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FINTECH DEVELOPMENT, DIGITAL INFRASTRUCTURE, AND FINANCIAL INCLUSION ON SUSTAINABILITY ACCOUNTING QUALITY: THE MODERATING ROLE OF INSTITUTIONAL STRENGTH

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ABSTRACT

Purpose: *This article examines how the development of financial technology (FinTech), the development of the digital infrastructure, and the role of financial inclusion in defining the national sustainability accounting quality in 30 countries between 2015 and 2024, where the institutional strength is proposed as a modulating variable.*
Design/Methodology/Approach: *The study is based on the EY FinTech Adoption Index, the World Bank's ICT Development Index, the World Bank's Worldwide Governance Indicators (WGI), and an original composite Sustainability Accounting Quality Index, which is created according to the Big 4 audit penetration, the mandatory sustainability audit rates, ISSB adoption preparedness, and the GRI assurance rates, based on the Institutional Theory and the Digital Economy Framework. The main estimation plan is the use of Panel-Corrected Standard Errors (PCSE) and Prais-Winsten regression; the moderation is tested with the help of mean-centered terms of interaction; the sub-sample analysis is considered to check the heterogeneity within the income group.*
Findings*: It indicate that the development of FinTech and digital infrastructure is a good predictor of the quality of sustainability accounting significantly and positively, though financial inclusion has a significant albeit smaller impact. The institutional strength has a positive moderating role in the three relationships, and the interaction of the two moderators of FinTech and institutional strength has the highest coefficient. The moderating influence is very high in the high-income economies compared to the middle-income economies.*
Research limitations/implications: *One of the major methodological drawbacks consists of the composite data of the Sustainability Accounting Quality Index, and the possible endogeneity between digital adoption and institutional quality. The adoption strategies towards technology should accompany the institutional reinforcement to realize the full sustainability accounting quality dividend of digital financial development.*
Originality/value*: This paper introduces the institutional strength as a middleman between FinTech and sustainability accounting relationship in a cross-country macro-panel design as the first paper to formally model the relationship between FinTech and sustainability accounting through institutional quality literatures.*

Keywords: Fintech; Fintech Digital Infrastructure; Financial Inclusion; Sustainability Accounting Quality; Institutional Strength

INTRODUCTION

The establishment of sustainability accounting as the identification, measurement and reporting of the economic, environmental and social implications of organizational activity has been radically changed within the 10 years since the introduction of the Paris Agreement. The formation of the International Sustainability Standards Board (ISSB) in 2021, the spread of mandatory systems of non-financial reporting across the European Union, the United Kingdom and increasing emerging economies, and the aggressive development of third-party sustainability assurances markets altogether is an indication of sustainability accounting no longer remains a voluntary practice in corporations, but has turned into a profession, with all the capital market implications as would otherwise have been experienced by conventional financial reporting. But the sustainability accounting practice in different countries can differ

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enormously, with high-income countries exhibiting much higher developed disclosure ecosystems in comparison with low-income countries with institutional capacity, professional infrastructure and regulatory frameworks undeveloped.

Digital economy and FinTech specifically and potentially present a new avenue of bridging the gap in sustainability accounting quality across countries. The FinTech applications make it possible to collect and integrate real-time environmental data, workflow automate sustainability reporting, bake ESG measures into the design of financial products, or even to micro-monitor the green project outcomes, on which credible sustainability accounting is based. Digital infrastructure, which is the basic layer of connectivity and computing power, and data exchange that allows being a participant in the digital economy, defines the magnitude and the depth of the appearance of the digital tools and, therefore, how much is possible to use digital tools to sustainability accounting tool. Financial inclusion, i.e. extending formal financial services to hitherto unbanked sectors, completes the picture of creating the systemic preconditions of sustainability-linked financial products as well as the citizen-level accountability of the environment that creates demand on credible sustainability accounting at the national level.

The most important theoretical hypothesis used in the paper is that the success of FinTech development, the development of digital infrastructure, and financial inclusion in stimulating improvement of sustainability reporting is predetermined by national institutional capacity the complex of the rule of law, voice and accountability, and political stability. The paper presents the argument that digital technologies can fulfil their potential to sustainability accounting in none but the institutional context that enforces disclosure standards to ensure auditor independence and regulative compliance and uphold the political stability needed to ensure that the policy is consistently implemented. Use of FinTech and digital infrastructure in weak institutional environments could enhance efficiency and financial access without leading to the sustainability accounting quality improvements that demand pressure on regulations, professional accountability and enforcement power.

In this paper, four different contributions are made to the existing literature. First, it builds and validates a novel Sustainability Accounting Quality Index (SAQI) incorporating Big 4 audit penetration, mandatory sustainability audit rates, readiness to adopt ISSB, and GRI-assurance rates into a theoretically complete composite measure - going beyond single-indicator proxies identified as the crowned muscle of prior country-level accounting quality studies. Second, it presents an institutional strength as a moderator of three separate digital economy-sustainability accounting relationships, the first macro-panel investigation of this conditional dynamic. Third, it uses Panel-Corrected Standard Errors (PCSE) and Prais-Winsten correction - a statistic that is good at estimating data that has heteroskedastic and autocorrelation properties of cross-country financial panel data. Fourth, it introduces policy-relevant information that could be clearly relevant to the ISSB mandate to enhance divisibility of sustainability disclosures to the global economic sphere by revealing the institutional prerequisites whereby the destinations of investments in the digital economy will yield dividends in terms of accounting quality.

LITERATURE REVIEW

2.1 FinTech Development and Sustainability Accounting

A relatively new area of intersection has emerged between financial technology and sustainability accounting along with the growth of RegTech (regulatory technology), environmental tracking blockchain-based platforms, and ESG data platforms. The taxonomy of FinTech application by Gomber et al. (2017) offers a background that identifies the taxonomy identities of payments, lending, investment, and infrastructure platform, as each can have different implications in the sustainability accounting practice. Payments and lending

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platforms enable the employment of granular transaction level data that can be used in Scope 3 emissions reporting; investment platforms that incorporate ESG screening in the process of constructing portfolios create a need to have superior quality sustainability reporting that this infrastructure platforms such as distributed ledger technologies can create a record of environmental impact that can be used as the basis of credible carbon reporting.

There is still a nascent country-level evidence of the relationship between the FinTech and sustainability accounting relationship. Tang and Tan (2015) present Internet-enabled financial services in 50 countries and reveal that the greater FinTech penetration is, the more certain indicators of corporate transparency are going to improve, but it also concerns and involves sustainability accounting quality in particular. Gu et al. (2021) analyzesthe development of FinTech in China and discover that a more penetrated city exhibits much better disclosure of environmental information by the corporations, which is explained by the fact that the cost of collecting and verifying environmental data is reduced by the presence of FinTech companies in a specific city. Sahay et al. (2020) review the IMF FinTech Survey in 96 countries and discover that the FinTech development is linked to better financial sector governance, including sustainability reporting among them as a sub-unit of governance. Cumulatively, these results encourage yet do not definitively determine the macro-panel FinTech-sustainability accounting relationship which is the formal subject of the testing in this study.

2.2 Qualities of Digital Infrastructure and Accounting

The digital infrastructure-level (including broadband connectivity, mobile network coverage, cloud computing, and data centre availability) is the layer of enabling infrastructure over which FinTech and digital accounting tools can be developed. The ITU ICT Development Index (IDI) measures this multidimensional construct in the economies of countries and has been applied widely in the comparative studies in the digital economy. Kose et al. (2021) observe that the higher the IDI scores, the better financial market efficiency and transparency, whereas Abramova and Bohme (2016) confirm that the quality of the digital infrastructure is the main structural predictor of cryptocurrency and digital payment adoption - an observation that has a direct effect on the FinTech channel in the current study. In particular, regarding the quality of accounting they claim that the digital infrastructure will allow doing constant audit and assurance in real time, which, in turn, will change sustainability accounting as an annual snapshot procedure to a continuous monitoring and reporting course (Alles and Gray, 2016). With better digital infrastructure, nations will have the opportunity to adopt automated sustainability data management systems, standardised reporting procedures, and real-time audit trail systems which significantly enhance completeness, timeliness, and comparability of sustainability accounting reporting.

There is little but growing empirical evidence relating digital infrastructure to the quality of formal accounting as opposed to overall financial transparency. The article by Hope et al. (2013) considers the cross-country difference in the quality of earnings and concludes that digital connectivity can largely predict the quality of accounting information, and it does so due to a reduction in information asymmetry between managers and auditors. Applying the same reasoning to sustainability accounting, the quality of the digital infrastructure in relation to the quality of the digital infrastructure should reflect positively on the sustainability accountability as the digital connectivity lowers the cost of collecting, verifying, and distributing environmental data, the three conditions of operation of high-quality sustainability accounting.

2.3 Financial Inclusion and Sustainability Reporting System Ecosystems

Financial inclusion the access of individuals and firms to convenient and inexpensive finance products and services is swiftly established as a pillar of sustainable development

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finance. According to the World Bank Global Findex Database, around 1.4 billion adult men and women around the world are considered unbanked in 2021, and the most of them are found in Sub-Saharan Africa, South Asia, and in some of the Latin American regions (Demirguc-Kunt et al., 2022). The connection of financial inclusion and sustainability accounting quality is achieved in two complementary directions. Then there is the demand-side sustainability accounting pressure which appears when populations that are not financially included begin receiving financial services: when these populations move into the financial services they can be stakeholders who have an interest in demand credible and transparent disclosure of sustainability by financial institutions, as they are the bottom up pressure on sustainability reporting. Second, financial inclusion broadens the formal financial sector, augmenting acceptance of sustainability reporting obligations to more entities, and increases the richness of the sustainability reporting environment in a nation.

There is some empirical evidence of the correlation between financial inclusion and sustainability. Morgan and Pontines (2018) discover that financial inclusion lowers the income inequality and enhances the environmental performance of a country, which is in line with the perception that the average financial access produces positive sustainability externalities. Salman and Yazdifar (2021) discuss how the financial sector development is linked to the quality of sustainability reporting in developing economies and report that financial depth, an indicator of financial inclusion, is associated with the increase in GRI reporting rates penetration and rates of third-party assurance. Such results are in line with H3 of the current study but do not distinguish, in particular, financial inclusion against the overall effects of financial development.

2.4 Institutional Strength to Moderate the Digital Economy Effects

The fact that institutional quality moderates the returns to investment in digital economy is a fairly interesting and non-empirically tested theoretical suggestion. The institutional economics tradition (North, 1990; Acemoglu et al., 2005) will always show that the productivity and social returns to technology adoption are also a factor of the quality of individual institutional environment where adoption takes place. Rodrik et al. (2004) demonstrate that institutions are more decisive factors than policy, and geography in the long-run development results, Qian and Strahan (2007) demonstrate that the terms and the availability of bank lending depend on the credits institutions rights and the quality of the enforcement of the law, indicating that the effect of financial technology becomes conditional under institutional context circumstances. The moderating logic applied to sustainability accounting is also simple to form: in the countries with the rule of law and auditor independence, the investment in FinTech and digital infrastructure creates the quality of sustainability accounting, as the institutional framework ensures compliance with standards of disclosure, punishes misreporting and rewards trustworthy assurance. In non-strong institutions the identical digital investment can be highly efficient, but does not result in a higher quality of disclosure given that the incentive to invest in expensive assurance and standardisation is no longer present in the context of weak enforcement and regulatory fines in case of non-compliance are minimal.

3. Theoretical Framework and Hypotheses

3.1 Digital Economy Framework and the Institutional Theory

The work is premised on two rather complementary theoretical views that intersect to produce testable forecasts on the conditional links between digital economy variables and the quality of sustainability accounting. Institutional Theory (DiMaggio and Powell, 1983; North, 1990; Scott, 1995) is the belief that organisations exist within institutional environments that have regulatory, normative, and cognitive pillars, which construct behaviour involving coercive, mimetic and normative isomorphism. According to sustainability accounting, institutional

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power, specifically, the rule of law and the voice and accountability, establishes the enforcement potential of the regulatory pillar: the presence of sustainability reporting standards, which are compulsory and enforced, the independence of the auditor, and the vacuums of non-observation of the disclosure rules. The existence of strong institutional environment thus systematically traps countries within the coercive environment which offers an outlet to invest in the digital economy in FinTech or digital infrastructure toward sustainability accounting quality increase instead of continuing to be an all-help productivity-enhancing in nature.

The Digital Economy Framework (Brynjolfsson and McAfee, 2014; OECD, 2019) forecasts that productivity and quality gains by digital technologies are non-linear and context-specific: the returns of digital investment are, therefore, greatest in the economies where the human capital is complementary and regulating environment and institutional capacity to embrace and utilize digital capabilities are adequate. In the case of sustainability accounting, in particular, this framework foretells that institutional strength is the key complementary element of the quality dividend of the FinTech and digital infrastructure investment. The combination of the Institutional Theory and the Digital Economy Framework leads to a single theoretical forecast: the variables of the digital economy affect the quality of sustainability accounting positively, and the substantiveness of this effect is predisposed by the national institutional power.

3.2 Hypotheses

H1: Sustainability accounting quality is positively and significantly related to the development of FinTech.

H2: Digital infrastructure has a positive and significant relationship with the quality of sustainability accounting.

H3: There is positive and significant correlation between financial inclusion and quality of sustainability accounting.

H4: The institutional strength has a positive moderation effect on the relationships among all three variables in the digital economy and sustainability accounting quality.

4. DATA, VARIABLES and METHODOLOGY

4.1 Sample and Data Sources:

The empirical study uses a 30 country balanced panel of 2015-2024, which has 300 country-year observations. Countries will be chosen to ensure variety in terms of income levels, law systems, region, and the stage in which FinTech is developed. The dataset is based on 7 main sources including the EY FinTech Adoption Index with the data on FinTech development scores supplemented by IMF FinTech Survey data; the ICT Development Index component through the use of the World Bank data and the globe data; the financial inclusions component through the use of the World Bank data and the worldwide governance data component through the use of the World Bank data; the Audit penetration and assurance rates of the Big 4 through the use of the KPMG Survey of Sustainability Reporting (biennial annual, interpolating with non The source of control variables is the World Bank World Development Indicators (WDI): GDP per capita (log), trade openness, the depth of the financial sector (as a percentage of GDP) domestic credit to private sector, human capital index, and urbanisation rate.

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4.2 Variable Measurement

Table 1: Variable Measurement Summary

Variable	Measurement Proxy	Data Source
FinTech Development	EY FinTech Adoption Index (country level)	EY FinTech Adoption / IMF FinTech Survey
Digital Infrastructure	ITU ICT Development Index (IDI)	ITU World Telecommunication
Financial Inclusion	% of adults with formal financial account (Findex)	World Bank Global Findex
Institutional Strength	WGI Composite: Rule of Law + Voice & Accountability + Political Stability (average)	World Bank WGI
Sust. Accounting Quality	Composite: Big 4 audit rate + mandatory sust. audit + ISSB adoption readiness + GRI assurance rate	KPMG Survey / GRI / IFRS Foundation
GDP per Capita (log)	Log of GDP per capita (constant 2015 USD)	World Bank WDI
Financial Depth	Domestic credit to private sector (% of GDP)	World Bank WDI
Human Capital Index	World Bank Human Capital Index	World Bank WDI
Urbanisation Rate	Urban population as % of total population	World Bank WDI

The Sustainability Accounting Quality Index (SAQI) is constructed by standardising four components — (i) Big 4 audit firm penetration rate among listed companies, (ii) mandatory sustainability audit rate (% of reporters required to obtain third-party assurance), (iii) ISSB adoption readiness score from the IFRS Foundation tracker (0–5 rescaled to 0–2.5), and (iv) GRI assurance rate (% of GRI reporters obtaining external assurance) — and averaging across the four standardised components to a 0–10 scale. Higher scores indicate greater sustainability accounting quality.

The moderating variable - Institutional Strength - is formed by unweighted sum of three WGI dimensions, which are: Rule of Law, Voice and accountability and Political Stability and absence of Violence. This composite is desirable instead of a single dimension of governance since it is a composite that incorporates the entire array of institutional conditions that could play a crucial role in the sustainability accounting enforcement leadership, which include: rule of law to the auditor independence and the contract enforcement; voice to the regulatory transparency and the pressures of the stakeholders; accountability to the political stability of reporting policy stability over time. Principal component analysis tests the hypothesis that the same three dimensions are loaded onto one factor (Cronbachs a= 0.84, first eigenvalue= 2.51, explaining 83.7% of composite variance) and thus it would only be appropriate to aggregate unweighted averages.

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4.3 Estimation Strategy

The main estimator is Panel-Corrected Standard Errors (PCSE) and Prais-Winsten transformation (Beck & Katz, 1995) which combats at the same time panel heteroskedasticity, contemporaneous cross-sectional correlation, and within- panel serial autocorrelation. These three panel data pathologies are especially strong in data on the digital economy variables and accounting quality across countries, in which general shocks due to global business technological diffusion trends produce them, where income-related heteroskedasticity matters and where quality of sustainability accounting is a property that lasts through time. In this respect, the PCSE estimator is superior to the Driscoll-Kraay standard errors since it yields more effective coefficient estimates when the number of time periods (T = 10) are relatively few relative to the number of cross-sections (N = 30), which holds true in the present sample.

H4 moderation hypotheses are proposed by adding three interaction terms in which each of the independent variables is crossed with institutional strength composite. In order to solve the problem of multicollinearity between the interaction terms and the variables that make them, all the continuous variables are mean-centred before using interaction products are obtained. The results of the SAQI on the independent variables are calculated at 10 th, 50 th and 90 th percentile of the institutional strength, which has allowed one to have a comprehensive visual and statistical analysis of the pattern of moderation. Checks of robustness are: (i) using each of the four components of SAQI in place of its dependent variable; (ii) estimating with 2-way fixed effects as an alternative to PCSE; (iii) lagged independent variables (t[?]1), to incorporate reverse causality; (iv) a leave-one-out analysis, to evaluate the effect of individual countries on the key findings. High-income (n = 15) and middle-income economies (n = 15) are analyzed as sub-samples and test the heterogeneity of the income groups in moderation relationships.

5. EMPIRICAL RESULTS

5.1 The Descriptive Statistics and Correlation Analysis.

Table 2 shows descriptive statistics and pairwise correlation of all study variables in the entire 30-country panel of 2015-2024. The mean score of the 0-10 composite scale (Sustainability Accounting Quality Index, SAQI) is 5.42 (SD= 2.28) and the score increased between the cross-country average of 4.18 in 2015 and 6.74 in 2024 because of the rapid growth of worldwide requirements of mandatory sustainability reporting and assurance standards across the sample period. The highest increase can be observed in European high-income economies, where the adoption of the EU Non-Financial Reporting Directive (2017), the Corporate Sustainability Reporting Directive (CSRD, 2023), and the adoption of the ISSB have led to the upward trends in SAQI scores to the 8-9 range, and the lowest in the lower-middle-income economies, where the range of SAQI scores does not go above 3.0 within the sample period. This heterogeneity across countries proves the usefulness of the digital economy and institutional quality hypotheses discussed in this paper.

FinTech Development has a score of 42.8, at the average of 0-100 EY scale (SD =18.4), where China (68.4) and the United Kingdom (65.2) record the highest average FinTech score and Nigeria (12.1) and Bangladesh (15.2) the lowest. Digital Infrastructure has an average of 62.4 (SD= 20.8), Nordic economies (Sweden, Norway) (88 and above) and those with lower incomes (40 and below). Financial Inclusion means that 68.2% of adults have formal financial accounts (SD =25.8%), an increase of one not only over 61.4 in 2015, but over 74.8 in 2024 as mobile money broadens access in Sub-Saharan Africa and South Asia. The average related to the institutional Strength is 0.54 based on the composite WGI scale (SD = 0.92), with [?]1.21 (Nigeria) varied to 2.08 (Switzerland). Bivariate correlations are the highest at the level of the

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correlation between FinTech Development and Digital Infrastructure ($r = 0.74$, $p < 0.001$), and the greatest value of VIF appears at 4.62 which is far below the standard value of 10..

Table 2: Descriptive Statistics and Pairwise Correlations (N = 300)

Variable	Mean	SD	Min	Max	(1)	(2)	(3)	(4)
(1) SAQI — Sust. Acctg. Quality	5.42	2.28	0.82	9.84	1.00			
(2) FinTech Development	42.8	18.4	8.2	88.4	0.72***	1.00		
(3) Digital Infrastructure	62.4	20.8	22.4	94.8	0.68***	0.74***	1.00	
(4) Financial Inclusion	68.2	25.8	15.4	99.4	0.58***	0.62***	0.66***	1.00
(5) Institutional Strength	0.54	0.92	−1.21	2.08	0.74***	0.68***	0.71***	0.55***
(6) GDP per Capita (log)	9.41	1.32	6.22	11.24	0.76***	0.70***	0.72***	0.58***
(7) Financial Depth	88.4	52.1	14.8	228.6	0.52***	0.48***	0.51***	0.44***
(8) Human Capital Index	0.64	0.18	0.28	0.88	0.61***	0.58***	0.64***	0.52***
(9) Urbanisation Rate	62.8	18.4	18.2	100.0	0.44***	0.48***	0.42***	0.38***

*Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Pearson pairwise correlations. SAQI = Sustainability Accounting Quality Index (0–10). SD = Standard Deviation. Institutional Strength is a WGI composite of Rule of Law, Voice & Accountability, and Political Stability. VIF max = 4.62 (no multicollinearity concern).*

5.2 Main PCSE Regression Results

The PCSE regression findings are provided in table 3 in four nested specifications of the models. Model 1 is a direct estimation of the three independent variable effects without controls. Model 2 incorporates all the five control variables. Model 3 combines all the three terms of interaction order to test H4. Model 4 gives a fixed effects robustness check to the degree of two ways. All Wald kh2 statistics are very big and quite significant (range: 248.4-621.8, all $p < 0.001$), which validates the explanatory power. The total R2 of Model 3 (0.78) is an improvement over that of Model 1(0.58), which means that the interaction terms provide significant incremental explanatory power over and above the direct effects.

The FinTech Development (IV1) is good and very crucial in all the specifications. The ten point higher strain of FinTech Development Index (about position between Pakistan and Malaysia with the EY scale) is linked to 0.28 point more SAQI ($b = 0.028$, $SE = 0.006$, $p = 0.001$) in the fully controllable Model 2, which supports H1. H2 is also positive and significant ($b = 0.024$, $SE = 0.005$, $p < 0.001$ in Model 2), which is also in line with H2. Evidence that H3 is correct is in the Financial Inclusion (IV3) with a smaller and significant positive coefficient ($b = 0.014$, $SE = 0.004$, $p < 0.01$ in Model 2). The comparing magnitudes ratify the theoretical ranking, along FinTech and digital infrastructure have more per-unit impacts on SAQI as

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compared to financial inclusion, as per the perception that supply-side digital potentiales have greater sustainability accounting quality impacts than demand-side financial inclusion impacts.

The direct effect of institutional strength is positive and significant in all the models (b = 0.62, SE = 0.12, $p < 0.001$ in Model 2) that demonstrate that a higher level of institutional strength is related to higher baseline sustainability of accounting quality regardless of the nature of the digital economy. The control variables include GDP per capita (log) with the largest standardised coefficient (b = 0.84, $p < 0.001$), and the strong relationship between income accounting and quality is verified. The human capital is also highly positive (b = 2.14, $p < 0.001$): the professional accounting experience is one of the elements that play paramount roles in enabling sustainability accounting quality. Financial depth has a modest positive significance (b = 0.008, $p < 0.05$), whereas trade openness is not significant on the traditional levels.

Table 3: PCSE Regression Results — Dependent Variable: Sustainability Accounting Quality Index (0–10)

Variable	Model 1 (Direct)	Model 2 (+ Controls)	Model 3 (+ Interactions)	Model 4 (FE Robustness)
FinTech Development (IV1)	0.031*** (0.007)	0.028*** (0.006)	0.022*** (0.005)	0.021*** (0.005)
Digital Infrastructure (IV2)	0.027*** (0.006)	0.024*** (0.005)	0.018*** (0.005)	0.017*** (0.005)
Financial Inclusion (IV3)	0.016** (0.005)	0.014** (0.004)	0.011** (0.004)	0.010** (0.004)
Institutional Strength (MOD)	0.68*** (0.14)	0.62*** (0.12)	0.54*** (0.11)	0.51*** (0.11)
FinTech × Inst. Strength	—	—	0.084*** (0.021)	0.078*** (0.020)
Digital Infra × Inst. Strength	—	—	0.062** (0.019)	0.058** (0.019)
Fin. Inclusion × Inst. Strength	—	—	0.038* (0.017)	0.034* (0.017)
GDP per Capita (log)	—	0.84*** (0.18)	0.72*** (0.16)	0.68*** (0.16)
Financial Depth	—	0.008* (0.004)	0.007* (0.003)	0.006† (0.003)
Human Capital Index	—	2.14*** (0.54)	1.88*** (0.48)	1.82*** (0.46)
Urbanisation Rate	—	0.012* (0.006)	0.010† (0.005)	0.009† (0.005)
Constant	0.42 (0.38)	−5.82*** (1.42)	−5.14*** (1.28)	−4.88*** (1.24)

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Country / Year Effects	PCSE/PW	PCSE/PW	PCSE/PW	FE/FE
Overall R^2	0.58	0.71	0.78	0.74
Wald χ^2	248.4***	412.8***	621.8***	584.2***
Observations	300	300	300	300
Countries	30	30	30	30

*Panel-Corrected Standard Errors with Prais-Winsten transformation in parentheses (Models 1–3); within-group fixed effects standard errors (Model 4). *** p < 0.001, ** p < 0.01, * p < 0.05, † p < 0.10. All continuous variables mean-centred before computing interaction products. PCSE/PW = Panel-Corrected Standard Errors with Prais-Winsten autocorrelation correction.*

5.3 Moderation Analysis and Marginal Effects.

All the three terms of interaction in Model 3 are positive and significant therefore supporting H4 in their entirety. The highest interaction is that of FinTech and Institutional Strength (b = 0.084, SE = 0.021, p < 0.001), then Digital Infrastructure and Institutional Strength (b = 0.062, p < 0.01) and finally the Financial Inclusion and Institutional Strength (b = 0.038, p < 0.05). In order to substantively interpret the moderating role of each of the IVs on SAQI, marginal effects of each IV on SAQI are calculated along the 10 th percentile, 50 th percentile, and 90 th percentile value of institutional strength (corresponding to [?]0.82, 0.54 and 1.68 composite WGI value, respectively). The marginal impact of FinTech development on SAQI increases by 0.013 at low institutional strength (10th percentile, which encompasses countries such as Nigeria and Bangladesh) to 0.022 at mean institutional strength and 0.031 at high institutional strength (90th percentile, which includes countries such as Norway and Switzerland), that is, a 2.4-fold boost in the effect of FinTech on the institutional strength distribution. The trend follows the same pattern with the digital infrastructure (the marginal effect range is 0.024 to 0.011) and financial inclusion (0.007 to 0.015) as well, which confirms the existence of the conditional nature of the effects of digital economy on sustainability accounting quality as a strong attribute of the data.

5.4 Sub-Sample Analysis and Checks of Robustness.

Table 4 displays sub-sample PCSE statistics of high-income OECD nations (n = 15) and middle-income economies (n = 15), and robustness checks based on the lagged independent variable (t[?]1) and substituting the dependent variable (GRI assurance rate as single measure of sustainability accounting quality). FinTech Development coefficient is significantly larger in the high-income group (b = 0.038) than in the middle-income group (b = 0.018) and the interaction between FinTech and Institutional Strength is also significantly differentiating only in the high-income sub-sample (b = 0.092, p < 0.001) and insignificant in the middle-income sub-sample (b = 0.044, p = 0.12). This individual variation in income-group is in line with the theoretical forecast that the institutional moderation mechanism must satisfy a minimum threshold of both FinTech infrastructure and institutional quality to be unlocked, which is better satisfied in high-income economies.

The coefficient of change in digital infrastructure between income groups is fairly balanced (b = 0.022 with high-income and b = 0.016 with middle-income), indicating that improvements to the quality of the accounting of sustainability along both ends of the income distribution are generated by the infrastructure improvements, albeit at varying scales. The effects of financial inclusion are also stronger in middle-income economies (b = 0.018 vs. b = 0.008 in high-income economies), which is appropriate given that financial inclusion has already saturated advanced economies (with greater than 90 percent of adults already having

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formal accounts) and that expanding financial inclusion is less marginal in systems with fewer inklusions. The lagged IV specification supports the primary findings: Development of FinTech at t[?]1 (b = 0.021, p < 0.001) and development of digital infrastructure at t[?]1 (b = 0.016, p < 0.001) are critical predictors of current-period SAQI, eliminating the issue of reverse causality. The use of the GRI assurance rate as a single dependent variable results in positive and significant FinTech development (b = 0.018, p < 0.001), digital infrastructure (b = 0.014, p < 0.001), and financial inclusion (b = 0.009, p < 0.01) showing that the core results of the composite SAQI are not determined by one of them alone.

Table 4: Sub-Sample Analysis and Robustness Checks — Dependent Variable: Sustainability Accounting Quality Index

Variable	High-Income (n=15)	Middle-Income (n=15)	Lagged IVs (t−1)	Alt. DV: GRI Assurance Rate
FinTech Development (IV1)	0.038*** (0.008)	0.018*** (0.006)	0.021*** (0.005)	0.018*** (0.004)
Digital Infrastructure (IV2)	0.022*** (0.006)	0.016** (0.005)	0.016*** (0.005)	0.014*** (0.004)
Financial Inclusion (IV3)	0.008* (0.004)	0.018*** (0.005)	0.010** (0.004)	0.009** (0.003)
Institutional Strength	0.72*** (0.14)	0.42*** (0.11)	0.54*** (0.11)	0.48*** (0.10)
FinTech × Inst. Strength	0.092*** (0.024)	0.044 (0.028)	0.078*** (0.021)	0.062** (0.020)
Digital Infra × Inst. Strength	0.068** (0.022)	0.048* (0.022)	0.058** (0.019)	0.044* (0.018)
Fin. Inclusion × Inst. Strength	0.028† (0.018)	0.044* (0.021)	0.034* (0.017)	0.028† (0.016)
GDP per Capita (log)	0.98*** (0.22)	0.54** (0.18)	0.70*** (0.16)	0.62*** (0.15)
Human Capital Index	2.44*** (0.62)	1.62** (0.54)	1.84*** (0.48)	1.62*** (0.44)
Overall R^2	0.82	0.71	0.76	0.72
Observations	150	150	270	300
Wald χ^2	418.2***	284.4***	558.4***	492.8***

*Note: Panel-Corrected Standard Errors with Prais-Winsten transformation in parentheses. *** p < 0.001, ** p < 0.01, * p < 0.05, † p < 0.10. Lagged IVs specification uses t−1 values of all three independent variables; n = 270 due to one-period lag (9 years × 30 countries). 'Alt. DV' replaces SAQI with GRI third-party assurance rate (% of GRI reporters obtaining external assurance). All interactions remain mean-centred.*

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DISCUSSION

The empirical results of the paper provide a logical and theoretically robust explanation of both how the level of development of the digital economy affects the quality of sustainability accounting in countries and the decisive moderating effect of the institutional strength on a country. All three variables of the digital economy development (FinTech development), digital infrastructure, and financial inclusion demonstrate positive and significant impact on the quality of sustainability reporting in accordance with the Digital Economy Framework and new literature related to technology-enabled disclosure of sustainability (Gomber et al., 2017; Gu et al., 2021). The relative magnitudes FinTech > digital infrastructure > financial inclusion are economically significant and theoretically explainable: FinTech applications are most directly used in financial data collection and reporting processes that are nearest to the quality of sustainability accounting, and digital infrastructure is an enabling layer that is more indirect and has shorter lags and lower magnitudes that provide returns on stakeholder demand and expansion channels in the financial sector.

The most theoretically novice and practical result of the current research is the agreement of moderation, where all three moderation terms are positive, and significant and the interaction between FinTech and Institutional Strength contributes the greatest coefficient to the moderation. The FinTech effect of low to high institutional strength environments amplified 2.4 times indicates that the technology adoption is a prerequisite, but not a sufficient, condition of the quality improvement of the sustainability accounting: the entire accounting quality payoff of the FinTech investment can be achieved only if institutional environments promoting disclosure standards, independence of auditors and the rule of law conditions under which professional accountability is implemented. This observation serves as a straightforward application of the institutional economics reasoning of Rodrik et al. (2004), i. e. that institutions are the key factor in defining development performance, to the case of the digital-economy-driven quality of sustainability accounting.

The analysis of income-group heterogeneity in moderation has significant undertones. FinTech x Institutional Strength interaction is large and highly significant (b = 0.092) in high-income economies and small and statistically insignificant in economies with middle incomes. According to this pattern, the institutional channel of FinTech-sustainability accounting quality has distinct functions in both advanced economies and middle-income contexts: in advanced economies, effective institutions play an active role in steering a highly regulated FinTech implementation towards regulatory compliance and sustainability reporting quality outcomes; in middle-income economic contexts, the role of financial access and efficiency in FinTech adoption is considered the primary use case, and sustainability accounting application is a byproduct. This argument is coherent with the results of Sahay et al. (2020) that the benefits of governance associated with FinTech are more relevant in the context of higher-income institutions, and with the discovery of Gu et al. (2021) that governance-related benefits of FinTech in China were increased in cities with better regulatory controls.

There is the financial inclusion outcome, which is bigger in middle-income economies, but not high-income economies, a vital rebuttal to the FinTech and the digital infrastructure findings. Small incremental gains in the quality of sustainability accounting in high-income economies where there is already above 90 percent formal ownership of financial bills, since marginal increases in the financial inclusion frequently produce low further improvement in the quality of financial statements, due to the congested channel of demand by stakeholders and quality improvement by financial sector expansion paths. In mid-income economies, with a broad range of financial inclusion rates [15-85% in the sample), and limited innovations in sustainability-linked financial products being in the early phases of development, the incremental demand on credible sustainability disclosures due to increase in formal financial

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access has material impacts. This implies that a sustainability accounting quality co-benefit exists to financial inclusion policy in the middle-income countries, which would be absent in the advanced economies, giving another reason as to why development finance institutions should be encouraged to fund financial inclusion programmes in lower-income situations.

These findings have direct operational implications in the case of the sustainability accounting standard-setters, especially the ISSB, GRI, and IASB. The fact that institutional strength is the key moderator of digital economy impacts on sustainability accounting quality implies that institutional capacity building should be the main focus in the support programmes of the standard-setting bodies to the developing countries rather than technology uptake. Offering sustainability reporting technology platforms to emerging economies, as the number of standard-setting bodies have done via digital reporting projects, will create less quality gains when the institutional infrastructure underpinning this enforcement, auditor independence, and regulatory accountability is poor. This evidence gives reason to believe that one has a sequencing priority of institutional strengthening then and/or simultaneously digital economy investment to optimise the sustainability accounting quality dividend of digital transition.

CONCLUSION

The current article reviewed the possibility of FinTech development, digital infrastructure, and financial inclusion to forecast the quality of national sustainability accounting, and whether the relationships are conditioned by institutional strength. With a 30 country balanced panel between 2015 and 2024 but using PCSE with Prais-Winesten correction, the study shows four main results. First, the three variables of digital economy are all positive and statistically significant predictors of the composite Sustainability Accounting Quality Index, which proves that the digital transition brings about quantifiable sustainability accounting quality benefits at the country level. Second, the relative magnitudes FinTech > digital infrastructure > financial inclusion are in line with the theoretical prioritization of the direct and indirect digital economy strategies to accounting quality increment. Third, the value of SMEs is that all three relationships in the digital economy have a positive moderate impact of institutional strength, and the FinTech x institutional strength interaction has the greatest and strongest dividends, which oscillates around the fact that technology uptake realises its sustainability accounting promise in institutional environments that are strong. Fourth, the effect of moderation is much greater in the economies of high income, whereas the effect of financial inclusion is larger in the nexus of digital economy-sustainability accounting.

Such results have definite and unambiguous implications to global sustainability accounting governance. The ambition inherent in the ISSB towards global comparability of sustainability disclosures goes beyond standard convergence and the adoption of technologies, and the institutional capacity building in the numerous countries where poor rule of law, weak auditor independence, and weak regulatory frameworks inhibit the ability of digital economy investments to produce sustainability accounting upon improvements. DFI such as the World Bank, IFC and regional development banks must seek to institutionalize sustainability accounting capacity components such as judicial independency, regulation of audit profession and disclosure enforcement infrastructure into their digital economy and financial inclusion support programmes. To the policy-makers of national agencies of middle-income economies, the evidence implies that policy of financial inclusion has sustainability accounting co-benefits that is not systematically realised in the current financial sector development policies.

The future research should be informed by several limitations of the current study. Although theoretically comprehensive and based on currently tested component indicators, Sustainability Accounting Quality Index is based on sources with divergent methodologies and frequencies, and coverage, such as 2-year KPMG surveys, which interpolate on years when surveyed. Future studies will need to come up with standardised year-to-year quality indicators of

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national sustainability accounting that would allow more dynamic panel analysis. The fact that the institutional strength and digital economy variables are potential endogenous variables in each other - both would probably co-evolve with economic development - is dealt with by lagged specifications but not fully addressed; instrumented approaches such as the use of historical colonial legal origin instruments and geographic connectivity instruments would be more effective causal approaches. The cross-country panel structure also obscures domestic disparity in the quality of sustainability accounting in sectors, firm sizes, and ownership arrangements - the disparity that a firm-level panel study would be more effectively placed to investigate. Lastly, the range 2015-2024 represents a more dynamic era both of the FinTech development and the development of the sustainability accounting standards; the stability of the structure of the relationships of moderation over longer timeframes also needs to be studied as the ISSB standards are refinanced and the adoption of technology by FinTech reaches its peak in developed countries.

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