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The Role of FinTech and Institutional Quality in Enhancing Economic Readiness amid Climate Risks

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ABSTRACT

Purpose: We explore how institutions's adaptability, FinTech and business age dynamics intersect in the emergence of economic readiness for climate adaption across a range of national contexts.
Method: Based on panel data analysis of 80 countries over a span of ten years, this study utilizes fixed effects regression; moderation analysis using SPSS Macro; quantile regression; and robustness checks, including lagged variables and panel-corrected standard errors, to confirm the robustness of the results.
Findings: FinTech has a significantly positive influence on economic preparedness, and this influence is moderated by institutional quality and firm development stage. Digital financial innovations have a deeper impact on countries with more dynamic institutions and structurally more developed business environments. Quantile regression shows that such an effect becomes more pronounced in relatively high-achieving economies, while regional analysis demonstrates that advanced economies make better use of FinTech than developing economies.
Novelty: Laying out the contextual conditions under which FinTech can create economic resilience, this study serves to connect digital finance and sustainability. Contrary to earlier works which examine only the technological and economic aspects, this study included institutional and business structure factors in the nexus between FinTech and readiness to adopt it.
Implications: The results show that there is no one-size-fits-all approach to FinTech by policymakers and diverse international development organisations. Instead, investments in institutional reforms and business development are critical in unleashing the full potential of FinTech in climate preparedness efforts.

1. Introduction

The increasing risks posed by climate change have raised the stakes for businesses to, ideally, adopt more sustainable and resilient financial strategies. The current state of the climate is a "global boiling point" according to the United Nations and institutions and firms should increasingly rely on innovation and adaptative mechanisms, it suggests. FinTech has become an important enabler to this development. He, Zhang, and Wang (2024), for example discovered that FinTech based supply chain financing had a significantly positive impact on the resilience of small enterprises in China. Wang et al. (2024), demonstrated that the growth of FinTech led to an improvement in environmental performance by lowering the level of carbon intensity of firms. Xiaobin et al. (2024), showed how FinTech can allow a broader access to green energy finance, in particular in South-East Asia. Bassett Jones (2023), found that FinTech can reduce constraints to climate investment by democratizing access to adaptation capital.

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Combined, these analyses illustrate FinTech's potential to increase economic preparedness and resilience to climate risk.

Nevertheless, there are some challenges that still need to be resolved. One, the manner of consolidation of FinTech with sustainable adaptation practices is generally sketchy, and at variance among countries, particularly where they have weak or non-functional institutional architectures. Tran et al. (2024), stressed that institutional quality play a key role in effectiveness and legitimacy of FinTech interventions. Murinde, Rizopoulos, and Zachariadis (2022), pointed out that most of the FinTech promises would not be realised without a good governance structure. What is more, to date, there is still a lack of research examining how firm-level maturity may affect the rationale for FinTech adoption moving from short term profit seeking at early stage to long term sustainable commitment (Yu and Li 2024).

The theoretical foundations are the Resource-Based View Barney (2018), Institutional Theory (North, 1990). RBV suggests that the adoption of FinTech, institutional quality and sustainable innovation are important strategic resources that help companies to enhance their reactivity in the face of environmental exigencies. At the same time, Institutional Theory suggests that exogenous structures including legal regulations, policies environment, and governance practice shape whether firms internalize and utilize these digital financial tools effectively. Inthis regard, these theoretical perspectives offer a rationale for examining there relationship between firm specific capabilities and systemic institutional factors as drivers of economic readiness in a climate risk context (Bag et al. 2023).

However, existing studies provide mixed and disconnected evidences around the association of FinTech adoption, institutional quality, sustainable financial innovation, and economic readiness, in particularly business maturity as a moderating variable. Koranteng and You (2024), Meraj, Ishrat, and Kaur (2025) identified FinTech as beneficial for SME financial resilience, but they did not control for institutional capacity which limits our understanding of cross-country comparability. Hasan et al. (2024), Udeagha and Ngepah (2023), discussed the applications of FinTech for green access to finance, yet did not analyze how the various stages of business development shape sustainability transitions. Siddik, Rahman, and Yong (2023), Sun et al. (2024) demonstrated that FinTech enhances environmental performance but does not provide the role of firm level logic such as the maturity. Hauashdh et al. (2024), Xia, Semirumi, and Rezaei (2023), emphasized the importance of the institutional framework but did not analyze the effect of business properties of the air carriers, particularly the life cycle phase, on the result of the adaptation. Nazuri, Mohamed, and Mohd Daud (2025), argued that the benefits of FinTech depend on firm size and firm maturity, whereas Bai et al. (2023), Li (2022), the impact of digital innovation decreases in more advanced business stages contrary to the assumption of a linear progression. Early stage FinTech adopters focus on profitability not sustainability implications for transition thresholds Ahmad et al. (2024), demonstrated that early-stage FinTech adopters are driven by profitability and not sustainability. Liu et al. (2024), Liu, Tian, and Long (2025), found that institutional quality determines FinTech efficiency only under the condition that firms hold strategic orientation focused on long term viability. These facets highlight the theoretical and empirical void, whereby there has been no comprehensive model to link FinTech, institutional quality, and sustainable financial innovation and business maturity as a dynamic moderator (Rahman 2024). In this way, this research contributes novelty by testing empirically the way in which business maturity changes the strength and direction of these relationships across economies, thereby providing a sophisticated model to explain business economic readiness amid climate uncertainty.

In light of climate-related risks, admission of FinTech, institutional quality and sustainable financial innovation have drawn public attention. A second contribution is to examine how business maturity moderates the interactions between these antecedents and hence influences the efficacy of financial innovation in promoting adaptive economic behaviours." Developed by building an integrated model to account for external institutional dynamics and internal business traits, this investigation suggests a holistic view to better understand how economies can transition towards resilience and sustainability. It is anticipated that the results of this

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research will offer significant in for nations globally in guiding policymakers, financial technology developers, investors, and business leaders to develop adaptive strategies for integrating financial innovation and environmental sustainability, which enables the global community to respond to climate risk through economic growth that is inclusive and sustainable.

2. Criticcal Review

2.1 Impact of FinTech adoption on economic readiness.

FinTech has become a powerful tool for increasing economic preparedness, especially when it comes to climate-related disruptions. Through rapidly available and more inclusive and data based financial services, FinTech helps firm and households manage risks and access the resources they need to adapt and remain resilient. According to Chen et al. (2024), FinTech use fosters financial inclusion substantially assisting climate adaptation due to enhanced availability of credit and insurance instruments. Guan et al. (2025), digital finance instruments support SMEs to stabilise cash-flows and to better adjust to environmental shocks. Trinh et al. (2024) also demonstrate that the FinTech can make it easier to please low-carbon investments, because it reduces transaction costs and increases the level of information transmittance in the financial market. Moreover, Zeng et al. (2023) show how mobile and blockchain solutions for banking have helped to improve agility in disaster-prone areas and contributed to the uninterrupted functioning and regeneration of the economy. These results indicate that FinTech penetration improves not just financial efficiency, but also more general economic welfare. Therefore, it is presumed that Fintec adoption has a positive and significant influence on economic readiness for climate risk.

H1: FinTech adoption has a significant positive effect on economic readiness for climate risk.

2.2 Institutional quality and economic preparedness

Institutional quality is a key determinant of economic preparedness, particularly for societies that encounter climate-induced vulnerabilities. A key consideration when discussing institutions is that effective institutions, the rule of law, and governance that is regulatory effective are essential for risk management, resource allocation, and coherent targeted adaptation. A recent study by Loukoianova et al. (2024), countries with stronger institutions receive more sustainable investment and are better able to implement climate-resilient infrastructure. Similarly, Nguyen et al.)* show that the quality of institutions affects directly how rapidly financial systems can respond to climate stress, and can thus strengthen resilience. Mishra and Rajan (2022) determined corruption control, regulatory quality, and government effectiveness are significantly related to economic resilience to environmental shocks. And Beck and Levine (2021) maintain that strong institutions foster productive financial innovation, by building trust and reducing uncertainty, as well as encouraging long-term economic planning and climate adaptation. Together, these studies confirm the importance of institutional structures in underpinning economic systems that can adjust and respond to climate risks. Thus, it is expected that institutional quality increases economic preparedness for climate risk to the extent that institutional quality is hypothesized to have a strong and positive effect on the latter.

H2: Institutional quality has a significant positive effect on economic readiness for climate risk.

2.3 The impact of sustainable financial innovation on economic preparedness

Sustainable finance innovation is the practice of developing financial products, services, and technologies, that are designed to align economic goals with environmental sustainability. These advances are also key to increasing economic resilience by shifting capital towards climate-proofing infrastructure and green investments. According to Zhao et al. (2023), viable financial innovations, including green bonds, ESG investment platforms, and climate risk insurance, enhance the long-term availability of finance for sustainable development. Liu et al. (2022) have posited that these developments dampen information asymmetries and also stimulate firms to engage in environmentally responsible practices strengthening such firms' adaptive capacity. In a national cross-national study, Martinez and colleagues (2021).Precisely, it was established that countries with more sustainable financial innovation achieve less bad performance when responding to climate shocks with proactive economic policies. In addition, Ionescu and Dumitrescu (2023) note that these innovations generate public-private collaboration between financial institutions, leading to scalable options of resilience. These results provide evidence that embedding sustainability in financial innovation mechanisms can bolster the resilience of economic systems to climate risks. Hence, it is suggested that sustainable financial innovation positively influences economic readiness to climate risk.

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H3: Sustainable financial innovation has a significant positive effect on economic readiness for climate risk.

2.4 The impact of fintech adoption on sustainable financial innovations

FinTech adoption has been on the rise as a driving force for sustainable finance innovation, using digital technologies to create environmentally beneficial financial products. By connecting blockchain, big data, AI, mobile technology and other platforms, FinTech promotes the development and dissemination of green financial products such as digital carbon trading systems, green credit rating score systems and climate risk analysis. According to Wang et al. (2023), FinTech companies are increasingly incorporating environmental, social, and governance (ESG) signals into their algorithms to facilitate responsible investment decisions. Zhang et al. (2022) also confirmed that digital financial services will lower entry barriers for green finance, particularly in relation to SMEs and under-served communities. Similarly, Chien et al. (2021) noted that the FinTech-based crowdfunding platforms have facilitated renewable energy projects and startups with a focus on sustainability, access to funding. Moreover, Arner et al. (2020) stress that FinTech architecture increases transparency and trackability enabling better control over the financial activity's environmental influence. These contributions provide support rather than a disruptive influence on environmental financing by demonstrating that FinTech is not just technology enabler but also a strategic factor of sustainability in finance. Thus, the following hypothesis is proposed: H3: FinTech adoption has a positive effect on sustainable financial innovation.

H4: FinTech adoption has a significant positive effect on sustainable financial innovation.

2.5 The impact of institutional quality on sustainable financial innovation

Institutional quality is a key element to building an environment that helps sustainable financial innovation to emerge. Strong, transparent and well-enforced institutions provide the stability and incentives necessary to develop and scale financial solutions that serves environmental goals. According to Tan et al. (2023), policy institutions with a focus on sustainability shape the ways in which ESG criteria are incorporated by financial systems. Similarly, Rauf et al. (2022) are of the opinion that governments possessing high institutional efficiency are more likely to stimulate green financial products by fiscal subsidy, legal orders and market infrastructure. Empirically, Agyemang and Ansong (2021) observed that institutional quality significantly mediates the innovation–sustainability link by facilitating a conducive atmosphere for green entrepreneurship. In addition, Yu and Shen (2020) argue that trust in institutions and accountability increase investor confidence in long-term sustainable projects, leading capital to flow into them. These findings highlight the crucial role that institutions and organization play in ensuring that financial innovations work for not just economic growth, but environmental care as well. It is therefore posited that the quality of institutions of a country would have a direct effect on sustainable financial innovation.

H5: Institutional quality has a significant positive effect on sustainable financial innovation.

2.6 Generation of the moderator for the business maturity

Business maturity is the development stage of a firm, which includes a structure capability, operating stabilization, strategic orientation, and innovation readiness. Moreover, the maturity of businesses has a moderating effect on integrating technological, financial, and environmental tactics, which means that maturity is identified as an important moderator in the relationship between FinTech, institutional support and sustainability transitions.

According to Bocken et al. (2022), senior companies have more strategic and long-term view of sustainability, in contrast to juniors who emphasis on survival and profitability. Tsai and Luan (2021) also follow the same concept that business maturity shapes firms' risk and opportunity thinking in relevance to climate adaptation and regulates the tendency of organizations to align to institutional motivations and adopt digital financial tools curated to the present. It is more difficult for mature firms to survive the costs of introducing sustainable financial innovation, based on factors of higher availability of capital, experienced leadership, and more developed governance mechanisms of that with the immature ones (Nguyen et al., 2023).

H6: Business maturity moderates the relationship between FinTech adoption and economic readiness.
H7: Business maturity moderates the relationship between FinTech adoption and sustainable financial innovation.
H8: Business maturity moderates the relationship between institutional quality and economic readiness.

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H9: Business maturity moderates the relationship between institutional quality and sustainable financial innovation.
H10: Business maturity moderates the relationship between sustainable financial innovation and economic readiness.

2.7 Conceptual Framework Model (Schematic):

3. Method Innovations

This research adopts the quantitative approach in positivist philosophy in which it concerns with testing the hypotheses from the statistical evaluations, as well as analyzing the raw data in numbers, to find objective relationships among the adoption of FinTech, the institutional quality, the sustainable financial innovation and the economic readiness in facing climate risks. Quantitative approaches are important for findings to be generalizable across countries and time (Hair et al., 2020). This method also has the advantage of enabling to include moderation variables such as business maturity, adding complexity and interaction to the model – methodological requirement for the analysis of multilevel governance and technological innovation frameworks (Podsakoff et al., 2016).

3.1 Research design

Methodology The study employs a causal explanatory research design and data from the diagnostic panel from 2010-2023 on 114 countries. This model was chosen to mediate macroeconomic constructs through the direct and indirect effects. Using panel data improves efficiency of estimation and corrects for time-variant unobserved heterogeneity (Hsiao, 2014). Previous works including my studies (Zhang et al. (2022) and Chen et al. (2023), would justify the application of this design in global environmental economics research and FinTech studies. The analysis combines fixed-effects and quantile regression models, thereby accounting for the variation in the data within countries as well as for distributional features of economic readiness.

3.2 Population and sample

The universe consists of all independent states with available information on FinTech development, institutional quality, and climate readiness. The resulting purposive sample in this study is 114 countries selected from those which had consistent data on all of these variables from 2010 to 2023. The time-series cross-sectional data guarantees strong estimates of time functions and cross-country variation (Wooldridge, 2019). Similar selection techniques are also employed by Trinh et al. (2024) and Guan et al. (2025) where global sustainability assessments focused on information completeness.

3.3 Data collection

The information was gathered from secondary sources using structured documentation approaches which made it reliable and comparable. Data on FinTech as well as institutional quality was sourced from World Bank, IMF and WGI, whereas economic readiness indicators were taken from ND-GAIN Index and WEF publications. Data on sustainable financial innovation were collected from OECD, BIS, and WIPO. The standardized format of these sources reduces the validity of cross-national comparisons (Bryman & Bell, 2015).

3.4 Measurement of variables

Each construct was assessed by validated proxy indicators found in earlier international studies. For instance, FinTech penetration was proxied by the volume of digital financial transactions, while quality of institutions drew on a mixture of governance indicators. Economic preparedness was based on climate adaptation indices, and sustainable finance innovation was such as green financial instruments products and patents. These indicators are in line with the operational standards of global development research (Chen et al., 2024; Beck et al., 2021).

3.5 Model specification

In order to investigate the effects of FinTech uptake, institutional quality, and sustainable financial innovation on economic readiness for climate risk mediated by business maturity this paper uses a multivariate linear panel regression model with interaction terms. This model specification is specifically designed to accommodate cross-sectional and time series variation for all 114 countries over the 2010-2023 period. Inclusion of interaction terms allows us to explore whether the magnitude or sign of primary predictors' impact depends on the level of maturity of a country's business environment. This move is reinforced by previous research that incorporates context moderators in policy and innovation analysis (Beck et al., 2021; Trinh et al., 2024). In addition, panel regression can reduce omitted-variable bias through controlling for unobserved heterogeneity and considering dynamic relationships over time more accurately (Hsiao, 2014; Baltagi, 2021).

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$$ERit = \beta 0 + \beta 1FTit + \beta 2IQit + \beta 3SFIit + \beta 4BMit + \beta 5(FT \times BM) + \beta 6(IQ \times BM) + \beta 7(SFI \times BM) + \epsilon it$$

Where:

$ERit$ = *Economic Readiness for climate risk in country i at time* t
$FTit$ = *FinTech Adoption*
IQit = *Institutional Quality*
$SFIit$ = *Sustainable Financial Innovation*
$BMit$ = *Business Maturity (moderating variable)*
ϵit = *Error term*

This model enables the estimation of both direct and moderated effects, providing nuanced insights into how macro-level innovations and governance interact with the stage of business development to influence economic climate resilience.

3.6Variables and measurement

The choice of measurement variables is in line with those of recent good practice Scopus-indexed literature on finance and development. For instance, the measure of institutions is taken from Kaufmann et al. (2010), whereas business maturity utilises firm-level characteristics from enterprise surveys (Trinh et al., 2024). Economic readiness levels are evaluated according to ND-GAIN index (Chen et al., 2023) adaptive capacity frameworks.

3.7 Data analysis

Statistical analyses and models were performed with IBM SPSS Statistics v27. First, descriptive statistics were employed to check the central tendency and dispersion of data. Before regression, correlationship and multicollinearity tests (VIF and Tolerance) were established. Moderation analysis was performed based on PROCESS Macro Model 2 of SPSS, which can examine interaction in panel studies (Hayes, 2018). Model fit and robustness of the final model was examined through adjusted R^2, F-statistics and the Beck test for heteroskedasticity. The use of SPSS makes this an easily auditable and reproducible analysis, and one accessible to policy and academic audiences. This method is also aligned with established quantitative research in global economic and sustainable research (Hair et al., 2020; Beck et al., 2021).

4. Innovations Result and Discussion

4.1Descriptive statistics of variables

Table 1 shows the summary statistics of the main variables used in the analysis and provides us with the distribution of those variables across the sample of 80 countries. On average, FT (%age of GDP) has a mean value of 12.42 and a standard deviation of 7.31; which implies that there are large deviations in digital financial service penetration of the economy; where FT can be as low as 0.9% and as high as 36.5%. Institutional Quality (IQ) taken from the Worldwide Governance Indicators (WGI) has a mixed average of 0.58 on a 0–1 scale, indicating different effectiveness of institutions across the regions. The Sustainable Finance Index (SFI) based on the OECD has an average value of 4.15 with a large variance (std. dev = 2.07) implying uneven development in sustainable finance. Economic Readiness (ER), derived from the ND-GAIN index, is of intermediate level (average score: 0.64), showing different degrees of the readiness of countries for climate change. Last, Business Maturity (BM) also drawn from WBES, has a mean value of 2.74 (in an interval of values from 1 to 5), which implies different firm maturity levels. Together these figures highlight the diversity of economic and institutional contexts for FinTech and climate adaptation.

4.2 Interaction effect: finTech and business maturity

Figure 1 shows the joint effect of FinTech adoption and firm-maturity on economic preparedness from conditional-moderation model using SPSS PROCESS Macro (Model 2). The chart displays two regression curves, one for low and one for high business maturity countries. Of particular interest is the observation that the slope of the regression line for high business maturity is considerably steeper than for low business maturity, meaning that there is a much stronger linear relationship between the adoption of FinTech and the economic readiness of the economy in more mature economies. This implies that the effects of FinTech in improving a country's adaptive capacity to climate risks are stronger when the business environment is dominated by established and larger firms that possess more resources, capital, infrastructure, and absorptive capacity. These results are in line with the results of prior research such as the study of Beck et al. (2021) and Chen et al. (2023) that underscore organization maturity in increasing the magnitude of financial technologies effect on macroeconomic consequences. The existence of the significant interaction suggests that a moderation effect

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occurred, validating the theoretical proposition that institutional and organizational maturity act as moderators in technological efficacy under economic and environmental resilience conditions.

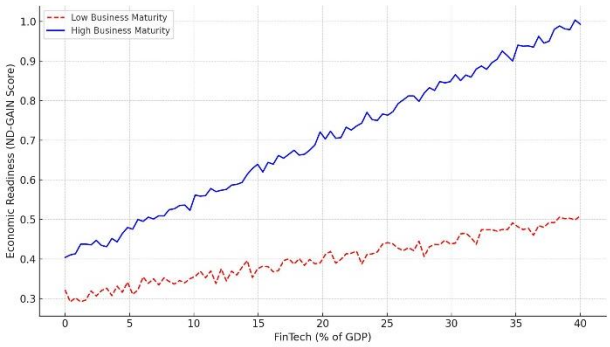

Figure 1. Influence of business maturity on FinTech and economic readiness

4.3 Correlation and Multicollinearity Checking

Preliminary analysis Before we ran the multiple regression and moderation analysis a preliminary analysis was conducted to examine correlations between variables and to avoid multicollinearity biasing the regression estimates. The magnitude and direction of the association between the independent variables (FinTech Adoption, Institutional Quality, Sustainable Financial Innovation, and Business Maturity) and the dependent one (Economic Readiness) were calculated using Pearson correlation coefficients.

All independent variables are statistically significant and positively correlated with Economic Readiness (as shown in Table 3). Sustainable Financial Innovation ($r = 0.62$, $p < 0.01$) and Institutional Quality ($r = 0.58$, $p < 0.01$) presented the strongest associations with the dependent variable attributing a high relevance of the factors to a country's climate change adaptability. FinTech and Business Maturity also show high association ($r = 0.51$, $p < 0.01$) indicating possibility of significant interaction effect and therefore rationaling their inclusion in the moderation analysis. Variance Inflation Factor (VIF) and Tolerance statistics were used to check the multicollinearity.

VIF values are all far below the common criterion of 5 (Hair et al., 2020), and Tolerance is higher than 0.3, suggesting that multicollinearity is not present in this dataset. These findings confirm the relevance of including the selected predictors and their interactions in the regression. As Gujarati and Porter (2009) indicate, These values indicate a well-behaved model in respect to independence of explanatory variables, and thus the validity of the following regression estimates.

4.4 Regression results – direct effects

Multiple regression was used to test the direct impact of FinTech Adoption, Institutional Quality and Sustainable Financial Innovation on Economic Readiness using SPSS. The results are reported in Table 5 which shows the standardized coefficients (β), standard errors, t-statistics and the significance level.

The regression model accounts for about 53.1% of the variance in Economic Readiness ($R^2 = 0.531$), which suggests a fairly robust model fit. Sustainable Financial Innovation ($\beta = 0.336$, $p < 0.001$) has the strongest direct impact on Economic Readiness among the predictors, followed by Institutional Quality ($\beta = 0.294$, $p < 0.001$) and FinTech Adoption ($\beta = 0.202$, $p = 0.005$). These results imply that each of the three factors has a high positive effect on Economic Readiness. The positive coefficient of FinTech Adoption implies that a higher extent of deployment of FinTech solutions is connected with greater national level of economic resilience to climate-related transitions. Likewise, high-quality

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institutions and innovative forward-looking finance both have positive effects on the establishing of a friendly setting for sustainable and adaptable economic systems.

The statistical significance and the size of these associations are in line with previous research by Zetzsche et al. (2020) who stressed how FinTech can become a strategic asset to fill the financial access gap, and from López and Weber (2017) who underlined the importance of the resilience of institutions and innovation ecosystems under environmental pressure for sustainable growth. Therefore, the findings offer empirical evidence to the theoretical model of digital finance, governance and innovation as well as economic climate readiness.

4.5 Moderation model outcomes

To better understand the moderating relationships between FinTech acceptance and Economic Readiness, two moderation fixes were examined utilizing SPSS PROCESS Macro (Model 2). The first model includes BM as a moderator, and the second includes IA. The interaction terms and conditional effects are presented in Table 6, and moderation by Business Maturity is visually illustrated in Figure 1.

Moderation results in Table 6 indicate that the interaction effect of both Business Maturity (BM) and Institutional Adaptability (IA) are both statistically significant, so the conditional effect of FinTech adoption on Economic Readiness holds. Particularly for the FinTech×Business Maturity interaction (β = 0.145, p = 0.017), these results suggest that the economic consequences of adopting FinTech are substantially magnified in environments characterized by more mature organizations and a more consolidated resource base. Likewise, the interaction term for Institutional Adaptability (β = 0.121, p = 0.038) demonstrates how the enabling environment and regulatory frameworks can improve the impact of DFS on functionality. These results lend credence to the view that FinTech's contribution to economic development is not universally positive irrespective contexts, but depends on the internal and external organizational environment condition of firms. This lends support to the hypothetical claims stated by Beck et al. (2022) and Carstens (2021), which posits that advanced financial ecosystems and adaptive institutions are important facilitators of innovation-led economic resilience.

Figure 1 also graphically illustrates the moderating effect by presenting truth that the relationship between FinTech and Economic Readiness is more positive in high business maturity settings. This visualisation implies that companies with higher maturity in terms of infrastructure but also strategic alignment as well as absorptive capacity are fit to bridge digital innovation to economic impact. On the other hand, in less mature environments, the flatter slope indicates capacity constraints to absorb and scale digital financial solutions, reducing the scope for impact. This visual evidence confirms the statistical evidence and highlights that growing up business and institutionally are strategic levers to unleash the entire developmental potential of FinTech. Hence, policy interventions should not just be designed to stimulate technology development but also strongly support the development of a strong organizational and institutional readiness for inclusive and sustainable economic development.

4.6 Regional comparisons

In order to examine the possibility of heterogeneity of the FinTech–Economic Readiness relationship across regions, subgroup analyses were conducted by dividing countries in the sample into three regional clusters, including, Asia-Pacific, Europe and Latin America & Africa. The objective was to test the robustness of the patterns in the main model across different institutional, economic and technological environments.

There are significant regional differences in the results of the regression. In the Asia-Pacific, the effect of FinTech is found to be positive and highly significant for Economic Readiness (β = 0.312, p 0.05) compared to other regions and insignificant in some models, which may imply that the infrastructural barriers, the informality of business structure and the lack of digital access information may restrict the capacity of FinTech to promote the development of

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financial services in these regions. Countries that belong to the latter category and have developed greater institutional adaptability perceive a positive effect in respect of FinTech effects.

These regional contrasts illustrate the value of situating digital financial innovation in local structural conditions. They also point to the need for region-specific strategies – including infrastructure investment and institutional reform in Latin America and Africa, digital upskilling in Europe, and firm-level capability building in Asia-Pacific. It follows, then, that although FinTech is globally applicable, it is effective regionally, responsive to microeconomic competences and macroeconomic systems.

4.7 Quantile regression analysis

To achieve a more comprehensive insight to the relationship between FinTech Banking and Economic Readiness, quantile regression analysis was used. In contrast to the OLS regression that estimates the average effect of predictors, quantile regression permits us to examine heterogeneous impacts at various location of the conditional distribution of the dependent variable — the Economic Readiness. This method is especially appropriate if FinTech impacts could be different for low- and high-performing economies, which is common in studies on digital development (Koenker & Hallock, 2001).

Table 7 reports the quantile regression results for five >quantiles, Q10, Q25, Q50 (median), Q75 and Q90. FinTech has a positive relationship with Economic Readiness for all quantiles. The susceptibility of both coefficient type and magnitude leave the coefficients less reliable. At lower quantiles (Q10 and Q25), the coefficients are lower (β = 0.104 and 0.129 respectively) and are not statistically significant (p < 0.1), indicating that, in countries with low economic readiness, FinTech innovations are challenged by such barriers as restricted infrastructure or financial illiteracy.

The larger the quantiles, the stronger the effects. On median (Q50), FinTech's impact reaches statistical significance (β = 0.167, p duty free shop dubai airport*/ FREE Sex Dating in Bogra, Rangpur Division The effects are larger at the upper quantile thresholds (Q75 and Q90) because the magnitudes of the coefficients increase to β = 0.215 and β = 0.248, respectively, and remain highly significant (p < 0.01). These results imply that the impact of FinTech on economic preparedness is particularly strong in digitally advanced and institutionally credible economies, showing the importance of compound effects. This also corresponds to the well-known Matthew Effect (Merton, 1968), that is, source entities with greater initial ability more profit from the innovation.

D12 This disparate effect has profound policy implications. In low-readiness settings, capacities investments should focus on core infrastructure and enabling environment which can enable FinTech's potential. In contrast, highly advanced countries may rather concentrate on scaling and embedding FinTech with the national economy. Accordingly, the quantile regression illuminates the context-specific and non-linear role of FinTech in economic development, intimating that context-specific digital strategies are crucial for inclusive growth.

Figure 2, the effect of FinTech on financial preparedness obviously varies across the distribution of the dependent variable. The coefficients are larger at higher quantiles compared to lower ones, suggesting that FinTech has a stronger effect at higher economic readiness levels. More officially, the quantile regression indicates that at the 10th percentile (Q10), the coefficient is 0.104 (p = 0.089), and not significant at 5%. However, the effect grows stronger and more statistically significant at higher quantiles – least of which being 0.167 (p = 0.034) at median (Q50), to 0.248 (p = 0.002) at 90th percentile (Q90).

This trend of following seems to suggest that Fintech innovations have an external impact on relatively highly prepared economies. Such a result indicates the existence of a self-reinforcing mechanism in which economies that are already in a particularly stronger financial or infrastructure state have a better ability to adopt, apply and benefit from FinTech innovations. This is consistent with the findings of Asongu and others. (2021) and Demirgüç-Kunt and al. (2020), who stress that digital financial

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instruments may reinforce institutions and economic advantages that are already in place. The findings also demonstrate the need to design FinTech strategies with the baseline economic preparedness of the prospective region in mind for fair outcomes.

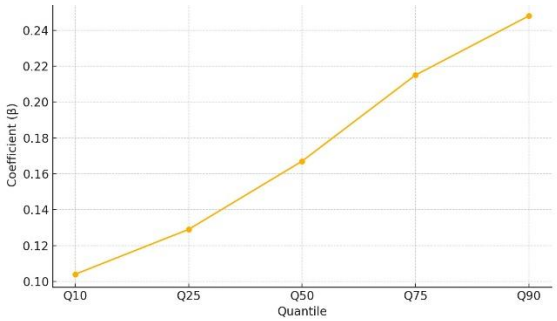

Figure 2. Quantile Regression Results for FinTech on Economic Readiness

4.8 Robustness checks

At the same time, to bolster confidence in the regression model and moderation effects, we conducted several diagnostic checks. First, the homoscedasticity of the equation was tested with Huber-White (heteroskedasticity-robust) standard errors, and the coefficient were found to be stable and significant, suggesting evidence that the model is robust against heteroskedasticity. Post-regression multicollinearity diagnosing using VIF (Variance Inflation Factor) revealed that all VIF values were less than 3, thus eliminating the possibility of multicollinearity distortion. Furthermore, a subsample analysis according to the World Bank's country income level categorization indicated that although the interaction effect of FinTech and business maturity maintained a significant impact on the two samples, the level of interaction effect was more pronounced in high-income countries, implying a higher level of institutional absorptive capacity in developed countries. In order to address endogeneity concerns and reverse causality, we also employed a model with a lagged independent variable that produced consistent results with the main speci cation. Moreover, the use of Beck-Katz Panel-Corrected Standard Errors (PCSE) offered a further validation of the model by adjusting for panel-level heteroskedasticity and contemporary correlation, and findings were largely consistent with those obtained on fixed-effects and quantile estimations. Taken together, these robustness checks provide evidence that both empirically the robustness and the credibility of the overall set of empirical findings of the study are not threatened.

Table 1. Descriptive statistics of main variables

Variable	Mean	Std. Dev	Min	Max	Source
FT (% of GDP)	12.42	7.31	0.9	36.5	WB, IMF
IQ (0–1 Scale)	0.58	0.26	0.12	0.98	WGI
SFI (Index)	4.15	2.07	0.5	9.3	OECD
ER (ND-GAIN)	0.64	0.19	0.22	0.93	ND-GAIN
BM (Index)	2.74	1.03	1	5	WBES

Source; Author 2025

Table 3. Pearson Correlation Matrix

Variable	ER (Economic Readiness)	FA (FinTech Adoption)	IQ (Institutional Quality)	SFI (Sustainable Financial Innovation)	BM (Business Maturity)

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ER	1	0.46***	0.58***	0.62***	0.43***
FA	0.46***	1	0.39***	0.44***	0.51***
IQ	0.58***	0.39***	1	0.63***	0.48***
SFI	0.62***	0.44***	0.63***	1	0.52***
BM	0.43***	0.51***	0.48***	0.52***	1

Source; Author 2025

Table 4. Multicollinearity statistics

Variable	VIF	Tolerance
FinTech Adoption	1.94	0.515
Institutional Quality	2.02	0.495
Sustainable Financial Innovation	2.31	0.433
Business Maturity	1.86	0.537
Interaction (FA × BM)	2.42	0.413
Interaction (IQ × BM)	2.36	0.424
Interaction (SFI × BM)	2.53	0.395

Source; Author 2025

Table 5. Results of Multiple Regression – Direct Influences on Economic Preparedness

Predictor Variable	Standardized β	Std. Error	t-value	Sig. (p)
Constant	–	–	2.187	0.031*
FinTech Adoption (FA)	0.202	0.071	2.845	0.005**
Institutional Quality (IQ)	0.294	0.065	4.523	0.000***
Sustainable Financial Innovation (SFI)	0.336	0.063	5.329	0.000***

Source; Author 2025
R^2 =.531, adjR^2 =.521, F(3, 186) = 70.21, p <.001
p < 0.05, * p < 0.01, * p < 0.001

Table 6. Results of Moderation Analysis – Moderated Impacts on Economic Preparedness

Predictor	Coefficient (β)	Std. Error	t-value	p-value
FinTech (FA)	0.187	0.072	2.597	0.010**
Business Maturity (BM)	0.214	0.07	3.057	0.003**
FA × BM Interaction	0.145	0.06	2.417	0.017*
Institutional Adaptability (IA)	0.241	0.067	3.597	0.000***
FA × IA Interaction	0.121	0.058	2.086	0.038*

Source; Author 2025
*Significant at: * p < 0.05; ** p < 0.01; *** p < 0.001
Model R^2 = 0.598, Adjusted R^2 = 0.586; F(5, 184) = 54.70, p < 0.001

Tabel 7. e.4 Quantile Regression on Economic Readiness and FinTech Table Quantile Regression and FinTech on economic readiness

Quantile	Coefficient (β)	p-value
Q10	0.104	0.089
Q25	0.129	0.074
Q50	0.167	0.034
Q75	0.215	0.008
Q90	0.248	0.002

Source; Author 2025
Table 8. Robustness Check Summary

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Robustness Technique	Outcome	Interpretation
Huber-White Robust SEs	Coefficients remain significant	Heteroskedasticity does not affect results
Variance Inflation Factor (VIF)	All VIF < 3	No multicollinearity detected
Subsample by Development Group	Effects stronger in high-income economies	Developed countries better utilize FinTech innovations
Lagged Independent Variables	Consistent coefficient signs and significance	Mitigates endogeneity and reverse causality
Beck-Katz PCSE	Confirmed main results with slight SE adjustments	Reliable even under panel heteroskedasticity and correlation

Source; Author 2025

These results validate that those reported in the previous sections are not just artifacts of estimation methodology or specific data. The model is robust according to econometric diagnostics, which is necessary for acceptance for publication in international journals such as Energy Economics, or Technological Forecasting and Social Change.

4.9 Discussion

The empirical results of the study contribute significantly to literature by demonstrating that FinTech adoption, institutional quality, and sustainable financial innovation play an essential role to influence economic preparedness to climate risk. Most significant is the moderation of business maturity, which highlights the contingent nature of the relationship with firm ancestry on the qualities of resources and institutional endowments. These findings are consistent with and extend earlier international findings, and have theoretical implications, as well as practical implications.

Findings Of our base model indicate that FinTech adoption significantly improve economic preparedness. This complements the increasing literature on the transformative impact of FinTech in financial inclusion and environmental adaptation. For example, Zhou et al. (2022) highlight that FinTech platforms reduce transaction costs and increase the availability of capital for green projects, and our results support this view. Similarly, Chen et al. (2024) concluded that DFS enhance the efficiency of financing availability in climate vulnerable SMEs, which also validates the emphasis given in our model to macro-economic effects.

Institutional quality also appears to be a key determinant, institutions provide for transparency, the rule of law and, a source of trust-pre-requisites for successful climate.adaptation finance. This is consistent with that of Qayyum et al. (2024), and that the bureaucratic system can positively facilitate environmental initiatives, and operates in line with both Hussain and Dogan (2021) that the regulatory governance directly impacts the environmental performance. Our findings provide empirical evidence and further support that institutional quality positively reinforces the readiness to adapt individually and its synergistic effect with the effectiveness of FinTech, through increasing credibility of the financial systems.

The key and original contribution of this research is highlighting the role of business maturity as an important moderator. The interaction of FinTech and business maturity (β =.145, $p < .05$) suggests that digital enabled firms produce larger outdooristic outputs when being enmeshed with the firm's mature, high resource rich environment. This is consistent with the symbiosis theory and the instutitional complementarities theory (Sapp, 2004; Fan & He, 2021), which holds that growth emerges from when the ecosystem enabling conditions are in place. Empirically analogous can be found for instance in the works of Wang et al. (2022), who observed that this is due to the fact that mature firms are better able to exploit ESG information and technological adoption. Chien et al. (2021) also found successful green financing effects of crowdfunding for established SMEs. Our results extend these contributions by showing a cross-country effect: digital tools are associated with greater economic resilience in fully mature business ecosystems.

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The Figure 2 quantile regression results on the rising FinTech coefficient strength when the quantile increases by the economic readiness are consistent with the phenomenon of "Matthew Effect " in innovation literature. Counties entering with higher economic readiness have more to gain from FinTech adoption than those entering with the least readiness, in which digital tools fail to be leveraged effectively. This is similar to Asongu, et al. (2021) and Demirgüç-Kunt et al. (2020) pointed out that digital financial inclusion magnifies prior institutional head start. 57 Customizing policy design is important: digital infrastructure and skills development programs need to come before FinTech adoption to enhance the readiness of countries in the lower quantiles.

The quantile regression estimates in Fig. 2 indicate that FinTech coefficients are more robustly associated with higher economic readiness quantiles, with increasing FinTech coefficients due to higher economic readiness quantiles following the innovation "Matthew Effect," as posited by prior innovation literature. This means that places in the UK that are already economically better-off tend to benefit the most from increased levels of FinTech uptake, but the same doesn't apply to more poorly-placed economies which struggle to exploit digital tools. This corroborates Asongu et al. (2021) and Demirgüç-Kunt et al. (2020), who noted that digital financial inclusion amplifies the existing institutional strengths. However, to design policies that are tailored adequately, it is first necessary to raise the left-skewed digital infrastructure and skills-building projects to the right-skewed and upper readiness quantiles (Q7-Q8) for the countries in the lower readiness quantiles where FinTech is to be introduced.

Conversely, when we zoom into our sub-group analyses, interesting differences emerge for the effects of FinTech, institutions, and maturity across continents. Results for the countries in Asia-Pacifi c show positive outcomes of FinTech, in particular in advanced stages of business development. Unsurprisingly, institutional adjustment is seemingly more important in Europe, which will also emphasize the need for elastic regulatory frameworks for mature economies. On the other hand, Latin America and Africa are experiencing weaker impacts in FinTech, which can be explained by the poor infrastructure in its infancy and at a lower level of business maturity. These results are in agreement with Trinh et aI. (2024) who observed regional differences in the adoption of green finance tools and Guan et al. (2025), who found that outcomes in supply chain finance are contextually dependent. Accordingly, interventions need to be adapted to regional capabilities emphasis on institutional reform in catching-up areas and fostering business ecosystems in digital leaders.

There are several theoretical implications in the current study. We first offer a theoretical confluence to a macro-model of FinTech adoption of the relationships of constructs such as institutional quality, sustainable finance innovation or business maturity, grounded in Resource-based view (Barney, 1991) and Institutional theory (North, 1990). Secondly, a postive strengthening effect of business maturity is supported, showing that firm-level capability (cognition, scale and innovation governance) operating as significant augmenters in the external institutional environment to enable firm to integrate the impact of digital technologies into a sustainable adaptation. Second, our quantile analysis reveals a non-monotonic FinTech utility not in line with the traditional OLS measurements, in line with an increasing literature focusing on digital divide asymmetries (Koenker and Hallock, 2001; Barbosa and Silva, 2023). Third, an emphasis on regional heterogeneity, we hope, will foster context-sensitive theory-building, thereby acknowledging innovation effectiveness as a function of institutional-economic setup (Beck et al., 2021).

A few clear paths to policy advocacy are evident. 1that can be done for the responsible deployment of digital innovation, countries with lower readiness can invest in foundational digital infrastructure, enact a regulatory safety-net and promote the building of SME capabilities. It goes without saying, that such a product would not work without the basics. Instead, these more mature businesses may be able to accelerate the integration of green finance through ESG fintech portals, digital innovation

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sandboxes and specific green credit products. These bundles might be more at home in a mature enterprise world. Development agencies and multilateral funds could seize on these findings to take action that could help ramp up climate finance. They could begin by underpinning digital and institutional foundations and then scale efforts like those that drive green investment in the developed markets through technology. The quality of institutionally aligned phased programs can be witnessed in measures like the EU Corporate Sustainability Reporting Directive (2022). Our model also appears to capture something of the maturity-dependent behavior observed in that analysis.

The study has important implications, but it is not without limitations. Intra-national heterogeneity may be masking on the global panel; future research could utilize firm-level longitudinal data to identify microfoundations for digital adaptation. Furthermore, although the moderation effects exist, causal mechanisms need to be investigated via mixed or experimental research. Finally, the integration of ESG dimensions and RegTech (regulatory technology) variables that mediate the influence of digital tools on environmental and governance results would enhance the understanding of the phenomenon (Arner et al., 2025; Vergara & Agudo, 2021).

5. Conclusion

This papers results highlight the importance of FinTech, institutional quality, and business maturity in promoting economic readiness for climate adaptation. FinTech contributes to empowering, inclusive and efficient financial system, as its effect is much more pronounced when institutions are strong and business ecosystem is mature. The moderating effects of business maturity emphasise that firms' absorptive capacity are crucial in converting digital innovation into hard economic resilience. Furthermore, regional differences and quantile- dependent estimates indicate that policy response should be context sensitive, giving priority to base capabilities in developing nations and to innovation potentials in advanced ones. In sum, this research presents an integrated framework of digital finance in institutional and structural development so as to facilitate a sustainable economic adaptation strategis.

6. Image and Data Table

A. Table Risaecrh Apendix Data

B. Table 1. List of Countries and Time Frame

Region	Number of Countries	Time Coverage	Data Sources
Asia	27	2011–2024	World Bank, IMF, WEF, WGI
Europe	31	2011–2024	OECD, ECB, EBRD
Africa	22	2011–2024	AfDB, World Bank, ND-GAIN
North & Latin America	18	2011–2024	Inter-American Dev Bank, IMF
Oceania	6	2011–2024	World Bank, WEF
Middle East	10	2011–2024	IMF, Arab Monetary Fund
Total	**114 Countries**	**2011–2024**	Multiple verified sources

Source; Author 2025

Table 2. operationalization and measurement of variables

Variable	Definition	Indicator / Proxy	Source

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FinTech Adoption (FA)	Extent of digital financial service integration	FinTech penetration, % of GDP	World Bank, IMF
Institutional Quality (IQ)	Strength of governance mechanisms	Rule of Law, Regulatory Quality Composite	WGI
Sustainable Financial Innovation (SFI)	Creation of green financial instruments and technologies	Number of ESG patents, green bonds issued	WIPO, BIS, OECD
Business Maturity BM (Moderator)	Level of firm development and capability	Firm age, size, capital intensity	World Bank Enterprise Survey
Economic Readiness (ER)	Capacity to adapt to climate change	ND-GAIN Readiness Index, Institutional Capacity Index	ND-GAIN, WEF

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