Research in International Business and Finance 73 (2025) 102543

Contents lists available at ScienceDirect

Research in International Business and Finance

journal homepage: www.elsevier.com/locate/ribaf

FinTech and economic readiness: Institutional navigation amid climate risks

Shajara Ul-Durar [a,b], Yassine Bakkar [c,*], Noman Arshed [d], Shabana Naveed [e], Beifan Zhang [f]

[a] University of Sunderland, Sunderland, United Kingdom
[b] Durham University, Durham, United Kingdom
[c] Queen's University Belfast, Belfast, United Kingdom
[d] Sunway University, Kuala Lumpur, Malaysia
[e] University of Central Punjab, Lahore, Pakistan
[f] University of Technology Sydney, Sydney, Australia

A R T I C L E I N F O

Keywords:
Institutional Quality Moderator Model
Quadratic FinTech adoption function
Climate action
Financial inclusion
Technology 4.0

A B S T R A C T

The current climate change is declared as a global boiling point by the UN; businesses are facing increasing costs in maintaining their supply chains and production standards and are being urged to adapt and innovate for environmental transition. With the Industrial Revolution 4.0, FinTech has helped develop households' and firms' resilience against climate change. This study explores how businesses use FinTech to increase economic readiness to attract adaptation investments. This study hypothesizes that, at initial levels of businesses, FinTech adoptions are typically targeted to improve profitability while, as businesses mature, their FinTech adoption shows a transition towards sustainability. Following this, the role of institutions in regulating an ecosystem is to promote sustainable financial innovations. This study employs a 114-country panel data analysis to investigate these dynamics empirically. The estimation using Panel Quantile Regression showed that institutional quality can moderate the U-shaped FinTech adoption and business readiness relationship to expedite the transition under Sustainable Development Goal 9. This research sheds light on the impact of institutional quality on improving businesses' ability to attract adaptation investments via promoting sustainable innovation. Outcomes offer valuable insights for policymakers, firms, and investors seeking to foster a more resilient economy.

1. Introduction

Climate change is a major global issue that has multifaceted effects on businesses. Extreme weather events like forest fires, glacial lake outbursts, and floods contribute to a direct impact on 70 % of economic sectors (Deloitte, 2021) disrupting supply chains and causing depreciation in productivity (Caleb, 2023). The world has declared the current state as global boiling from global warming (Niranjan, 2023). Climate change has posed itself as a major risk to financial stability. Initiatives like the Task force of Climate-related

* Corresponding author.
E-mail addresses: Shajara.ul-durar@sunderland.ac.uk, Shajara.ul-durar@durham.ac.uk (S. Ul-Durar), y.bakkar@qub.ac.uk (Y. Bakkar), nouman.arshed@gmail.com (N. Arshed), shabananaveed@ucp.edu.pk (S. Naveed), Beifan.Zhang@student.uts.edu.au (B. Zhang).

https://doi.org/10.1016/j.ribaf.2024.102543
Received 23 April 2024; Received in revised form 7 August 2024; Accepted 21 August 2024
Available online 26 August 2024
0275-5319/

Financial Disclosures (TCFD) and the Network for Greening the Financial System (NGFS) are increasing pressure on businesses to improve their regulation related to risk management and climate-related awareness (Coppola and Blohmke, 2019) in order to achieve Sustainable Development Goal (SDG) 9 of building resilience infrastructure. This increasing pressure is coming from all dimensions including stakeholders, customers, and employees demanding businesses to become adaptive and sustain a company's reputation (Garst et al., 2017).

Businesses with high energy intensity are contributing to the emissions and need a major overhaul in making their businesses adaptive to climate change requirements to meet the regional and industry-specific challenges (HBS, 2022). This transition is required and is discussed under the sustainable business model innovation (SBMI) (Ferlito and Faraci, 2022). Studies have discussed several ways in which businesses can adapt to climate change. Innovation for a low-carbon energy transition can help save fossil energy and secure a sustainable future (Abdelzaher et al., 2020). This can help in reputation enhancement while serving customer needs (Bakker, 2016; McDonald and Bailey, 2020). Making businesses resilient is imperative in times when there are high risks of climate change (Hower, 2015). Businesses need to revolutionize the way they create value which requires a major reallocation of capital for net-zero emissions (Haas et al., 2023; Yanosek and Victor, 2022). Businesses need to come forward to fight climate change in order to help mitigate large-scale climate change impacts (Bakker, 2016; HBS, 2022).

The business community and government need to come together to remove hurdles in making businesses adaptive to climate change. Several challenges need to be addressed in this transition. Increased heatwaves and global warming are increasing the demand for cooling energy which is increasing the differential between energy demand in winters and summers (Fontaine, 2008). There is a looming risk of regulatory sanctions from TCFD and NGFS for non-compliance with climate change regulations (Fomenko, 2022; WEF, 2023a). The World Economic Forum (WEF) (2023a) has declared climate change mitigation and adaptation failure as the top three global risks. Businesses and governments need to be on the same page while approaching adaptation; presently businesses have an opportunity perspective and government has a risk perspective (WEF, 2023b).

Financial technology, namely FinTech, has revolutionized the working of businesses in managing their Business-to-Business (B2B) and Business-to-Customer (B2C) transactions. FinTech can automate processes in order to reduce operational costs and increase efficiency by reducing human errors (Kagan, 2024; Malucha, 2023). It helps in expediting transactions and credit score estimations (credolab, 2021). The adoption of FinTech helps in increasing transaction security and ensuring trust with their clients (Columbia Engineering, 2021). This financial technology can help businesses to become adaptive to climate change in many ways. It can facilitate in climate finance by developing a renewable energy fund for the energy sector or fund research to develop climate-resilient seeds for farmers (UN, 2023; UNFCCC, 2023). Financial technology improves environmental performance and biodiversity by reducing waste and water (BDC, 2022; Iqbal et al., 2024; Ul-Durar et al., 2024a). FinTech has the ability to foster collaborations among stakeholders with a goal to address climate change (WEF, 2023a).

This study proposes that the adoption of financial technology transitions businesses in two phases. Theoretically, the first phase advocates that FinTech adoption increases business profitability by enhancing operational efficiency, the reduction of costs, and better risk management (He, 2024; Lv et al., 2022; Singh et al., 2021). This early adoption of FinTech helps businesses gain market shares and compete with others (Anan et al., 2023). The increased market share would reduce the number of firms but also increase climate resilience as high profit enables them to finance climate adaptation strategies with the help of environmental, social and governance principles (Mhlanga, 2023, 2022). In this stage, the overall market adaptive capacity would experience a fall. The second phase focuses on the mass adoption of financial technology promoting new businesses via financial inclusion effect for startups (Firmansyah et al., 2023; World Bank Group, 2022). In this phase, FinTech eases financing for climate change resilience irrespective of the size of the firms (Mhlanga, 2023, 2022). The mass-adoption of FinTech would drive businesses from profit-driven to sustainability-focused and there will be a prominent increase in economic readiness (adaptive capacity) of businesses against climate change. This change in transition can be tested by use of a quadratic function (Haans et al., 2015) within which this study hypothesized a U-shaped effect of FinTech adoption with economic readiness to explore the domain of profitability with a purpose (Bonini and Swartz, 2014).

Institutions do play an important role in the pursuit of increasing the resilience of businesses and FinTech adoption. Initially studies like Bokpin (2017) and Omri and Bel Hadj (2020) had discussed that institutional quality can help in regulating capital flows for the environment. He et al. (2023) stated that better institutions can help Chinese banks to adopt FinTech and improve operational efficiency. Kaur et al.'s (2023) study led to the conclusion that institutions can also facilitate financial inclusion. FinTech can also play a role in altering corporate investments because of change in cost of capital (Lu et al., 2024). Governments can adopt climate FinTech to understand the exposure and sensitivity to climate change in order to make informed investments (Jian, 2023). This climate-FinTech led startups to leverage from technology 4.0 to accelerate the greening of capital flows (Zec and Brunet, 2021). The gains from FinTech is not straightforward; they are visible when a broader policy and strategy is initiated by the government for sustainability (Clancy, 2022). Studies have shown that good institutions help to make a conducive environment for the financial technology-led transition. They provide incentives for the startups and provide necessary regulatory infrastructure (Firmansyah et al., 2023; He et al., 2023; Kaur et al., 2023). Institutions can help enforce sustainable business practices related to renewable energy use and waste reduction (Ghorbani et al., 2023; Aysan et al., 2023; World Bank, 2020). The tax incentives can drive green innovation by firms to expedite transitions (Obobisa et al., 2023). Institutions can help set ambitious targets for climate resilience and help this transformation change through accountability and non-compliance penalties (Ghorbani et al., 2023).

Based on the discussion, this study sets its aim to explore the complicated role of financial technology adoption at the national level on the economic readiness of businesses against climate change risks. This study further explores how institutional quality can moderate the non-linear relationship between financial technology adoption and economic readiness for climate change risks thus making a model to assess one dimension of business transformation readiness (WEF, 2020).

This study acquires the data from reputed sources like the World Bank Index (WDI, 2021), IMF (Svirydzenka, 2016), and the Notre

Dame Index (Chen et al., 2015), and applies second-generation panel quantile regression (Ul-Durar et al., 2024b). The robust long run estimates showed that FinTech has a U-shaped effect on economic readiness while institution quality shifts the curve upward denoting that, at every level of FinTech adoption, better institutions help in achieving higher economic readiness to climate change while the model has been controlled for the globalization and aggregate demand effect. Further, the estimates are compared for pre-and post-COP19 (19th Meeting of the Conference of the Parties) regimes and robustness of estimates are conducted using technological innovations instead of FinTech.

Using the second-generation panel quantile ARDL analysis of 114 countries spanning time periods of 1996–2022, the results indicate that FinTech follows a positive exponential economic readiness effect. Institutional quality has shown a supportive effect but persistent regulatory amendments may increase compliance costs. Robustness analysis highlighted that the post-Covid-19 period has seen improved effects of institutions and globalization to foster economic resilience. This study augments the academic literature by integrating FinTech and institutional quality as a tool in enhancing the economic readiness of the business sector. The outcomes are aligned with the outcome of FinTech's transformative impact on businesses (Berman et al., 2022; Dusil and Cerny, 2018) and its ability to drive climate resilience (Hong et al., 2020; Mhlanga, 2022). While institutional quality's ability to enhance adaptive capacity and environmental management has been discussed by several studies (Javaid et al., 2022; Kumar et al., 2023).

This study has several notable academic contributions in the domain of business readiness to climate change, financial technology adoption, and institutional quality. This study has integrated the behavior shift using a U-shaped functional form in a second-generation, dynamic and robust panel data estimation along with its robustness analysis in order to curtail the complex behavior of data. These contributions collectively help in understanding the complex behavior of financial technology and innovation in determining business readiness to climate change.

Following the introduction in Section 1, Section 2 provides an overview of the relevant literature. Section 3 discusses the methods and materials for the study followed by results and discussions in Section 4. Section 5 concludes the study with discussions and policy implications.

2. Literature review

The large capital requirements by new businesses are aided by financial technologies enabling them to access funds and gain profits (Sutikno and Kuruppuarachchi, 2021). Financial innovation has shown a positive effect on business performance in India (Singh and Mungila Hillemane, 2023). Financial innovation has substantially increased entrepreneurship in the investment consultancy domain and made them capable to compete with larger incumbents (Berman et al., 2022). Blockchain within FinTech is used by startups to develop innovative business models (Dusil and Cerny, 2018). FinTech helps local businesses to compete with international businesses because of its disruptive ability (Anshari et al., 2020).

Innovative financial inclusion has helped agri-businesses to cater to climate risks (Oostendorp et al., 2019). This financial innovation addresses climate change by investment facilitation, risk identification and green energy development (Richardson, 2014). Financial technology increases sustainability in investments, decision-making (Alonso and Marqués, 2019), and increases climate finance (Hong et al., 2020) to potentially boost the adaptive capacity against climate change (Monasterolo, 2020). Mhlanga (2022) stated that FinTech can aid resilience across companies against rapid and gradual climate change. The ability of making green financing affordable makes FinTech a suitable tool for industrial economies to achieve sustainable growth (Pawlowska et al., 2022). FinTech adoption helps the industry to align their environmental sustainability targets for Chinese and Indian Firms (Ramamohan et al., 2021). FinTech helps in increasing the natural resource efficiency in protecting the ecology (Ul-Durar et al., 2024a).

While discussing institutional quality for aiding resilience in businesses, it has been noticed that institutions can improve the social, governance, and economic readiness for climate change mitigation in the case of South Africa (Sarkodie and Adams, 2018). Institutions can extract the positive effect of financial development on the environment in the case of South Asia (Hunjra et al., 2020). Innovation and institutions have a positive relationship with entrepreneurship in African countries (Ben Youssef et al., 2018). Institutional policy frameworks can shape business strategies to address climate change impacts for a resilient future (Kumar et al., 2023). Huang et al. (2023) confirmed that institutional quality mitigates the climate change risk effect on social development in high climate affected countries. A similar outcome is confirmed by Javaid et al. (2022) for a panel data of 114 countries where institutions directly reduce the climate change risks. Better institutions can boost the economic adaptive capacity against climate change by investing in organizations, and decision making of tropical coastal communities (Cinner et al., 2018). Institutions engage and support the social actors in climate change planning to promote adaptive capacity (Gupta et al., 2010). Du et al. (2024) highlighted the role of governmental institutions in forming environmental management strategies in Chinese companies between 2008 and 2021

Globalization leads to tourism, trade, and economic growth which undermines the climate change resilience of the economy (Leichenko, 2012). It leads to an increase in global warming affecting food businesses (Curtis, 2007). Dai et al. (2022) showed that an increase in trade openness as an indicator of globalization leads to an increase in economic vulnerability to climate change in G7 countries, however, it can also facilitate climate change adaptation by increasing ties between developed and developing countries in terms of business and technology (Khan and Islam, 2015; Kumar et al., 2023). Thus, globalization provides opportunities and threats to international businesses in their attempt to become resilient (Islam et al., 2019).

An increase in economic growth or demand beyond the capacity to produce by the country would place pressure on the production systems and meeting the demand would require a focus on sub-sustainable production measures. Increased demand would over utilize the resources, cause inflationary pressure, and create productivity challenges (IMF, 2014; Irwin, 2024). it would also increase in climate change risk from economic activities and population growth (Tong and Ebi, 2019). Studies like Kalim et al. (2023) showed that demand is an important indicator in explaining the environmental outcomes of the economy where innovation and institutions are required as interventions to protect the environment. Past studies have explored the direct role of technology and institutions on the adaptability to climate change (Arshed et al., 2023) but most of these studies ignored the business transformation dimension hinted at by Kalim et al. (2023). This study explored the non-linear role of financial technology in transitioning from low to high economic readiness while assessing how institutions can support businesses in the transition process.

3. Methods

3.1. Sampling and data sources

This study uses quantitative panel data of 114 countries based on data availability of data of readiness (provided in Table 1). The economic readiness to climate change risk (ERC) index is a dependent variable taken from Chen et al. (2015) with average values shown in Table 1. This economic readiness represents the business sector's adaptive capacity to climate change and presents itself as an important component for climate change adaptability.

The quadratic function of financial technology (FinTech) is developed as an index of financial development (FD) (Svirydzenka, 2016), access to internet (INTR), and mobile phone subscriptions (MOB) (WDI, 2021). This combination was previously used by Liu et al. (2022), Iqbal et al. (2024) and Ul-Durar et al. (2024a). Liu et al. (2022) defined FinTech as the use of advanced technology to extend financial services in the economy. Institutional quality (IQ) has been used as a moderator as an index of six governance indicators provided in Table 1 (WGI, 2021) developed into index form (Hassan et al., 2020). The control variables include the globalization index (GI) (Gygli et al., 2019) and demand (DM) in the economy is developed as a sum of consumption, investment, government expenditures, and imports as percentage of GDP using data from the WDI (2021) previously proposed by Kalim et al. (2023). The indices are developed using the principal component analysis method. A definition of the variables are provided in Table 2.

3.2. Equation and estimation methods

This study has developed indices from FinTech (Iqbal et al., 2024; Ul-Durar et al., 2024a) and IQ (Hassan et al., 2020) using principal component analysis (PCA) merited because of its ability to reduce the data without proportional reduction in the efficiency. Further, if the items are used as independent variables their commonality would lead to multicollinearity-led biases in the estimates (Arshed, 2020).

Eq. 1 below is the parametrized version of the estimation equation proposed by this study.

$$ERC_{it} = \alpha_0 + \alpha_1 FinTech_{it} + \alpha_2 FinTech_{it}^2 + \alpha_3 IQ_{it} + \alpha_4 (FinTech_{it} * IQ_{it}) + \alpha_5 (FinTech_{it}^2 * IQ_{it}) + \alpha_6 GI_{it} + \alpha_7 DM_{it} + e_{it} \text{——} \quad (1)$$

Table 1
Sample country list with economic readiness.

Country	Readiness	Country	Readiness	Country	Readiness	Country	Readiness
Albania	0.36	Cyprus	0.54	Kiribati	0.37	Saudi Arabia	0.47
Algeria	0.34	Denmark	0.64	Kyrgyz Republic	0.41	Senegal	0.25
Angola	0.19	Dominican Republic	0.33	Latvia	0.53	Seychelle	0.48
Argentina	0.33	Ecuador	0.34	Lebanon	0.34	Sierra Leone	0.23
Australia	0.61	El Salvador	0.35	Lithuania	0.56	Singapore	0.67
Austria	0.53	Finland	0.62	Luxembourg	0.56	Slovak Republic	0.43
Bahamas	0.49	France	0.52	Malaysia	0.49	Solomon Island	0.33
Bangladesh	0.49	Gabon	0.31	Mali	0.26	South Africa	0.39
Barbados	0.54	Gambia	0.37	Malta	0.53	Spain	0.46
Belgium	0.50	Georgia	0.55	Mauritius	0.55	Sri Lanka	0.38
Belize	0.40	Germany	0.56	Mexico	0.57	Sudan	0.38
Benin	0.25	Ghana	0.36	Mongolia	0.41	Sweden	0.57
Bhutan	0.43	Greece	0.41	Morocco	0.42	Switzerland	0.58
Bosnia and Herzegovina	0.30	Guatemala	0.34	Namibia	0.38	Syria	0.32
Botswana	0.39	Guinea	0.29	Nepal	0.41	Thailand	0.50
Brazil	0.43	Guinea-Bissau	0.30	New Zealand	0.66	Togo	0.28
Brunei Darussalam	0.50	Haiti	0.27	Nicaragua	0.30	Tonga	0.47
Bulgaria	0.43	Honduras	0.30	Niger	0.25	Tunisia	0.49
Burkina Faso	0.26	Hungary	0.45	Norway	0.66	Türkiye	0.41
Burundi	0.28	Iceland	0.63	Oman	0.53	Uganda	0.31
Cambodia	0.27	India	0.48	Pakistan	0.52	Ukraine	0.28
Cameroon	0.22	Indonesia	0.51	Panama	0.39	United Arab Emirates	0.59
Canada	0.57	Ireland	0.54	Paraguay	0.37	United Kingdom	0.59
Central African Republic	0.14	Israel	0.44	Peru	0.41	United States of America	0.65
Chad	0.15	Italy	0.39	Philippines	0.31	Uruguay	0.37
Chile	0.48	Jamaica	0.38	Portugal	0.49	Vanuatu	0.39
Colombia	0.38	Japan	0.64	Romania	0.42	Vietnam	0.41
Congo	0.20	Jordan	0.36	Russia	0.63		
Costa Rica	0.38	Kenya	0.32	Rwanda	0.38		

Note: Set of countries included in the sample with their average value of economic readiness

Table 2
Variables and their definitions.

Name (Symbol)	Definition (Units)	Source
Economic readiness to climate change risk (ERC)	It is the investment climate that facilitates mobilization of private sector capital	Sub-component of Notre Dame Gain Index from Chen et al.
Financial innovation (FinTech)	Index measuring integration of financial development with digital accessibility. The index is based on following items: Index of financial development (FD), Access to internet (INTR), and Mobile phone subscriptions (MOB)	Index using WDI and Svirydzenka
Institutional quality (IQ)	Index measures the traditions and institutions by which authority in a country is exercised. This index is based on: CC = Control for Corruption, GE = Government Effectiveness, PS = Political Stability, RQ = Regulatory Quality, RL = Rule of Law, VA = Voice and Accountability	WGI
Globalization (GI)	It shows the intensity of intra country networks based on economic, social, and political dimensions	KOF index from Gygli et al.
Aggregate demand (DM)	Sum of consumption, investment, government, and import expenditures as % of GDP	WDI

Note: Description of variables included in the sample

The data acquired ranges from 1996 to 2022. The variation of variables across time and countries makes the data structure as panel data. Furthermore, since the number of years per cross section is in excess of 19 years this study safely allows the variables to be non-stationary in nature to form a dynamic panel data. This study uses the Panel Auto Regressive Distributed Lag (ARDL) model with a pooled mean group (PMG) specification as a basic functional form of the study developed by Blackburne and Frank (2007) and Pesaran et al. (2001), and was used in literature in several studies.

This study has used several cross sectional dependence tests like Fan et al. (2015), Joudis and Reese (2021), Pesaran, (2014), and Pesaran and Xie (2023) and a second generation panel cointegration tests (Pedroni, 2004; Westerlund, 2005). This study has adopted the transformation of the Common Correlated effects Mean Group (CCMG) which makes the model robust to cross sectional dependence (Pesaran, 2006) to include cross sectional averages over time of the variables in the specification. It helps in reducing the time specific variation and mitigates cross-sectional autocorrelation (Ul-Durar et al., 2024b; Wooldridge, 2010).

Previously, Iqbal et al. (2024) has used this transformation in a static model to make it a second generation model while Ul-Durar et al. (2024b) used this transformation in dynamic Quantile ARDL model. This study has added the cross-sectional averages of all variables in the long run while they are dropped from short run automatically as they are constant across time within the cross section. This study further deployed the panel quantile regression algorithm which allows the estimates to be robust to the presence of outliers and distributional heteroskedasticity (Powell, 2022). Arshed et al. (2023), (2022a), Arshed (2023) and Ul-Durar et al. (2024a), (2023) also previously used this model in the panel data setup. This quantile regression is estimated using the bootstrap method to have efficient estimate of variance-covariance matrix. This model is superior to exiting Panel ARDL, Cross Sectional (CS)-ARDL and Augmented Mean Group (AMG) models in terms of their ability to estimate the marginal effects (long- and short-run) at any position of distribution and tails while also exhibiting an ability to handle post regression issues like the said models.

Lastly, the quadratic function with moderation specification is adapted using Haans et al. (2015) which is then visualized using Dawson (2013). Thus, conclusively this used model can handle unobserved heteroscedasticity by providing cross sectional specific short-run effects, distributional heteroskedasticity by providing outlier robust slope estimates at different quantile positions, and slope variability heteroskedasticity by providing curvilinear slope transition with respect to FinTech. This novel transformation makes this model robust to timeseries autocorrelation, cross sectional dependence, (cross sectional, slope, and distributional) heteroskedasticity, miss-specification, and non-normality.

After adopting all specifications, the long (Eq. 2) and short run (Eq. 3) equations are provided below whereby variables vary across 'i' cross sections and 't' time periods. The model is estimated at different quantiles 'τ' of dependent variable to varying slope and error terms.

$$ERC_{\tau it} = \alpha_{\tau 0} + \alpha_{\tau 1} FinTech_{it} + \alpha_{\tau 2} FinTech_{it}^2 + \alpha_{\tau 3} IQ_{it} + \alpha_{\tau 4}(FinTech_{it} * IQ_{it}) + \alpha_{\tau 5}(FinTech_{it}^2 * IQ_{it}) + \alpha_{\tau 6} GI_{it} + \alpha_{\tau 7} DM_{it} + \beta_{\tau 0}\overline{ERC}_{it} + \beta_{\tau 1}\overline{FinTech}_{it} + \beta_{\tau 2}\overline{FinTech}_{it}^2 + \beta_{\tau 3}\overline{IQ}_{it} + \beta_{\tau 4}(\overline{FinTech}_{it} * \overline{IQ}_{it}) + \beta_{\tau 5}(\overline{FinTech}_{it}^2 * \overline{IQ}_{it}) + \beta_{\tau 6}\overline{GI}_{it} + \beta_{\tau 7}\overline{DM}_{it} + e_{\tau it} \tag{2}$$

$$\Delta ERC_{\tau it} = \alpha_{\tau 0} + \alpha_{\tau 1}\Delta FinTech_{it} + \alpha_{\tau 2}\Delta FinTech_{it}^2 + \alpha_{\tau 3}\Delta IQ_{it} + \alpha_{\tau 4}(\Delta FinTech_{it} * \Delta IQ_{it}) + \alpha_{\tau 5}(\Delta FinTech_{it}^2 * \Delta IQ_{it}) + \alpha_{\tau 6}\Delta GI_{it} + \alpha_{\tau 7}\Delta DM_{it} + \delta_{\tau 0} e_{\tau it-1} + v_{\tau it} \tag{3}$$

4. Results and discussions

4.1. Baseline results

Table 3 shows the Keiser Mayer Olkin (KMO) values of the items used to make the index. There are three items used to make the FinTech index as proposed by Iqbal et al. (2024), Ul-Durar et al. (2024a) and there are six items used to make the institutional quality index as used by Hassan et al. (2020). Here it can be seen that for all cases the KMO values are above 0.5 showing that the items are suitable to make the index.

Table 4 shows the descriptive statistics of the variables. Here, FinTech and Institutional Quality (IQ) have means smaller than standard deviation making them over dispersed while all other variables are under dispersed. Based on the probability values of the Shapiro Wilk test it can be concluded that all the variables are not normally distributed. Further correlations show that FinTech, IQ, and GI are strong positively correlated with the ERC while DM is weak positively correlated. Similarly, in Table 4 the pairwise correlations between independent variables are not high enough to conclude that there is multicollinearity among the variables (Gujarati, 2009).

Fig. 1 presents the scatter plot; it is evident here that there is a strong positive association between financial technology and economic readiness while the linear fit line is also indicating that there is an exponential positive relationship between them. This hinted towards the use of the quadratic function of FinTech in the model. Table 5 provides the cross-sectional dependence tests. The presence of dependence necessitates the use of second-generation panel data models as the model is susceptive of cross-sectional autocorrelation. Here, Table 3 shows that within the four tests of cross-sectional dependence there is a presence of dependence for variables indicated by majority of tests. Table 6 provides the outcome of panel cointegration test. This study has used the second generation cointegration test as the variables are cross-sectionally dependent. The results show that using both the Westerlund and Demeaned Pedroni test there is evidence that the set variables are cointegrated in long run.

Table 7 provides the long run relationships. The estimates are provided for the 25th, 50th, and 75th percentiles. The estimates are based on a sample size of 2772 observations from 114 countries between 1996 and 2022. The Wald coefficient restriction test is significant for all percentiles showing that the overall model is fit. R square is in excess of 0.56 showing that, in the long run, the selected variables explain at least 56 % of the variation in the dependent variable.

For the case of demand (DM) variable, in the long run it has a negative effect on economic readiness at the 25th percentile while it is insignificant at other percentiles. The country averages of demand $\overline{DM}$ showed a positive effect on economic readiness at the 25th percentile while it is insignificant at other percentiles. This concludes that an annual increase in demand tends to put pressure on businesses to fulfil in order to get profits and trade-off sustainability but, if this pattern continues, an overall average increase in demand for a country would lead to an increase in readiness as businesses will structurally upgrade their businesses to the increased demand. These outcomes are similar to the conclusion of studies by Reichheld et al. (2023) and Xing and Ye (2022).

For the case of globalization (GI), it has no significant effect on the long run but its cross-sectional average $\overline{GI}$ tends to have a positive long-term effect on readiness at the 25th percentile and a negative effect on readiness at the 75th percentile. This shows that in economies with low levels of readiness, globalization average at national level would lead to an increase in readiness because of international collaboration and knowledge sharing (Magni et al., 2021) while in economies with high readiness, globalization average at national level would lead to a decrease in readiness because the increased demand of their products globally would place pressure on production systems (Nystrom et al., 2019).

Institutional quality (IQ) generally has a positive effect on economic readiness at all percentile levels. A 1 % increase in quality of institutions would lead to an increase in readiness by at least 0.30 %. This shows that betterment in institutions tends to assist businesses to align with national goals, However, the national average increase in institutional quality $\overline{IQ}$ has a negative long-term effect on economic readiness. This means that a persistent increase in institutional quality would lead to an increase in regulatory compliance costs and there will be bureaucratic delays that may discourage businesses to invest in the innovation for becoming adaptive to climate change. This outcome is similar to the study by Arshed et al. (2022a), (2022b).

Discussing the effect of financial technology (FinTech), it has a positive effect via both FinTech and $FinTech^2$ in all percentiles. Understanding from the coefficients it is clear that FinTech has a positive exponential effect on economic readiness. Nevertheless, since FinTech is an index its mean is zero, thus denoting that some portion of data has negative values so the positive exponential effect is

Table 3
KMO values of items used to make index.

FinTech Index		Institutional Quality Index	
Items	KMO	Items	KMO
INTE	0.55	CC	0.91
MOB	0.58	GE	0.87
FD	0.66	PS	0.94
		RQ	0.89
		RL	0.88
		VA	0.94
Total	0.58	Total	0.90

Note: Statistics indicating the health of the formed index of FinTech and Institutional Quality

Table 4
Descriptives and correlations.

Statistic	ERC	FinTech	IQ	GI	DM
Mean	0.42	0.00	0.00	2.99	5.10
Median	0.41	−0.27	−0.35	2.99	5.07
Standard Dev.	0.14	1.49	2.26	0.29	0.21
Skewness	0.55	0.41	0.19	−0.27	0.87
Kurtosis	3.71	1.93	2.24	2.58	5.86
S-Wilk	10.87	12.91	10.75	10.12	12.45
Prob	0.00*	0.00*	0.00*	0.00*	0.00*
Correlations					
ERC	1.00				
FinTech	0.62	1.00			
IQ	0.66	0.68	1.00		
GI	0.55	0.81	0.72	1.00	
DM	0.05	0.08	0.16	0.09	1.00

Note: descriptive statistics and correlation matrix of variables used for data analysis.
* Significant at 1 %

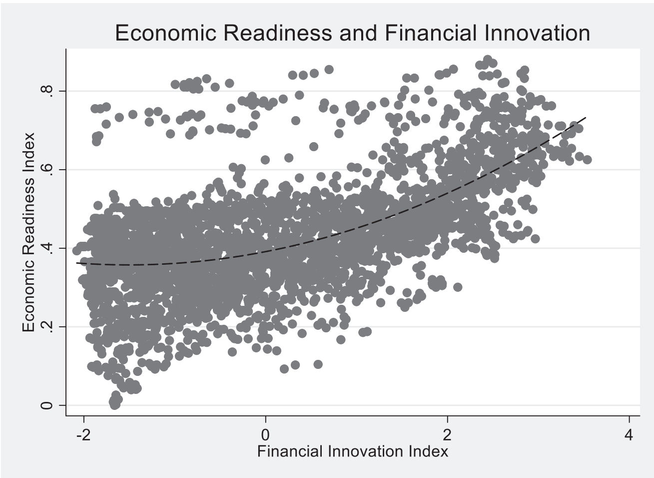

Fig. 1. – *Scatter plot of Economic Readiness and FinTech.* Note: Scatter plot with equadratic fit between economic readiness and financial innovation (FinTech) showing positive association.

Table 5
Cross sectional dependence tests.

Variable	CD	CDw	CDw+	CD*
ERC	338.68 (0.00)*	3.85 (0.00)*	51789.10 (0.00)*	1.12 (0.26)
FinTech	267.57 (0.00)*	4.99 (0.00)*	40949.24 (0.00)*	4.06 (0.00)*
IQ	0.13 (0.90)	−0.08 (0.94)	45941.28 (0.00)*	3.72 (0.00)*
GI	606.24 (0.00)*	4.18 (0.00)*	92812.10 (0.00)*	1.59 (0.11)
DM	37.89 (0**.00)***	−1.79 (0.07)***	26962.38 (0.00)*	−1.05 (0.29)

Note: cross sectional dependence test for the selected variables
* Significant at 1 %
** Significant at 10 %. CD = cross sectional dependence test by Pesaran [90], CDw = weighted CD test by Pesaran [111], CDw+ = power weighted CD test by Joudis & Reese [89] and CD* = Pesaran & Xie [91] CD test.

transformed into a U-shaped effect when low (negative) FinTech values interact with the positive FinTech coefficient. Such a relationship is already discussed with respect to growth by Bu et al. (2023). This means that an initial increase in FinTech would firstly increase the profitability because of propriety knowledge gained by the businesses making them profit-driven (Song et al., 2023) but, with the public dissemination of FinTech knowledge, there will be an increase in new businesses venturing into the market forcing businesses to focus on sustainability (Vergara and Agudo, 2021). The coefficients $\overline{FinTech}$ and $\overline{FinTech}^2$ are negative showing that a persistent increase in FinTech would harm the economic readiness as it would lead to a scale effect of increase in economic growth that would damage the balance between economy and environment.

Table 6
Panel cointegration test.

Test	Statistic	Prob. Value
Westerlund Variance Ratio	−2.40	0.01**
Modified Phillips-Perron t	6.11	0.00*
Phillips-Perron t	−1.99	0.02**
Augmented Dickey-Fuller t	−1.63	0.05***

Note: Panel cointegration test for the selected variables
* Significant at 1 %
** Significant at 5 % and
*** Significant at 10 %

Table 7
Long run estimates of economic readiness using panel quantile regression.

Independent Variables	25th Percentile Coefficient (Prob)	50th Percentile Coefficient (Prob)	75th Percentile Coefficient (Prob)
FinTech	0.013 (0.00)*	0.016 (0.00)*	0.015 (0.00)*
$FinTech^2$	0.018 (0.00)*	0.018 (0.00)*	0.021 (0.00)*
IQ	0.036 (0.00)*	0.030 (0.00)*	0.034 (0.00)*
FinTech* IQ	0.001 (0.27)	0.004 (0.00)*	0.004 (0.00)*
$FinTech^2$* IQ	−0.001 (0.24)	−0.001 (0.00)*	−0.002 (0.00)*
GI	−0.055 (0.14)	−0.033 (0.12)	0.025 (0.24)
DM	−0.033 (0.03)**	−0.033 (0.14)	−0.034 (0.10)
$\overline{ECR}$	0.759 (0.00)*	0.889 (0.00)*	1.110 (0.00)*
$\overline{FinTech}$	−0.004 (0.48)	−0.015 (0.00)*	−0.018 (0.00)*
$\overline{FinTech}^2$	−0.023 (0.00)*	−0.015 (0.00)*	−0.010 (0.00)*
$\overline{IQ}$	−0.034 (0.00)*	−0.028 (0.00)*	−0.035 (0.00)*
$\overline{FinTech} * \overline{IQ}$	−0.004 (0.02)**	−0.005 (0.00)*	−0.004 (0.09)***
$\overline{FinTech}^2 * \overline{IQ}$	0.003 (0.01)**	0.001 (0.15)	0.0002 (0.86)
$\overline{GI}$	0.073 (0.06)***	0.029 (0.18)	−0.040 (0.09)***
$\overline{DM}$	0.056 (0.01)**	0.033 (0.15)	0.008 (0.72)
Cons	−0.118 (0.07)***	0.053 (0.55)	0.152 (0.03)**
Sample	2772	2772	2772
Pseudo R^2	0.56	0.57	0.60
Wald Test (Prob)	685.14 (0.00)*	1901.38 (0.00)*	1740.80 (0.00)*

Note: Long run Panel Quantile ARDL estimates for 25th, 50th and 75th percentiles of dependent variable.
* Significant at 1 %
** Significant at 5 % and
*** Significant at 10 %

Exploring the interaction of IQ with FinTech, the coefficient FinTech * IQ is generally positive at high percentiles and coefficient of $FinTech^2$ * IQ is generally negative at high percentiles. This means that an increase in institutional quality tends to magnify the positive effect of FinTech on economic readiness at initial levels of FinTech by providing facilitative regulation for businesses to adopt FinTech for sustainability (Arner et al., 2020; Vergara and Agudo, 2021). However, at high levels of IQ it diminishes the positive effect of FinTech. This is because high regulations lead to an increase in compliance costs. Further, there is a negative effect of $\overline{FinTech} * \overline{IQ}$ on economic readiness which shows the combined effect of scale effect and regulatory compliance costs.

Conclusively, Fig. 2 provides the visual demonstration of Eq. 2 which can be understood by using the framework of Haans et al. (2015). Fig. 2 shows that at median there is a U-shaped effect of FinTech on economic readiness while the positive direct effect of IQ shifts the curve upward and the positive moderating effect of IQ increases the gap between these two curves with the increase in FinTech. Thus, it can be understood from this figure that it takes time for FinTech to exhibit a positive effect on the economic readiness to climate change beyond threshold but, if the institutional support is provided, businesses can shift to a higher level of economic readiness for each level of FinTech. It means that better institutions can extract more gains out of FinTech. Further, the integrated pursuit of FinTech and regulation would lead to a further increase in the readiness as the gap between the dotted and solid line is increasing.

Table 8 provides the pooled short run estimates of the second-generation panel quantile regression. The cross-sectional average variables are dropped from this model as they are constant across time so for regression they are constant. Here it can be seen that the convergence coefficient is significant at the 25th and 75th percentiles while insignificant at the 50th percentile. The significance of convergence coefficient denotes that the long run model is suitable for policy intervention. Most of the short run variables are insignificant showing that policy intervention using the provided independent variables will not create short run noise but rather they will impart a long run effect on the dependent variables.

Though the median pooled short run regression is showing insignificant convergence coefficient, the model used in the study is

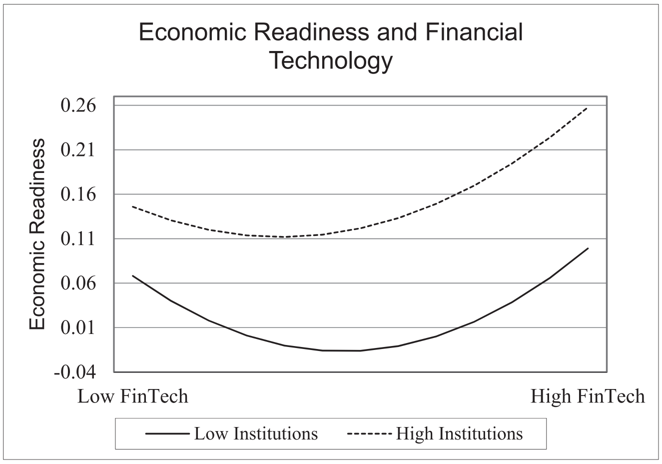

Fig. 2. – Visualization of Moderating Effect. Note: Moderating effect of institutional quality plot showing the U-shaped relation between economic readiness and FinTech being shifted upward because of increase in institutional quality. The graph is made by plotting the deviation of FinTech −1.5 standard deviation to 1.5 standard deviation which defines the low and high values of FinTech and the effect of institutions is shown by plotting −1 standard deviation to 1 standard deviation defining low institutions and high institutions. So, according to calculation, when there are low institutions FinTech must grow beyond its mean value to initiate positive effect but at high institutions only FinTech must be higher than mean – 0.5 standard deviation to initiate positive effect. This shows the fact that when institutions increase it shifts the cutoff leftward also shifts curve upward.

Table 8
Short run estimates of economic readiness using panel quantile regression.

Variables	**25th Percentile Coefficient (Prob)**	**50th Percentile Coefficient (Prob)**	**75th Percentile Coefficient (Prob)**
ΔFinTech	−0.002 (0.27)	0.001 (0.40)	0.015 (0.00)*
$\Delta FinTech^2$	0.001 (0.39)	0.0005 (0.41)	0.011 (0.00)*
ΔIQ	0.004 (0.07)***	−0.0002 (0.39)	0.003 (0.42)
ΔFinTech* ΔIQ	0.004 (0.00)*	−0.0003 (0.38)	−0.005 (0.00)*
$\Delta FinTech^{2}$ * ΔIQ	−0.001 (0.07)***	−0.0001 (0.38)	0.00001 (0.99)
ΔGI	0.047 (0.00)*	0.0001 (0.50)	−0.041 (0.00)*
ΔDM	−0.008 (0.96)	−0.000002 (0.94)	−0.004 (0.44)
ECM−1	−0.021 (0.00)*	−0.00004 (0.68)	−0.013 (0.06)***
Cons	−0.004 (0.00)*	0.000001 (0.79)	0.006 (0.00)*
Sample	2659	2658	2658

Note: Short run panel quantile ARDL estimates at 25th, 50th, and 75th percentiles of dependent variable
* Significant at 1 % ** Significant at 5 % and *** Significant at 10 %

pooled mean group where the short run effects are estimated for each country before pooling them as a pooled short run. Fig. 3 shows the convergence coefficient of each country from the short run model estimated at median. Here it is visible that most of the countries have a convergence coefficient between the suitable range of −1 and 0. The difference is the convergence speed denotes the effectiveness of the generalized long run model in the study. Here, higher effectiveness of the model is explaining dependent variable changes as dependent variable tends to show higher convergence speeds. These differences open doors for further research for countries with low convergence speeds to learn from high convergence speeds for best practices or to explore a better fit model based on country's indigenous knowledge. In terms of convergence, Hungary, Mauritius, and Nicaragua had the highest convergence speed while Denmark, Rwanda, and Oman had the slowest convergence speed. In the sample of 114 countries, 26 countries did not show convergence at median (shown in Table 9) which points towards an in-depth examination of these countries based on appropriate variables that explain changes in readiness.

4.2. Pre- and post-COP19 estimates

Table 10 compares the median estimates with the before and after COP19 agreement (2016) period in order to compare the changes in the estimates. Since the number of years are less post-COP19, the result showed an insignificant effect of a few of the variables like FinTech. This is the major difference between pre- and post-COP19. In the case of post-COP19, it has led to an improvement in the effect of institutions and globalization in favor of increasing economic resilience in the economy. Table 11 also adds that, for post-COP19, the overall convergence coefficient is significant showing that the selected variables are more connected with the changes in the economic readiness of the businesses.

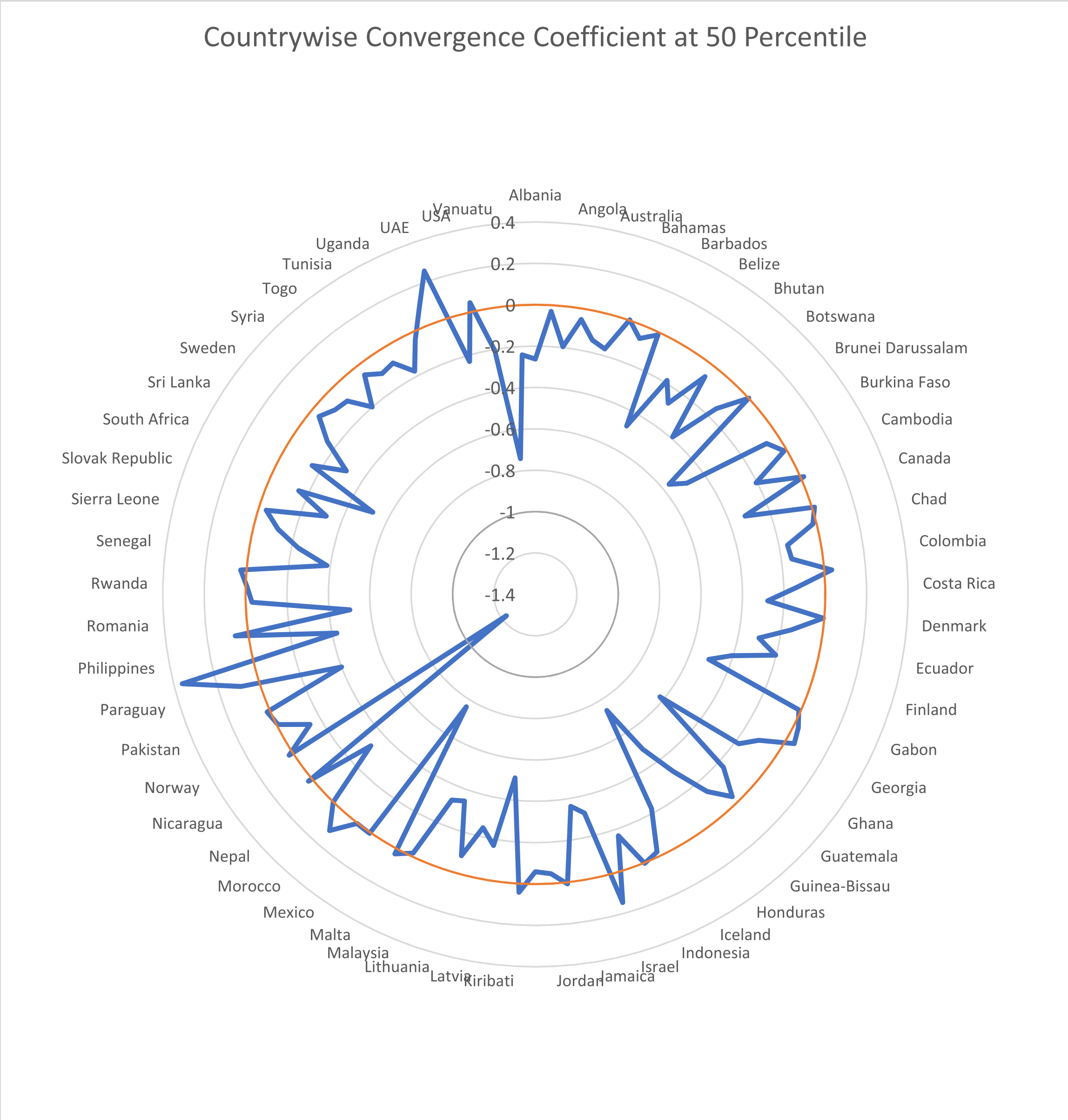

Fig. 3. – Short run country wise convergence coefficient. Note: Country-wise convergence coefficient estimates visualization. These estimates are generated as the model used is panel ARDL with PMG specification which provides country-wise short run estimates.

4.3. Robustness of estimates using technological innovations

This study further assessed the robustness of the estimates using the overall technological innovation instead of financial innovations. Table 12 had estimated the effects of patents registered in the economy per 1000 people. The results are similar for the case of the 25th percentile while for the case of the 50th and 75th percentile the results are similar with the positive contribution of institutions in boosting the effectiveness of innovations in increasing economic readiness.

5. Conclusion and policy recommendations

In the era of global boiling, businesses need to transform their practices to become resilient. The reliance on fossil energy and businesses with high carbon footprints is increasing the costs of maintaining the quality of goods. This study proposed the potential of financial innovation/technology adoption as a strategy to boost economic readiness of businesses against climate change risks and further include the role of institutional quality in facilitating FinTech adoption for making businesses climate change resilient.

Table 9
Countries with no convergence at median level of economic readiness.

Bahamas	Mongolia
Brazil	Morocco
Cameroon	Namibia
Central African Republic	New Zealand
Congo	Niger
Gambia	Pakistan
Georgia	Paraguay
Indonesia	Peru
Israel	Portugal
Japan	Saudi Arabia
Kiribati	United Arab Emirates
Malta	Ukraine
Mexico	United States of America

Note: List of countries which showed lack of convergence at 50th percentile

Table 10
Long run QARDL estimates for overall sample and subsample of pre- and post-COP21 at medians.

Independent Variables	Overall Data Coefficient (Prob)	Pre-COP21 Coefficient (Prob)	Post-COP21 Coefficient (Prob)
FinTech	0.016 (0.00)*	0.021 (0.00)*	0.017 (0.22)
$FinTech^2$	0.018 (0.00)*	0.026 (0.00)*	−0.001 (0.89)
IQ	0.030 (0.00)*	0.026 (0.00)*	0.032 (0.00)*
FinTech* IQ	0.004 (0.00)*	0.001 (0.268)	0.006 (0.45)
$FinTech^{2*}$ IQ	−0.001 (0.00)*	−0.002 (0.00)*	−0.002 (0.31)
GI	−0.033 (0.12)	−0.027 (0.138)	0.253 (0.06)
DM	−0.033 (0.14)	−0.017 (0.514)	0.005 (0.93)
$\overline{ECR}$	0.889 (0.00)*	0.879 (0.00)*	1.046 (0.00)*
$\overline{FinTech}$	−0.015 (0.00)*	−0.007 (0.389)	−0.014 (0.48)
$\overline{FinTech}^2$	−0.015 (0.00)*	−0.021 (0.00)*	0.014 (0.29)
$\overline{IQ}$	−0.028 (0.00)*	−0.026 (0.00)*	−0.040 (0.00)*
$\overline{FinTech} * \overline{IQ}$	−0.005 (0.00)*	−0.005 (0.00)*	−0.010 (0.31)
$\overline{FinTech}^2 * \overline{IQ}$	0.001 (0.15)	0.003 (0.00)*	0.006 (0.08)
$\overline{GI}$	0.029 (0.18)	0.016 (0.513)	−0.212 (0.06)***
$\overline{DM}$	0.033 (0.15)	0.015 (0.582)	0.015 (0.78)
Cons	0.053 (0.55)	0.098 (0.362)	−0.324 (0.15)
Sample	2772	2215	557
Pseudo R^2	0.57	0.56	0.65
Wald Test (Prob)	1901.38 (0.00)*	2370.82 (0.00)*	2066.11 (0.00)*

Note: Long run panel quantile ARDL estimates of overall sample, pre- and post-COP19 time period estimated at medians
* Significant at 1 % ** Significant at 5 % and *** Significant at 10 %

Table 11
Short run QARDL estimates for overall sample and subsample of pre- and post-COP21 at medians.

Variables	Overall Sample Coefficient (Prob)	Before COP21 Coefficient (Prob)	After COP21 Coefficient (Prob)
ΔFinTech	0.001 (0.40)	0.006 (0.00)*	0.025 (0.03)**
$\Delta FinTech^2$	0.0005 (0.41)	0.002 (0.00)*	−0.006 (0.09)***
ΔIQ	−0.0002 (0.39)	−0.001 (0.00)*	0.004 (0.46)
ΔFinTech* ΔIQ	−0.0003 (0.38)	−0.001 (0.00)*	0.005 (0.22)
$\Delta FinTech^{2*}$ ΔIQ	−0.0001 (0.38)	−0.0004 (0.00)*	−0.0002 (0.84)
ΔGI	0.0001 (0.50)	0.0001 (0.55)	0.020 (0.66)
ΔDM	−0.000002 (0.94)	0.00001 (0.95)	−0.017 (0.34)
ECM−1	−0.00004 (0.68)	−0.0002 (0.56)	−0.029 (0.01)**
Cons	0.000001 (**0.79)	0.00004 (0.01)**	−0.005 (0.00)*
Sample	2658****	2101	557

Note: Short run panel quantile ARDL estimates of overall sample, pre- and post-COP19 time period estimated at medians
* Significant at 1 %
** Significant at 5 % and
*** Significant at 10 %

Table 12
QARDL estimates with patents as instrument for technology at 25th, 50th, and 75th percentiles.

Independent Variables	25th Percentile Coefficient (Prob)	50th Percentile Coefficient (Prob)	75th Percentile Coefficient (Prob)
Patents	0.077 (0.32)	0.182 (0.00)*	0.204 (0.06)***
$Patents^2$	0.090 (0.02)**	−0.116 (0.00)*	−0.190 (0.00)*
IQ	0.009 (0.02)**	0.008 (0.19)	0.004 (0.56)
Patents* IQ	−0.055 (0.01)**	−0.098 (0.00)*	−0.086 (0.56)
$Patents^2$* IQ	0.030 (0.00)*	0.039 (0.00)*	0.054 (0.00)*
GI	−0.025 (0.22)	0.056 (0.00)*	0.099 (0.00)*
DM	0.016 (0.45)	0.002 (0.93)	0.016 (0.65)
$\overline{ECR}$	0.726 (0.00)*	0.911 (0.00)*	1.282 (0.00)*
$\overline{Patents}$	−0.080 (0.36)	−0.173 (0.03)**	−0.204 (0.09)***
$\overline{Patents}^2$	0.095 (0.18)	0.082 (0.15)	0.206 (0.00)*
$\overline{IQ}$	−0.001 (0.78)	−0.008 (0.20)	−0.012 (0.11)
$\overline{Patents} * \overline{IQ}$	0.041 (0.09)***	0.111 (0.00)*	0.093 (0.00)*
$\overline{Patents}^2 * \overline{IQ}$	−0.027 (0.24)	−0.035 (0.06)***	−0.061 (0.00)*
$\overline{GI}$	0.032 (0.24)	−0.046 (0.02)**	−0.116 (0.00)*
$\overline{DM}$	−0.004 (0.88)	0.007 (0.85)	−0.037 (0.27)
Cons	−0.015 (0.87)	−0.056 (0.51)	0.100 (0.41)
Sample	2274	2274	2274
Pseudo R^2	0.43	0.46	0.51
Wald Test (Prob)	352.87 (0.00)*	1137.81 (0.00)*	1041.00 (0.00)*

Note: Panel ARDL estimates for robustness using financial technology (Patents)
* Significant at 1 %
** Significant at 5 % and
*** Significant at 10 %

The data was acquired from 114 countries between 1996 and 2022 to fulfil the objectives. The dependent variable was economic readiness to climate change. FinTech is used in quadratic form as the independent variable (institutional quality) is used as a moderator to FinTech-economic readiness relation while globalization and demand are used as controlling variables. This study has used a novel estimation method named as Second-Generation Panel Bootstrap Quadratic Quantile Regression with Pooled Mean Group specification. This hybrid estimation model has the ability to rule out all common post-estimation issues like heteroskedasticity, autocorrelation, normality, and non-linearity.

The results showed that FinTech follows a U-shaped effect which indicates that economies need to boost FinTech adoption beyond a certain threshold (the value of Fintech at the lowest value of U-shape) so that further increases in adoption would lead to transformation of businesses from profitability-driven to sustainability-focused. However, the adoption process is commercially motivated; unless businesses decide to do so themselves or there is an incentive to adopt there will be no increase in FinTech adoption. In such a scenario, this study has introduced the institutional quality as a moderator which can increase the gains from FinTech so that even at low levels of FinTech adoption the economy can experience a significant increase in the level of economic readiness of businesses. The results also depicted this outcome and confirmed the objective that governments can use regulations to make FinTech adoption more effective for a common goal of increasing climate change resilience. The robustness assessment provided some extra insights for improving the economic readiness of businesses such as COP19 helping improve the role of institutions and globalization in forming adaptive capacity. The overall model effectiveness is also improved post-COP19. Institutions also have shown robust effects in the technological innovation model.

Based on the results this study proposes that each country should first assess their current level of FinTech adoption and compare it with the minimum level of FinTech required to initiate the transition toward economic readiness of businesses. Learning from the commercial gains of FinTech adoption, businesses should form sectoral alliances to assist each other for this financial innovation revolution. The government can find and mitigate the adoption related hurdles along with regulation in order to maximize both commercial and environmental gains. The cross-sectional averages show a negative effect indicating that there is a need to reconstitute the international regulatory bodies to homogenize and integrate the business transition process by assisting in the domain of financial technology and national regulatory policies.

Future studies can explore the role of financial technology and their challenges in different business sectors, especially in developing and high climate risk countries (Mirza et al., 2023). The development of a macroeconomic index of technology 4.0 is the need of the hour to assess on a broader spectrum of how economies can gain in terms of finding sustainable solutions for posterity.

Ethical declarations

Ethical approval: The entire research process is in line with our institutional research ethics policy. We declare that all ethical standards are met and complied with in true letter and spirit.

Informed consent

All participants in this study volunteered themselves during the entire research process, and their consent was taken at inception.

Funding

Nothing to declare.

CRediT authorship contribution statement

Shajara Ul-Durar: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Yassine Bakkar:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Noman Arshed:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Shabana Naveed:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Beifan Zhang:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

References

Abdelzaher, D.M., Martynov, A., Abdel Zaher, A.M., 2020. Vulnerability to climate change: are innovative countries in a better position? Res. Int. Bus. Financ. 51, 101098 https://doi.org/10.1016/j.ribaf.2019.101098.

Alonso, A., Marqués, J.M., 2019. Financial Innovation for a Sustainable Economy. https://doi.org/10.2139/ssrn.3471742.

Anan, L., Isaza, D.C., Figueiredo, F., Flototto, M., Jerenz, A., Krivkovich, A., Nadeau, M., Olanrewaju, T., Orlando, Z., Vassallo, A., 2023. The future of fintech growth. McKinsey & Company.

Anshari, M., Almunawar, M.N., Masri, M., 2020. Financial technology and disruptive innovation in business: concept and application. Int. J. Asian Bus. Inf. Manag. (IJABIM) 11, 29–43. https://doi.org/10.4018/IJABIM.2020100103.

Arner, D.W., Buckley, R.P., Zetzsche, D.A., Veidt, R., 2020. Sustainability, fintech and financial inclusion. Eur. Bus. Organ. Law Rev. 21, 7–35.

Arshed, N., 2020. Applied Cross-Sectional Econometrics. KSP Books.

Arshed, N., 2023. Intervening long-run fundamentals of fossil energy demand - an effort towards responsible and clean energy consumption. Environ. Sci. Pollut. Res.

Arshed, N., Hanif, N., Aziz, O., Croteau, M., 2022a. Exploring the potential of institutional quality in determining technological innovation. Technol. Soc. 68.

Arshed, Noman, Nasir, S., Saeed, M.I., 2022b. Impact of the external debt on standard of living: a case of Asian countries. Soc. Indic. Res. 163, 321–340. https://doi.org/10.1007/s11205-022-02906-9.

Arshed, N., Saeed, M.I., Salem, S., Hanif, U., Abbas, M., 2023. National strategy for climate change adaptability: a case study of extreme climate-vulnerable countries. Environ. Dev. Sustain. https://doi.org/10.1007/s10668-023-04122-y.

Aysan, A.F., Bakkar, Y., Ul-Durar, S., Kayani, U.N., 2023. Natural resources governance and conflicts: retrospective analysis. Resour. Policy 85 (2)), 103942.

Bakker, P., 2016. The role of business in climate change - World Business Council for Sustainable Development (WBCSD) [WWW Document]. URL https://www.wbcsd.org/Overview/News-Insights/Insights-from-the-CEO/The-role-of-business-in-climate-change (accessed 3.24.24).

BDC, 2022. Using technology to adapt to climate change [WWW Document]. BDC.ca. URL https://www.bdc.ca/en/articles-tools/sustainability/environment/how-digital-technology-can-help-adapt-your-business-climate-change (accessed 3.25.24).

Ben Youssef, A., Boubaker, S., Omri, A., 2018. Entrepreneurship and sustainability: the need for innovative and institutional solutions. Technol. Forecast. Soc. Change 129, 232–241. https://doi.org/10.1016/j.techfore.2017.11.003.

Berman, A., Cano-Kollmann, M., Mudambi, R., 2022. Innovation and entrepreneurial ecosystems: fintech in the financial services industry. Rev. Manag. Sci. 16, 45–64.

Blackburne, E.F., Frank, M.W., 2007. Estimation of nonstationary heterogeneous panels. Stata J. 7, 197–208.

Bokpin, G.A., 2017. Foreign direct investment and environmental sustainability in Africa: the role of institutions and governance. Res. Int. Bus. Financ. 39, 239–247. https://doi.org/10.1016/j.ribaf.2016.07.038.

Bonini, S., Swartz, S., 2014. How organizing for sustainability can benefit the bottom line. Sustainability & Resource Productivity. McKinsey & Company.

Bu, Y., Yu, X., Li, H., 2023. The nonlinear impact of FinTech on the real economic growth: evidence from China. Econ. Innov. N. Technol. 32, 1138–1155. https://doi.org/10.1080/10438599.2022.2095512.

Caleb, C., 2023. "Navigating Climate Change: Opportunities and Challenges for Businesses." Medium. URL https://medium.com/@crowncaleb45/navigating-climate-change-opportunities-and-challenges-for-businesses-dbd0752eb83e (accessed 3.24.24).

Chen, C., Nobel, I., Hellmann, J., Coffee, J., Murillo, M., Chawla, N., 2015. Univ. Notre Dame Glob. Adapt. Index.

Cinner, J.E., Adger, W.N., Allison, E.H., Barnes, M.L., Brown, K., Cohen, P.J., Gelcich, S., Hicks, C.C., Hughes, T.P., Lau, J., Marshall, N.A., Morrison, T.H., 2018. Building adaptive capacity to climate change in tropical coastal communities. Nat. Clim. Change 8, 117–123. https://doi.org/10.1038/s41558-017-0065-x.

Clancy, H., 2022. The exciting intersection of fintech and climate tech [WWW Document]. Greenbiz. URL https://www.greenbiz.com/article/exciting-intersection-fintech-and-climate-tech (accessed 3.27.24).

Columbia Engineering, 2021. What is Financial Technology (FinTech)? A Beginner's Guide for 2023. Columbia Engineering Boot Camps. URL https://bootcamp.cvn.columbia.edu/blog/what-is-fintech/ (accessed 3.25.24).
Coppola, M., Blohmke, J., 2019. Feeling the heat? Companies are under pressure on climate change and need to do more [WWW Document]. Deloitte Insights. URL https://www2.deloitte.com/us/en/insights/topics/strategy/impact-and-opportunities-of-climate-change-on-business.html (accessed 3.24.24).
credolab, 2021. 5 benefits of technology in the financial industry [WWW Document]. URL https://www.credolab.com/blog/5-benefits-of-technology-in-the-financial-industry (accessed 3.25.24).
Curtis, F., 2007. Climate change, peak oil, and globalization: contradictions of natural capital. Rev. Radic. Political Econ. 39, 385–390. https://doi.org/10.1177/0486613407305288.
Dai, H., Mamkhezri, J., Arshed, N., Javaid, A., Salem, S., Khan, Y.A., 2022. Role of energy mix in determining climate change vulnerability in G7 countries. Sustainability 14.
Dawson, J.F., 2013. Moderation in management research: what, why, when, and how. J. Bus. Psychol. 29, 1–19. https://doi.org/10.1007/s10869-013-9308-7.
Deloitte, 2021. Deloitte BrandVoice: Organizations Are Feeling The Pain Of Climate Change: Here Are Five Ways It's Affecting Their Business [WWW Document]. Forbes. URL https://www.forbes.com/sites/deloitte/2021/04/16/organizations-are-feeling-the-pain-of-climate-change-here-are-five-ways-its-affecting-their-business/ (accessed 3.24.24).
Du, Q., Xue, M., Li, Z., Min Du, A., Yang, T., 2024. Economic vulnerabilities and sustainability in energy utilities: managing climate change in the face of geopolitical turmoil. Res. Int. Bus. Financ. 71, 102436 https://doi.org/10.1016/j.ribaf.2024.102436.
Dusil, G., Cerny, D., 2018. The Next Evolution in Funding Innovation, in: 2018 International Joint Conference on Neural Networks (IJCNN). Presented at the 2018 International Joint Conference on Neural Networks (IJCNN), pp. 1–4. https://doi.org/10.1109/IJCNN.2018.8489236.
Fan, J., Liao, Y., Yao, J., 2015. Power enhancement in high-dimensional cross-sectional tests. Econometrica 83, 1497–1541.
Ferlito, R., Faraci, R., 2022. Business model innovation for sustainability: a new framework. Innov. Manag. Rev. 19, 222–236. https://doi.org/10.1108/INMR-07-2021-0125.
Firmansyah, E.A., Masri, M., Anshari, M., Besar, M.H.A., 2023. Factors affecting fintech adoption: a systematic literature review. FinTech 2, 21–33. https://doi.org/10.3390/fintech2010002.
Fomenko, V., 2022. It's Time for Businesses to Adapt to Climate Change. How Should They Do It? [WWW Document]. Entrepreneur. URL https://www.entrepreneur.com/growing-a-business/its-time-for-businesses-to-adapt-to-climate-change-how/403652 (accessed 3.24.24).
Fontaine, A. d, 2008. Adapting to Climate Change: A New Frontier for Business. Center for Climate and Energy Solutions. URL https://www.c2es.org/document/adapting-to-climate-change-a-new-frontier-for-business/ (accessed 3.24.24).
Garst, J., Blok, V., Jasen, L., Omta, O.S.W.F., 2017. Responsibility versus Profit: the motives of food firms for healthy product innovation. Sustainability 9.
Ghorbani, A., Siddiki, S., Bravo, G., 2023. Editorial: Institutional adaptation and transformation for climate resilience. Front. Environ. Sci. 11.
Gujarati, D.N., 2009. Basic econometrics. Tata McGraw Hill Education.
Gupta, J., Termeer, C., Klostermann, J., Meijerink, S., van den Brink, M., Jong, P., Nooteboom, S., Bergsma, E., 2010. The adaptive capacity wheel: a method to assess the inherent characteristics of institutions to enable the adaptive capacity of society. Environ. Sci. Policy 13, 459–471. https://doi.org/10.1016/j.envsci.2010.05.006.
Gygli, S., Haelg, F., Potrafke, N., Sturm, J.-E., 2019. The KOF globalisation index – revisited. Rev. Int. Organ. 14, 543–574. https://doi.org/10.1007/s11558-019-09344-2.
Haans, R.F.J., Pieters, C., He, Z.-L., 2015. Thinking about U: Theorizing and testing U- and inverted U-shaped relationships in strategy research. Strateg. Manag. J. 37, 1177–1195. https://doi.org/10.1002/smj.2399.
Haas, C., Jahns, H., Kempa, K., Moslener, U., 2023. Deep uncertainty and the transition to a low-carbon economy. Energy Res. Soc. Sci. 100, 103060 https://doi.org/10.1016/j.erss.2023.103060.
Hassan, M.S., Bukhari, S., Arshed, N., 2020. Competitiveness, governance and globalization: what matters for poverty alleviation? Environ., Dev. Sustain. 22, 3491–3518.
HBS, 2022. 7 Ways Climate Change Affects Global Businesses [WWW Document]. Business Insights Blog. URL https://online.hbs.edu/blog/post/climate-change-affecting-businesses (accessed 3.24.24).
He, Y., 2024. Chinese fintech goes global: political challenges and business strategies. Asia Policy 19, 35–50.
He, M., Song, G., Chen, Q., 2023. Fintech adoption, internal control quality and bank risk taking: evidence from Chinese listed banks. Financ. Res. Lett. 57, 104235 https://doi.org/10.1016/j.frl.2023.104235.
Hong, H., Karolyi, G.A., Scheinkman, J.A., 2020. Climate finance. Rev. Financ. Stud. 33, 1011–1023. https://doi.org/10.1093/rfs/hhz146.
Hower, M., 2015. The business benefits of the climate fight [WWW Document]. Greenbiz. URL https://www.greenbiz.com/article/business-benefits-climate-fight (accessed 3.24.24).
Huang, X., Khan, Y.A., Arshed, N., Salem, S., Shabeer, M.G., Hanif, U., 2023. Increasing social resilience against climate change risks: a case of extreme climate affected countries. Int. J. Clim. Change Strateg. Manag. 15, 412–431. https://doi.org/10.1108/IJCCSM-04-2022-0051.
Hunjra, A.I., Tayachi, T., Chani, M.I., Verhoeven, P., Mehmood, A., 2020. The moderating effect of institutional quality on the financial development and environmental quality Nexus. Sustainability 12, 3805. https://doi.org/10.3390/su12093805.
IMF, 2014. The Output Gap: Veering from Potential - Back to Basics Compilation Book [WWW Document]. IMF Finance & Development magazine. URL https://www.imf.org/external/pubs/ft/fandd/basics/22_output-gap.htm (accessed 3.28.24).
Iqbal, M., Arshed, N., Chan, L.-F., 2024. Exploring the dynamics: biodiversity impacts of natural resource extraction with moderating influence of FinTech for sustainable practices in resource-rich nations. Resour. Policy 91, 104933. https://doi.org/10.1016/j.resourpol.2024.104933.
Irwin, N., 2024. The U.S. could see a productivity boom, McKinsey report says [WWW Document]. AXIOS. URL https://www.axios.com/2024/03/27/productivity-mckinsey-report-boom (accessed 3.28.24).
Islam, R., Fakhrorazi, A., Hartini, H., Raihan, M.A., 2019. Globalization and its impact on international business. HSSR 7, 256–265. https://doi.org/10.18510/hssr.2019.7130.
Javaid, A., Arshed, N., Munir, M., Zakaria, Z.A., Alamri, F.S., Khalifa, H.A.E.W., Hanif, U., 2022. Econometric assessment of institutional quality in mitigating climate-change risk. Sustainability 14, 669.
Jian, L.C., 2023. Climate Fintech: The Key to Unlocking Wider Climate Tech Solutions [WWW Document]. Financial IT. URL https://financialit.net/blog/fintech/climate-fintech-key-unlocking-wider-climate-tech-solutions (accessed 3.27.24).
Juodis, A., Reese, S., 2021. The incidental parameters problem in testing for remaining cross-section correlation. J. Bus. Econ. Stat. 40, 1191–1203.
Kagan, J., 2024. Financial Technology (Fintech): Its Uses and Impact on Our Lives [WWW Document]. Investopedia. URL https://www.investopedia.com/terms/f/fintech.asp (accessed 3.25.24).
Kalim, R., Ul-Durar, S., Iqbal, M., Arshed, N., Shahbaz, M., 2023. Role of knowledge economy in managing demand-based environmental Kuznets Curve. Geosci. Front., 101594 https://doi.org/10.1016/j.gsf.2023.101594.
Kaur, H., Singh, K., Kumar, P., Kaur, A., 2023. Assessing the environmental sustainability corridor: an empirical study of renewable energy consumption in BRICS nation. IOP Conf. Ser.: Earth Environ. Sci. 1110, 012053 https://doi.org/10.1088/1755-1315/1110/1/012053.
Khan, M.M., Islam, M.S., 2015. Climate change adaptation in developing countries: does globalization act as facilitator? J. Glob. Stud. 4, 62–74.
Kumar, Y.V., Srija, K., Snehitha, L., Sunkara, L.K., 2023. The impact of climate change on international business strategies. IJRASET 11, 461–465. https://doi.org/10.22214/ijraset.2023.54687.
Leichenko, R., 2012. Climate Change, Globalization, and the Double Exposure Challenge to Sustainability: Rolling the Dice in Coastal New Jersey. In: Weinstein, M.P., Turner, R.E. (Eds.), Sustainability Science: The Emerging Paradigm and the Urban Environment. Springer, New York, NY, pp. 315–328. https://doi.org/10.1007/978-1-4614-3188-6_15.

Liu, H., Yao, P., Latif, S., Aslam, S., Iqbal, N., 2022. Impact of green financing, fintech, and financial inclusion on energy efficiency. Environ. Sci. Pollut. Res. 29, 18955–19866.
Lu, Y., Zhan, S., Zhan, M., 2024. Has FinTech changed the sensitivity of corporate investment to interest rates?—Evidence from China. Res. Int. Bus. Financ. 68, 102168 https://doi.org/10.1016/j.ribaf.2023.102168.
Lv, S., Du, Y., Liu, Y., 2022. How Do Fintechs Impact Banks' Profitability?—An Empirical Study Based on Banks in China. FinTech 1, 155–163. https://doi.org/10.3390/fintech1020012.
Magni, D., Chierici, R., Fait, M., Lefebvre, K., 2021. A network model approach to enhance knowledge sharing for internationalization readiness of SMEs. Int. Mark. Rev. 39, 626–652. https://doi.org/10.1108/IMR-03-2021-0110.
Malucha, M., 2023. 6 Advantages of FinTech Applications in Finance. CSHARK. URL https://cshark.com/6-advantages-of-fintech-applications-in-finance/ (accessed 3.25.24).
McDonald, S., Bailey, R., 2020. Climate Change Is An Opportunity For Business To Thrive [WWW Document]. Oliver Wyman. URL https://www.oliverwyman.com/our-expertise/insights/2020/oct/climate-change-is-an-opportunity-for-business-to-thrive.html (accessed 3.24.24).
Mhlanga, D., 2022. The role of financial inclusion and FinTech in addressing climate-related challenges in the industry 4.0: lessons for sustainable development goals. Front. Clim. 4.
Mhlanga, D., 2023. FinTech and Climate-Related Challenges in the Fourth Industrial Revolution. In: Mhlanga, D. (Ed.), FinTech and Artificial Intelligence for Sustainable Development: The Role of Smart Technologies in Achieving Development Goals. Springer Nature Switzerland, Cham, pp. 213–239. https://doi.org/10.1007/978-3-031-37776-1_10.
Mirza, N., Elhoseny, M., Umar, M., Metawa, N., 2023. Safeguarding FinTech innovations with machine learning: comparative assessment of various approaches. Res. Int. Bus. Financ. 66, 102009 https://doi.org/10.1016/j.ribaf.2023.102009.
Monasterolo, I., 2020. Climate Change and the Financial System. https://doi.org/10.2139/ssrn.3479380.
Niranjan, A., 2023. ' says UN chief as July set to be hottest month on record. The Guardian. Era Glob. Boil. Has. arrived.
Nystrom, M., Jouffray, J.B., Norstrom, A.V., Crona, B., Jorgensen, P.S., Carpenter, S.R., Bodin, O., Galaz, V., Folke, C., 2019. Anatomy and resilience of the global production ecosystem. Nature 575, 98–108.
Obobisa, E.S., Chen, H., Mensah, I.A., 2023. Transitions to sustainable development: the role of green innovation and institutional quality. Environ., Dev. Sustain. 25, 6751–6780.
Omri, A., Bel Hadj, T., 2020. Foreign investment and air pollution: do good governance and technological innovation matter? Environ. Res. 185, 109469 https://doi.org/10.1016/j.envres.2020.109469.
Oostendorp, R., van Asseldonk, M., Gathiaka, J., Mulwa, R., Radeny, M., Recha, J., Wattel, C., van Wesenbeeck, L., 2019. Inclusive agribusiness under climate change: a brief review of the role of finance. Curr. Opin. Environ. Sustain., Sustain. Sci.: Incl. Bus.: A multi-Stakehold. Issue 41, 18–22. https://doi.org/10.1016/j.cosust.2019.09.014.
Pawlowska, M., Staniszewska, A., Grzelak, M., 2022. Impact of FinTech on sustainable development. Financ. Sci. 27, 49–66.
Pedroni, P., 2004. Panel cointegration: asymptotic and finite sample properties of pooled time series tests with an application to the ppp hypothesis. Econom. Theory 20. https://doi.org/10.1017/s0266466604203073.
Pesaran, M.H., 2006. Estimation and inference in large heterogeneous panels with a multifactor error structure. Econometrica 74, 967–1012. https://doi.org/10.1111/j.1468-0262.2006.00692.x.
Pesaran, M.H., 2014. Testing weak cross-sectional dependence in large panels. Econom. Rev. 34, 1089–1117. https://doi.org/10.1080/07474938.2014.956623.
Pesaran, M.H., Shin, Y., Smith, R.J., 2001. Bounds testing approaches to the analysis of level relationships. J. Appl. Econ. 16, 289–326.
Pesaran, M.H., Xie, Y., 2023. A Bias-Corrected CD Test for Error Cross-Sectional Dependence in Panel Data Models with Latent Factors. https://doi.org/10.48550/arXiv.2109.00408.
Powell, D., 2022. Quantile regression with nonadditive fixed effects. Empir. Econ. 63, 2675–2691. https://doi.org/10.1007/s00181-022-02216-6.
Ramamohan, M., Mehta, M., K., S.B., Ramamohan, M., Mehta, M., K., S.B., 2021. FinTech and Sustainable Development: A Comparative Study of Indian and Chinese FinTech Ecosystems [WWW Document]. https://services.igi-global.com/resolvedoi/resolve.aspx?doi=10.4018/978-1-7998-6643-5.ch018. URL https://www.igi-global.com/gateway/chapter/www.igi-global.com/gateway/chapter/279453 (accessed 3.27.24).
Reichheld, A., Peto, J., Ritthaler, C., 2023. Research: Consumers' Sustainability Demands Are Rising [WWW Document]. Harvard Business Review. URL https://hbr.org/2023/09/research-consumers-sustainability-demands-are-rising (accessed 3.29.24).
Richardson, B.J., 2014. The evolving marketscape of climate finance. Clim. Law 4, 94–106. https://doi.org/10.1163/18786561-00402008.
Sarkodie, S.A., Adams, S., 2018. Renewable energy, nuclear energy, and environmental pollution: accounting for political institutional quality in South Africa. Sci. Total Environ. 643, 1590–1601. https://doi.org/10.1016/j.scitotenv.2018.06.320.
Singh, R., Malik, G., Jain, V., 2021. FinTech effect: measuring impact of FinTech adoption on banks' profitability. IJMP 14, 411. https://doi.org/10.1504/IJMP.2021.116587.
Singh, S., Mungila Hillemane, B.S., 2023. An analysis of the financial performance of tech startups: do quantum and sources of finance make a difference in India? Small Enterp. Res. 30, 374–399. https://doi.org/10.1080/13215906.2023.2270447.
Song, X., Yu, H., He, Z., 2023. Heterogeneous impact of fintech on the profitability of commercial banks: competition and spillover effects. J. Risk Financ. Manag. 16, 471. https://doi.org/10.3390/jrfm16110471.
Sutikno, S., Kuruppuarachchi, D., 2021. Finance technology as a solution to get capital for small business today. J. Keuang. Dan. Perbank. (KEBAN) 1, 1–13. https://doi.org/10.30656/jkk.v1i1.3964.
Svirydzenka, K., 2016. Introducing a New Broad-based Index of Financial Development. IMF Working Papers WP/16/5.
Tong, S., Ebi, K., 2019. Preventing and mitigating health risks of climate change. Environ. Res. 174, 9–13. https://doi.org/10.1016/j.envres.2019.04.012.
Ul-Durar, S., Arshed, N., Anwar, A., Sharif, A., Lin, W., 2023. How does economic complexity affect natural resource extraction in resource rich countries? Resour. Policy 86, 104214.
Ul-Durar, S., Arshed, N., De Sisto, M., Nazarian, A., Sadaf, A., 2024a. Modeling green energy and innovation for ecological risk management using second generation dynamic quantile panel data model. J. Environ. Manag. 366, 121741 https://doi.org/10.1016/j.jenvman.2024.121741.
Ul-Durar, S., De Sisto, M., Arshed, N., Naveed, S., Farooqi, M.R., 2024b. FinTech adoption in achieving ecologically sustainable mineral management in Asian OBOR countries – A cross-section and time autoregressive robust analysis. Resour. Policy 91, 104939. https://doi.org/10.1016/j.resourpol.2024.104939.
UN, 2023. Why finance climate action? [WWW Document]. United Nations. URL https://www.un.org/en/climatechange/why-finance-climate-action (accessed 3.25.24).
UNFCCC, 2023. Introduction to Climate Finance [WWW Document]. URL https://unfccc.int/topics/introduction-to-climate-finance (accessed 3.25.24).
Vergara, C.C., Agudo, L.F., 2021. Fintech and sustainability: do they affect each other? Sustainability 13, 7012. https://doi.org/10.3390/su13137012.
WDI, 2021. World Development Indicators [WWW Document].
WEF, 2020. Section 5: Assessing Countries' Transformation Readiness, Global Competitiveness Report 2020. World Economic Forum.
WEF, 2023a. Accelerating business action on climate change adaptation. World Economic Forum.
WEF, 2023b. Davos AM23 - Building Momentum towards COP28 - Original [WWW Document]. URL https://cdn.jwplayer.com/previews/jjEheH6E-ncRE1zO6 (accessed 3.24.24).
Westerlund, J., 2005. New simple tests for panel cointegration. Econom. Rev. 24, 297–316. https://doi.org/10.1080/07474930500243019.
WGI, 2021. Worldwide Governance Indicators [WWW Document].
Wooldridge, J.M., 2010. Econometric Analysis of Cross Section and Panel data. MIT Press, London England.
World Bank, 2020. The Adaptation Principles: 6 Ways to Build Resilience to Climate Change [WWW Document]. World Bank. URL https://www.worldbank.org/en/news/feature/2020/11/17/the-adaptation-principles-6-ways-to-build-resilience-to-climate-change (accessed 3.27.24).
World Bank Group, 2022. Fintech and the Future of Finance. World Bank, Washington DC.

Xing, X., Ye, A., 2022. Consumption upgrading and industrial structural change: a general equilibrium analysis and empirical test with low-carbon green transition constraints. Sustainability 14.

Yanosek, K., Victor, D.G., 2022. How Big Business Is Taking the Lead on Climate Change [WWW Document]. McKinsey Sustainability. URL https://www.mckinsey.com/capabilities/sustainability/our-insights/sustainability-blog/how-big-business-is-taking-the-lead-on-climate-change (accessed 3.24.24).

Zec, J., Brunet, A., 2021. Climate Fintech: using data and AI to fight climate change and create business opportunities [WWW Document]. CITI Ventures. URL https://www.citi.com/ventures/perspectives/opinion/climate-fintech.html (accessed 3.27.24)..