy strengthens the impact of TFD on ESG performance. By improving connectivity and access to information, IPP serves as a catalyst that reduces barriers to technology adoption and enables financial institutions to improve transparency, efficiency, and collaboration in their ESG efforts (M. Wang et al., 2023). The synergy of TFD and IPP allows firms to benefit from policy support by leveraging technology for innovation (Y. Chen & Hassink, 2022; M. Wang et al., 2023). This finding aligns with the institutional theory, as it emphasizes the role of institutional policy in influencing decision-making and organizational behavior (DiMaggio & Powell, 1983). Internet plus policy acts as an institutional force or framework that influences corporate behavior and direction (North, 1990). These findings align with the United Nations SDGs, emphasizing the place of technology and institutional backing in driving sustainability. SDG 9 (Industry, Innovation, and Infrastructure) and SDG 12 (Responsible Consumption and Production) provide actionable insights for achieving sustainable development in these areas. The findings are laden with potential for global applicability because technological advancement is boundless, and many countries are implementing similar policies to encourage sustainability. The 'Digital Single Market Strategy' and the 'Green Deal Strategy' by the European Union, India's 'Digital India Campaign', and the 'Digital Transformation with Africa (DTA) Initiative' by the United States all reflect similar efforts to integrate financial technology for sustainability (Eckert & Kovalevska, 2021; R. Gupta et al., 2020; Schmidt & Krimmer, 2022). Policymakers worldwide can learn from the Chinese experience in driving sustainability through targeted digitalization policies.

On the contrary, the negative interaction effect of TFD and business climate uncertainty on ESG performance confirms H3. This implies that the effectiveness of technological transformation to support ESG performance weakens in a business climate characterized by uncertainties (Zyznarska-Dworczak, 2022). Rising uncertainty often dampens strategic initiatives and focuses on stability; hence, the outcome indicates that the need for firms to optimize financial technology for sustainability may be reduced (Foss & Saebi, 2017). (Bin-Feng et al., 2024) established that an entity's ESG performance is adversely affected by environmental uncertainty due to factors like financial constraints and competition. Firms may face a trade-off in strategic decision-making during uncertainty to balance risks and rewards (Bollaert et al., 2021; Myers, 1977). The trade-off theory puts forth that to manage risks and ensure survival due to risk aversion and capital constraints, firms under financial constraints may reduce investments in non-core activities. The impact of BCU is more evident in emerging markets, where economic volatility often disrupts sustainable investments. Recent crises, such as Russia's invasion of Ukraine, the COVID-19 epidemic, rising inflation, trade rifts between nations, and geopolitical tensions, have increased the uncertainties that come with the business climate (Al-Thaqeb et al., 2022; Farooq et al., 2024; Ringim & Güngör, 2024; Shao et al., 2024; Ullah et al., 2024; Zhavoronok et al., 2022). These situations heightened global economic uncertainties, leading to constraints on firms' sustainability initiatives and investment. The government and institutions are making efforts to provide support to aid businesses. However, managers need to balance the role of institutional support and financial resources by adopting proactive strategies that prioritize long-term ESG goals, regardless of whether the business environment is favorable or unfavorable. The global implications of these findings are significant. In developing economies and regions experiencing high macroeconomic volatility, firms may struggle to align financial innovations with

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sustainability goals. They may not perceive any motivation to commit more resources to ESG initiatives or consider it a priority area for surviving the tides.

The control factors' results are mixed, with firm size positively impacting ESG performance significantly. Firm size outcomes reveal that larger firms exhibit better ESG performance, suggesting that as economies of scale are achieved by firms as they grow, it also positively impacts their capacity to expand their investments in ESG and sustainability efforts(Jiang et al., 2023; C. Wang et al., 2024). Stakeholder theory positions support the findings because as institutions grow, their stakeholders' expectations grow too (Freeman, 2010; Kolk & Pinkse, 2010). Additionally, the macroeconomic conditions' positive impact on ESG performance is highly significant, highlighting the critical role of economic stability in supporting sustainable practices. The findings of W. Li & Pang (2023), that ESG performance is positively impacted by the level of financial development, align with the result.

In Model 2, a noteworthy finding is risk management, with an impact that is adversely significant on ESG performance. The trade-off theory is consistent with these findings, indicating that entities are often confronted with a trade-off between risk mitigation and growth-oriented strategies (Myers, 1977). The result suggests that firms may adopt conservative strategies, prioritizing risk management. Hence, firms focus on short-term financial stability as a trade-off for long-term sustainability initiatives. These firms may reduce their commitment to sustainability as they perceive ESG investments to be risky or costly in the short term. Luo & Bhattacharya (2009) highlighted similar trade-offs, where firms with higher risk aversion tend to underinvest in ESG initiatives. However, this finding also emphasizes the need for entities to develop frameworks that integrate risk management with sustainability strategies, as effective ESG performance can mitigate long-term risks. Similarly, stakeholder management theory opined in this regard that firms' managers must devote the necessary attention to all valid stakeholders to achieve better performance by adopting an integrated approach to decision-making that simultaneously satisfies multiple stakeholders, as against taking a stakeholder-by-stakeholder approach (Freeman & McVea, 2005; Verbeke & Tung, 2013).

The robustness checks revealed outcomes with similar directions as the main models, with the additional variables of socioeconomic conditions (inflation), total liabilities, and risk-taking, all turning out with a negatively significant relationship with ESG performance. Socioeconomic conditions (inflation) negatively impact ESG performance, which aligns with the findings of (Hamdi et al., 2022), highlighting the importance of economic stability in promoting sustainability. In inflationary environments, firms are often forced to focus on immediate financial survival, such as cost-cutting and margin protection, rather than long-term ESG investments (Chan et al., 2017). The negative relationship also resonates with the trade-off theory, as firms face constraints in allocating scarce financial resources during periods of rising costs (Myers, 1977). Inflationary pressures in most economies lead to reduced sustainability (ESG) spending due to increased operational costs, as rising prices for goods and services strain their budgets, forcing them to prioritize core business operations over social initiatives. In the same vein, Mão-de-Ferro & Ramelli (2022) found inflation to be a form of crisis for ESG performance.

The result of risk-taking (liability leverage rate) aligns with agency theory, which implies that managers in highly leveraged firms may prioritize short-term financial performance to appease debt holders, often at the expense of long-term sustainability goals (Cabaleiro-Cerviño & Mendi, 2024; Ghoul et al., 2017; Jensen & Meckling, 1979). Overall, the study emphasizes the interplay between technology, institutional backing, and policy in driving the financial industry's ESG performance and sustainable development. While the findings are generally applicable, they also offer specific insights for businesses and policymakers in both developed and developing economies, bringing strategies into line with theories and the Sustainable Development Goals of the United Nations and urging stakeholders to work in collaboration to create and achieve a more inclusive and sustainable future.

## CONCLUSION, POLICY IMPLICATIONS, AND FUTURE RESEARCH DIRECTIONS

This study explores the impact of tech-enabled financial disruptions on ESG performance and the moderating effect of internet plus and business climate uncertainty on the relationship. The study used a two-step system

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GMM estimation technique to provide an in-depth analysis. The results of the main models provide insights into the critical roles of technological change, digital policies, institutional support, macroeconomic factors, and risk management in influencing ESG performance. To begin with, the study finds the impact of TFD on ESG performance to be significantly positive and validates hypothesis one (H1) of this study, a confirmation that financial digitalization enhances sustainability outcomes. The findings indicate that firms leveraging digitalization experience improved ESG outcomes owing to transformational benefits accruing from technological advancement in the field of finance. The interaction effects highlight the niceties and complexities of technological, institutional influences, and business climate. The moderating effect of IPP shows that supportive institutional policies aid digital transformation, encourage corporate governance, and advance sustainable investment strategies, which enhances the impact of TFD on ESG performance. Conversely, financial institutions operating in uncertain business environments find it challenging to fully leverage digital financial innovation for sustainability. The reliability and consistency of the outcomes were validated by robustness checks, which further provided valuable insights into other factors influencing ESG performance. These findings contribute to the validation of empirical studies and align with multiple theoretical frameworks. Incorporating these well-established theories into the ESG context highlights the significance of strategic resource allocation, stakeholder involvement, and institutional support in promoting sustainability outcomes. This study underscores the significance of technology, policy, and institutional support in promoting sustainable development and provides new insights into the trade-offs that firms encounter in managing digital transformation, financial obligations, risk management, and sustainability initiatives. The influences of firm size, risk management, GDP, inflation, and financial leverage on ESG performance were emphasized. Our findings' implications have broad generalizations leading to the United Nations SDGs, the sustainability goals for 2030 and 2060, and collaboration to achieve a more sustainable and inclusive future in diverse economic contexts.

Our study findings highlight some policy implications for stakeholders seeking to ensure the benefits of digital transformation and innovations are harnessed for effective ESG practices and performance. Our findings suggest that investing in digital platforms enhances sustainability through service efficiency, accessibility, transparency, and accountability. Therefore, policymakers should prioritize integrating and expanding technological infrastructure to improve firms' ability to provide access to digital solutions in the markets they serve. Furthermore, our findings reveal a significant moderating effect of IPP on the impact of TFD on ESG performance; this indicates that government policy interventions play a crucial role in transformative economic growth through technology. However, it is imperative for governments to enact and promote digital transformation policies that create an enabling environment for firms to leverage financial technology to implement sustainable practices. According to the findings, BCU adversely truncates the impact of TFD on ESG performance. We suggest that policymakers, regulatory bodies, and government authorities adopt and implement strategies to mitigate the uncertainties in the business environment. We also assert that there is a need to uphold policy consistency, strengthen risk mitigation frameworks, support sustainable investments with incentives, and encourage long-term sustainability commitments. Furthermore, governments, regulatory bodies, and other relevant stakeholders should establish clear guidelines for measuring ESG considerations across various industries. This will assist in ensuring appropriate regulations for ESG performance measurement across the board. Additionally, collaboration is essential to accelerate tech-enabled solutions for ESG integration. Policymakers should consider cultivating collaborations to develop innovative financial solutions that align digital financial services with the objective of enhancing sustainability.

Institutional managers can find this study insightful in terms of how to harness and leverage digital financial tools to enhance ESG performance. First, managers can align digital financial resources with their firms' ESG objectives to improve sustainability outcomes by adopting blockchain-based financial transparency mechanisms, AI-driven sustainability analytics, and digital supply chain financing. Second, corporate managers should not shy away from actively engaging with government initiatives, such as the IPP, to enhance digital transformation strategies that support sustainability. By aligning business models with national digitalization policies, firms can improve their ESG performance while benefiting from government incentives. Third, this study highlights the challenges posed by business climate uncertainty. Hence, managers must develop risk mitigation strategies that balance financial sustainability with long-term ESG investments, incorporate ESG risk factors into enterprise risk management frameworks, and diversify their ESG investment

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portfolios. Fourth, digital financial technologies provide opportunities for firms to improve stakeholder engagement. Managers should leverage FinTech solutions, such as mobile banking, digital payment platforms, and financial inclusion initiatives, to foster transparent and inclusive ESG practices. Fifth, different industries exhibit varying ESG priorities. Managers should tailor digital financial strategies to industry-specific ESG needs, such as green FinTech solutions in the energy sector, digital microfinance for social sustainability, and AI-driven governance risk assessment in financial institutions.

This study offers robust empirical evidence of the connection between TFD and ESG performance, but also offers several avenues for future research. This study focuses on financial institutions in China. While financial institutions may have similarities across jurisdictions, regulatory frameworks may differ; hence, future studies should consider the role of regulatory frameworks in the nexus between TFD and ESG performance. Future research should conduct cross-country comparisons to examine how digital financial innovation influences ESG performance under different regulatory environments and economic conditions. Future research should explore industry-specific dynamics by analyzing the impact across diverse sectors, such as manufacturing, healthcare, and technology, as the mechanisms may differ across sectors. The availability of data restricted our study to a period of twelve years. Future studies should examine the effects of digital financial innovation on sustainability over a longer term. A longer time horizon would provide deeper insights into the causal relationship between TFD and ESG performance. This study primarily focuses on firm-level financial and economic indicators. Future research can also incorporate financial psychology (behavioral finance) perspectives to understand how ESG performance in digital financial ecosystems is influenced by managerial decision-making and investor perception. While this study uses standardized ESG performance measures, future research could explore alternative sustainability metrics, including carbon footprint reduction, social impact investments, and governance quality assessments, to provide a more nuanced understanding of ESG outcomes. Future studies can also explore the individual dimensions of ESG differently, to expand on the specific mechanisms through which technology affects each of the dimensions. Furthermore, our study used a dummy variable for the internet plus policy; which has its limitations, future studies could construct a continuous Internet Plus Policy Intensity Index using Provincial Digital Economy Investment or Broadband Penetration Rate. The findings of this study underscore the transformative potential of tech-enabled financial disruption in advancing ESG performance, which can help firms drive sustainable economic development while enhancing financial inclusion and corporate accountability. This can be achieved by integrating FinTech solutions, leveraging institutional policies, and mitigating business climate uncertainty. Collaboration between policymakers, governments, financial regulators, and corporate managers is important to create an enabling environment that fosters digital financial innovation as a strategic driver of ESG excellence and to achieve global sustainable development goals.

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# APPENDIX

**Table 2: Diagnostic Tests**

| **Heterogeneity Slope Test** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Delta | P-value | | | |
| | | | 47.748 | 0.000 | | | |
| | Adjusted Delta | | 53.664 | 0.000 | | | |
| **Shapiro-Wilk W Test for Normal Data** | | | | | | | |
| Variables | | Obs | W | V | z | Prob>z | |
| ESG | | 5,856 | 0.98678 | 41.201 | 9.804 | 0.00000 | |
| Tech-enabled Financial Disruptions | | 5,856 | 0.92817 | 223.948 | 14.268 | 0.00000 | |
| Internet Plus Policy | | 5,856 | 0.99951 | 1.513 | 1.092 | 0.13732 | |
| Business Climate Uncertainty | | 5,856 | 0.81446 | 578.476 | 16.77 | 0.00000 | |
| Firm Size | | 5,856 | 0.99373 | 19.546 | 7.838 | 0.00000 | |
| Transaction Magnitude | | 5,856 | 0.97745 | 70.284 | 11.212 | 0.00000 | |
| Macroeconomic Condition (GDP) | | 5,856 | 0.97112 | 90.039 | 11.865 | 0.00000 | |
| Risk Management | | 5,856 | 0.95850 | 129.391 | 12.821 | 0.00000 | |
| Socioeconomic Condition | | 5,856 | 0.92320 | 239.431 | 14.444 | 0.00000 | |
| Note: The normal approximation to the sampling distribution of W' is valid for 4<=n<=2000 | | | | | | | |
| **Shapiro-Francia W Test for Normal Data** | | | | | | | |
| Variables | | Obs | W | V | z | Prob>z | |
| ESG | | 5856 | 0.98726 | 43.105 | 9.625 | 0.00001 | |
| Tech-enabled Financial Disruptions | | 5856 | 0.92830 | 242.601 | 14.044 | 0.00001 | |
| Internet Plus Policy | | 5856 | 1.00000 | 0.000 | . | 0.00001 | |
| Business Climate Uncertainty | | 5856 | 0.81383 | 629.895 | 16.484 | 0.00001 | |

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| | | | | | | |
|---|---|---|---|---|---|---|
| Firm Size | 5856 | 0.99390 | 20.636 | 7.742 | 0.00001 | |
| Transaction Magnitude | 5856 | 0.97744 | 76.286 | 11.085 | 0.00001 | |
| Macroeconomic Condition (GDP) | 5856 | 0.97121 | 97.416 | 11.711 | 0.00001 | |
| Risk Management | 5856 | 0.95856 | 140.202 | 12.642 | 0.00001 | |
| Socioeconomic Condition | 5856 | 0.92310 | 260.191 | 14.223 | 0.00001 | |
| Note: The normal approximation to the sampling distribution of W' is valid for 10<=n<=5000 under the log transformation. | | | | | | |
| **Breusch-Pagan/Cook-Weisberg Test for Heteroskedasticity** | | | | | | |
| Test | Chi2(1) | Prob>Chi2 | Test | F(8, 5847) | Prob>F | |
| Fitted values of ESG | 51.19 | 0.0000 | Independent Variables | 16.78 | 0.0000 | |
| **White Heteroskedasticity/ Cameron and Trivedi's Decomposition IM Test** | | | | | | |
| Test | | H1 | Chi2(43) | P >Chi2 | | |
| White's test for heteroskedasticity | | Unrestricted | 318.78 | 0.0000 | | |
| **Cameron and Trivedi's IM Test Decomposition** | | | | | | |
| Source | | Chi2 | Df | p-value | | |
| Heteroskedasticity | | 318.78 | 43 | 0.0000 | | |
| Skewness | | 241.26 | 8 | 0.0000 | | |
| Kurtosis | | 57.82 | 1 | 0.0000 | | |
| Total | | 617.85 | 52 | 0.0000 | | |
| **Cross-sectional Dependence Test** | | | | | | |
| Test | | Value | P-value | | | |
| Pesaran | | 34.806 | 0.0000 | | | |
| Friedman | | 883.312 | 0.0000 | | | |
| Frees | | 12.825 | 0.0000 | | | |
| **Pesaran CIPS Analysis for Second-Generation Unit Root Test Results** | | | | | | |
| Variables | | Level | First Diff | Decision | | |
| ESG | | -2.999*** | - | I(0) | | |
| Tech-enabled Financial Disruptions | | 2.610*** | - | I(0) | | |
| Internet Plus Policy | | 2.610*** | - | I(0) | | |
| Business Climate Uncertainty | | -2.483*** | - | I(0) | | |
| Firm Size | | -3.198*** | - | I(0) | | |
| Transaction Magnitude | | -4.059*** | - | I(0) | | |
| Macroeconomic Condition (GDP) | | 2.610*** | - | I(0) | | |
| Risk Management | | 2.610*** | - | I(0) | | |
| Socioeconomic Condition | | 2.610*** | - | I(0) | | |
| Note(s): ***, **, and * indicate 1 percent, 5 percent, and 10 percent. | | | | | | |