Policy Journal of Social Science Review

Online ISSN 3006-4635

Print ISSN 3006-4627

Vol. 4 No. 2 (2026)

Impact of Financial Technology on Sustainable Development with Moderating Role of Financial Development: Evidence from Asian Countries

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Abstract

This study investigates financial growth in Asian countries as a moderating variable in the relationship between financial technology (fintech) and sustainable development. Digital financial services such as mobile banking, digital payments, and online lending are increasingly widespread and have the potential to support the achievement of the United Nations' Sustainable Development Goals (SDGs). This growing relevance has encouraged extensive research in this area. The stability of the financial system is crucial for Fintech's capacity to provide access and foster growth. This will be achieved by using secondary panel data gathered from diverse sources, including the World Bank, the United Nations Development Program, and the State Bank of Pakistan, throughout the period of 2010–2023. A variety of indicators are used to monitor Sustainable Development, including economic advancement, gender parity, access to energy and potable water, and poverty alleviation. Digital payment and technology utilization serve as proxies for the degree of Fintech adoption, while credit to the private sector and money supply act as indicators of financial growth. Pooled ordinary least squares (OLS), fixed effects models, random effects models, and moderation analysis are econometric approaches used to analyses relationships. the findings, which will direct policymakers, financial institutions, and development agencies in their implementation of fintech innovation and financial sector reform.

Keywords: Financial Technology (Fintech), Sustainable Development, Financial Development,

Article Details:

Received on 16 Jan, 2026

Accepted on 02 Feb, 2026

Published on 04 Feb, 2026

Corresponding Authors*

Policy Journal of Social Science Review

Online ISSN 3006-4635

Print ISSN 3006-4627

Vol. 4 No. 2 (2026)

1. INTRODUCTION

Sustainable development is an international goal which is focused on the achievement of environmental preservation, social equality and economic development. In most Asian nations, however, such as Pakistan, Afghanistan, Nepal, India, Sri Lanka, and Bangladesh attainment of Sustainable development remains a major challenge because of the existing economic, social, and financial constraints (World Bank, 2021). A solution to this problem has been found in the form of financial technology (Fintech), offers a promising solution as mobile banking, digital payments, and other online financial services can significantly improve access to financial resources. For illustrate, in Bangladesh and India, the efficiency of transactions has been increased because of a fast increase in mobile banking, and in Pakistan and Sri Lanka, the personal financial management has become easier with the development of digital wallets. Although it has potentials, little is known about how Fintech will influence sustainable development in Asia. The financial development, such as the presence of the efficient financial system and favorable legal setting, is significant to enhance the efficacy of Fintech. Nevertheless, issues like low digital literacy, cybersecurity threats, and regulatory restrictions continue to exist throughout the Asian economies. Pakistan Telecommunication Authority (PTA, 2021) states that in Pakistan, there are over 180 million users of mobile phones, which has offered substantial possibilities in Fintech growth. However, access is not enough to ensure sustainability results, with financial development possibly being the factor in defining whether Fintech can effectively lead to sustainable development or not.

Financial development can be described as the power, stability the efficiency of the financial markets and financial institutions such as banks, insurance firms, stock markets and digital payment systems with effective regulation (Levine, 2005). An established financial system makes it easier, less risky, and efficient to do business by Fintech companies. On the contrary, less developed financial systems may create fraud, cybercrime, and a lack of trust, thus restricting the use and effectiveness of Fintech (Beck et al., 2018). So, the financial development can reinforce or undermine the Fintech and sustainable development association. According to the Sustainable Development Goals (SDGs) of the United Nations, sustainable development is aimed at balanced economic development, minimization of poverty, gender equality, and environmental sustainability (United Nations, 2015). The following are the targets that can be supported by fintech, entrepreneurship, less corruption via digital transactions, women-led business, and green finance support (such as renewable energy projects), among others (Mhlanga, 2022). These donations underscore how the contributions of the Fintech could be beneficial towards inclusive and sustainable economic development. Nevertheless, in making Fintech effective in ensuring sustainable development, there are a number of challenges. A large number of people have no digital expertise to operate financial technologies, especially in underdeveloped and rural areas (Zins & Weill, 2016). The restricted use of internet, poor regulatory systems, and cybersecurity issues are also limiting the adoption of Fintech. Until these issues are resolved, the possible potential of Fintech in reducing poverty and sustainable development can remain unachieved (Cihak et al., 2015).

The literature on this topic has mostly analyzed Fintech or sustainable development separately, but has not paid much attention to the mediating function of financial development in this association (Bhuyan and Thakker, 2024). This paper strives to bridge this gap by examining the connection between Fintech and sustainable development in the Asian countries introduced by financial development. The timeliness of the study comes particularly in the wake of the COVID-19 where digital financial services will be instrumental in keeping

Policy Journal of Social Science Review
Online ISSN 3006-4635
Print ISSN 3006-4627
Vol. 4 No. 2 (2026)

the economy running throughout the lockdowns and enhancing business and household resilience (Sahay et al., 2020).

To conclude, it is possible to note that this paper merges Fintech and sustainable development by adding financial development as a moderating variable. Concentrating on the Asian economies, the study draws attention to regional challenges and opportunities of the developing countries. The results should help policymakers, financial institutions and development agencies to develop effective policies to foster inclusive, sustainable development as well as to ensure that Fintech can lead to a positive development contribution in relation to long-term development objective.

2. LITERATURE REVIEW

Fintech fulfils an important part in promoting access to financial services making transaction swifter and safer, at lower cost. Benefits are particularly felt in Asian countries such as Pakistan, Afghanistan, Nepal, India, Sri Lanka, or Bangladesh, where many people how low literacy level and limited access to traditional banks. Incentivize sustainable investments, mitigate environmental impact such as carbon emissions, and enhance financial literacy, contributing to the achievements of sustainable Development Goals (SDGs) (Gilo,2018; CAI, 2018).

Fintech services In Asia include payments platforms, crowdfunding, and peer-to-peer credit. Mobile Wallets like Easypaisa and jazz cash have expanded digital payments to remote communities. FinTech-driven students micro-lending initiatives and savings accounts for individuals provide financial cushioning for students and low-income individuals. Integrations of fintech into e-comrace p portals facilities online transactions, while fintech apps enable quick and smooth lending for small businesses and individuals (Ozili, 2021).

Feng & Li (2024) experimentally demonstrate that fintech, including environmental levies, contributes to carbon emissions reduction in Asian countries. However, the full impact of fintech on all SDGs remains underexplored. PPNL and SEM are two advanced ways to estimate are applied to assess whether fintech has direct or indirect implication on SDGs, particularly when mediated by financial development.

2.1 Financial Technologies (fintech)

FinTech encompasses modern Technology in banking, online lending, and digital payments, making financial services more accessible (Arner et al., 2020). It lowers services expenses and improves efficiency, becoming an essential avenue to reach customers in areas lacking conventional banking services.

2.2 Sustainable Development

Sustainable Development makes sure that the demands of today are satisfied without hurting the needs of future generations. It emphasizes economic developments, social inclusion, and environmental protection. The UN (2015) came up with 17 SDGs, including reducing poverty, encouraging gender equality, and providing renewable energy. Fintech supports these goals by providing tools to boost revenue generate new enterprise, and facilities access governments services (Bhuyan & Thakker, 2024).

2.3 Link Between FinTech and Sustainability

Research shows that fintech enhances small business assistance and mitigate environmental degradation through green finance (Malanga, 2022). The impact of fintech on sustainability depends on the penetrations and development level of the country finance systems (Green et al., 2020). Similar consequence is expected in Asian countries; however additional investigation is needed to confirms this.

Policy Journal of Social Science Review

Online ISSN 3006-4635

Print ISSN 3006-4627

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2.3 Role of Financial Development

Financial development refers to strong financial institutions and markets. Fintech thrives in robust financial systems, which stimulate innovations, reduces financial risks, and boost investments (Levine,2005). Poor financial systems with crimes, weak regulations, or low trust can limit fintech's impact. Thus, financial development may operate as moderating variable between fintech and sustainable development.

2.4 Relevant Theories

2.5 Financial Intermediation Theory

institutions link people with lendable funds to these seeking loans. Fintech accelerates this process through mobile banking and online lending, reducing barriers (Arner, Buckley, & Zetsche 2020).

2.6 Financial Innovation Theory

Technologies such as mobile money and digital wallets expand financial services and economic and economic participation, participation, especially in location with little access to standard financial services (Mhlanga, 2020).

2.7 Empirical Review

Fintech influence long-term economic growth. (Beck et al. 2018). found that mobile banking and digital payments provide cost-effective access to finance for rural and poor populations. Digital platform reduces loan costs, ease access to financial services, and help business raise capital. Bank competitions and financial stability are influenced by digital finance, enhancing economic strength in countries like Bangladesh, Pakistan, and India (Demirguc-Kunt & Huizinga, 2010, Global Findex Database, 2018).

Fintech tools such as online loans crowdfunding, and mobile payments can reduce poverty and promote gender parity. Nations where fintech is more prevalent perform better in achieving SDGs (Bhuyan & Thakkar, 2024; Malanga, 2022). However, weak financial systems can limit these effects due to poor regulations, low trust, or inadequate infrastructure (Cihak et al., 2010; Levine, 2005).

2.8 Hypothesis Development

H_0: Fintech has no effects on sustainable development in Asian countries.

H_0 : Financial development does not moderate the relationship between Fintech and sustainable development in Asian countries.

2.9 Conceptual Framework

This study looks at how fintech affects sustainable development in Asian countries, utilizing financial development as a variable that changes the results. enhance the accessibility and efficiency of financial institutions, while financial development strengthens this effect through sound infrastructure, competent regulations, and efficient intermediary service. Control variable includes trade openness, population, inflations, and government spending.

Policy Journal of Social Science Review
Online ISSN 3006-4635
Print ISSN 3006-4627
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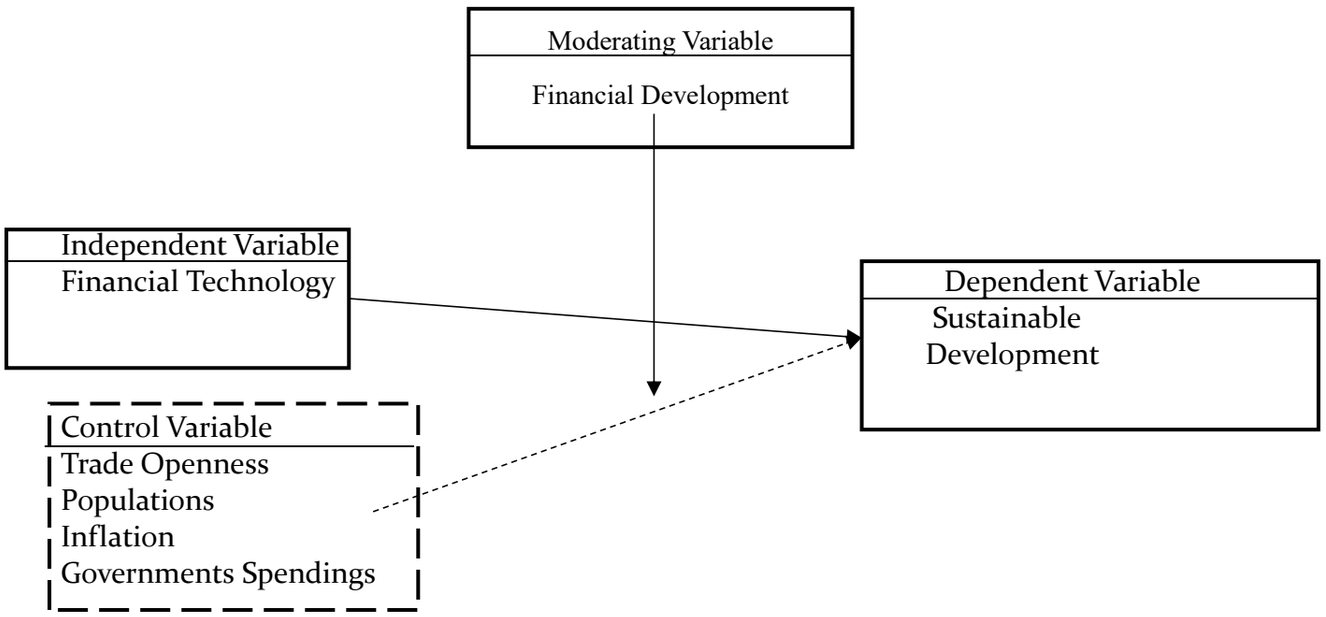

Figure 1: Conceptual Framework

3. Research Methodology

3.1 Data and Source

This study uses a quantitative based on Panel data from Asian countries covering the period 2010-2023. Secondary data were obtained from internationally recognized database including the World Bank (WDI), UNDP, Findex, SWIID, and the financial structure Database. These sources provide consistent cross-country indicators for fintech usage, sustainable Development outcomes, and financial development.

3.2 Data Analysis

This study uses quantitative techniques to examine study the impact of financial technology on sustainable development in Asian countries, with financial development as a moderating variable. Descriptive statistics summarize the data, correlation analysis examines relationships, and panel regression with integration terms assesses moderation. Alternative model specifications are also tested to ensure robustness.

3.3 Fixed effect Method

The fixed effect model is used to control for country certain features that remain constant across time, such is cultural, historical and geographical factor. The dependent variable includes key SDG indicators, namely poverty, alleviations, gender parity, educations enhancements, and economic expansion. Fintech adoption in the main independent variable and is measured by the percentage of adults using digital payments services. Trade openness, inflations, governments spending, populations growth, and regulatory quality are included as control variables. This approach helps identify the impact of fintech on sustainable development by reducing bias from country-specific factors (Thakkar & Bhuyan, 2024).

3.4 Random effects model

According to Greene (2000), the random effects model is estimated using the generalized least squares (GLS) approach. This model assumes that the individual specific effects is treated as a group-specific random disturbance rather than a fixed parameter in the regression model.

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Online ISSN 3006-4635

Print ISSN 3006-4627

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3.5 Hausman Test

According to Asteriou and Hall (2007), the Hausman (1978) test is used to determine the appropriate choice between the fixed effects and random effects models. A statistically insignificant Hausman test statistic indicates that the random effects model is preferred, as it suggests no systematic difference between the estimator of the two models.

3.6 Estimation Strategies

The analysis begins with descriptive statistic and correlation analysis to summarize data patterns. Panel regression technique is then applied, including Pooled OLS, Fixed effects, Randoms Effects, and PPML, estimations. To address potential econometric issues such as heteroskedasticity, or autocorrelation, alternative approaches such as GMM. The Durbin-Wu-Hausman test, and Breusch-Pagan LM test are utilized.

3.7 Robustness Checks

To ensure reliable results, several robustness procedures are applied, including tests for multicollinearity (VIF), heteroskedasticity (Breusch-Pagan), auto correlation (Durbin-Watson), and model comparison tests such as the Hausman test. Additional estimation such as PPML and 3sls/SEM are conducted to verify model stability and consistency.

3.8 Variables and Measurement

The key independent variable is fintech, measured using Findex indicators representing the share of adults (15+) who send or receive digital payments. The dependent variable is sustainable development, captured through several SDG-related indicators such as poverty reduction (poverty headcount ratio), income inequality (Gini index), gender equality (Women, Business and Law Index), GDP per capita growth, access to clean energy, sanitation and reenable energy use. Control Variables include trade openness, inflations, government expenditure, and populations growth, secured from WDI. The moderating variable, financial development, is measured using domestic lending to the private sector (%of GDP) and other financial depth measures.

3.9 Model Specification

To explore the impact of fintech on sustainable development, the following panel regressions models are estimated.

$$SDG = \beta 0 + \beta 1 Fintech_{it} + \beta 2 Trdop_{it} + \beta 3 Inf_{it} + \beta 4 Govsp_{it} + \beta 5 Pop_{it} + \varepsilon \quad (1)$$

SDG, Fintech, Trdop, Inf, Govsp and Pop represent Sustainable development Goals, Financial Technology. Trade openness, Inflation rate, Government Spending and Population, and i, represent country and t represent Time.

$$SDG = \beta 0 + \beta 1 Fintech_{it} \times \beta 2 FD_{it} + \beta 3 Trdop_{it} + \beta 4 Inf_{it} + \beta 5 Govsp_{it} + \beta 6 Pop_{it} + \varepsilon \quad ($$

SDG, Fintech, FD, Trdop, Inf, Govsp and Pop represent Sustainable Development Goals, Financial Technology, Financial Development. Trade openness, Inflation rate, Government Spending and Population, and i, represent Country and t represent Time.

4. Results

The results imply that the research variables are not regularly distributed. Moreover, the correlation analysis verifies the study's assumptions by demonstrating a considerably substantial link between financial technology, financial development, and sustainable development.

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Online ISSN 3006-4635

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4.1 Descriptive Statistic

Table 4.1 Descriptive Statistics

Variables	Obs	Mean	Sta Dev.	Minimum	Maximum	Variance	Skewness	Kurtosis
Fintech	84	1.19e-09	1.000005	-0.6623018	2.040715	1.000009	1.95159	6.799337
SD	84	8.33e-09	1	-1.79079	1.456015	1.000001	-0.1894282	1.745148
FD	84	2.02e-08	1.00001	-1.250348	2.471354	1.000019	0.7722761	3.149985
Trdop	84	40.46281	9.419821	24.70158	55.62388	48.73304	0.5016692	3.635462
Inf	84	1.052812	2.280257	-0.2033222	1.298282	5.199573	6.827984	9.97451
GDP	84	7.681891	47.35936	-0.3702289	33.3821	242.909	5.614671	8.18845
Govsp	84	0.9470622	0.1326806	0.7023739	1.326135	0.0176041	0.6381365	4.650697

Note: variables which shown in 1 table are explained in previous chapter research methodology of this thesis.

Table 4.1 reports Descriptive statistic indicate heterogeneity across Asian countries. FinTech adoption shows positive skewness (1.95) and high kurtosis (6.80), suggesting a few countries have very high adoption rates. Sd and FD distributions are approximately normal. GDP and inflation exhibit extreme outliers, reflecting economic disparities in the sample.

4.2 Correlation Results Sustainable Development, Fintech, Trade Openness, GDP, Inflation, Government Spending

Variables	SDG	Fintech	Trdop	GDP	Inf	Govsp
SD	1.0000					
Fintech	0.1564	1.0000				
Trdop	0.0307	0.1010	1.0000			
GDP	0.2184	0.0205	0.1999	1.0000		
Inf	0.0163	-0.0158	0.2287	-0.1984	1.0000	
Govsp	-0.3050	-0.0193	0.3153	-0.0353	0.1206	1.0000

Here in the Table 4.2 the correlation between SD and Fintech have positive correlation of 0.1564, which means that as Fintech improves, sustainable development also increases slightly. However, the relationship is still weak. Similarly, the correlation value between SD and Trdop show a very weak positive correlation 0.0307, suggesting that trade openness has a minimum direct relationship with sustainability in this case. The Correlation between SD and GDP have moderate positive correlation 0.2184. this indicates that higher GDP (economic growth) is somewhat associated with better sustainable development. Similarly, the correlation value between SD and Inf show a very weak positive correlation 0.0163. this means inflations has almost no direct impact on sustainable development in the data sample. The correlation between SD and Govsp have moderate negative correlation -0.3050. this suggests that is government spending increases, sustainable development tends to decease. This may reflect inefficiencies in public spending or lack of alignment with sustainability objectives.

4.3 Correlation Matrix Sustainable Development, Fintech, Financial Development, Trade Openness, GDP, Inflation, Government Spending

Table 4.3: ***Correlation Matrix***

Variables	SDG	Fintech	FD	Trdop	GDP	Inf	Govsp
SD	1.0000						
Fintech	0.1564	1.0000					
FD	-0.1136	0.4700	1.0000				
Trdop	0.0307	0.1010	0.2626	1.0000			
GDP	0.2184	0.0205	0.0968	0.1999	1.0000		

Policy Journal of Social Science Review

Online ISSN 3006-4635

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Inf	0.0163	-0.0158	-0.0646	0.2287	-0.1984	1.0000	
Govsp	-0.3050	-0.0193	-0.1662	0.3153	-0.0353	0.1206	1.0000

Table- 4.3 presents the correlations coefficient between the key variables of the study. Sustainable Development, Fintech, Financial Development, Trade Openness, GDP, Inflation and Government Spending based on 84 observations.

Sustainable Development (SD) shows a positive but weak correlation with Fintech 0.1564 and GDP 0.2184, suggesting that an increase in financial technology and economic growth may slightly support sustainable development. It also has a moderate negative correlation with Govsp -0.3050 which may indicate inefficient government spending or misalignment with sustainability goals. Financial Development (FD) and Fintech have Positive correlation 0.4700. this makes sense because fintech can boost the banking industry and increase access to financial services. Growth in the financial sector may be supported by more open trade and larger economics, as seen by the positive correlation between FD and trade of GDP 0.2626 and GDP 0.0968. Higher inflation may be detrimental to both economic growth and sustainability, as evidenced by the negative correlations found between Inflation and GDP -0.1984 and the very weak positive correlation with sustainable development 0.0163, there may be inefficiencies in spending to promote growth or financial development, as evidenced by the negative correlation between Government Spending (Govsp) and Financial Development (FD) -0.1662 and GDP -0.0353, but a positive correlation with Trade of GDP 0.3153.

4.4 Fixed Effects (FE) with Sustainable Development, Fintech, Trade Openness, GDP, Inflation, Government spending

Table 4.4: ***Results of Fixed Effect (FE)***

Sustainable Development	**Coef.**	**St. Err.**	**t-value**	**p-value**	**[95% Conf**	**Interval]**	**Sig**
Fintech	-0.1	.045	-2.22	0.029	-.189	-.01	**
Trdop	-6.629	2.633	-2.52	0.014	-11.875	-1.382	**
Inf	0.638	.331	1.93	0.058	-.022	1.299	*
GDP	0.464	.226	2.05	0.044	.013	.915	**
Govsp	-0.219	1.315	-0.17	0.868	-2.841	2.402	
Constant	1.253	.545	2.30	0.024	.167	2.339	**
Mean dependent var		0.000	SD dependent var		1.000		
R-squared		0.171	Number of Obs		84		
F-test		3.004	Prob > F		0.003		
Akaike crit. (AIC)		65.755	Bayesian crit. (BIC)		80.340		

*** p<.01, ** p<.05, * p<.1*

Table 4.4 presents fixed effects regression results indicate that financial technology has negative and statistically significant impact on sustainable development, which contrasts with most previous studies reported a positive fintech sustainable development relationship (Bhuyan & Thakkar, 2024; Arner et al., 2020; Mhlanga, 2022) this divergence may be attributed to uniquely access to digital financial services, low digital literacy, and weak regulatory frameworks in developing Asian economies, where fintech benefits are often concentrated among urban and elite populations. Trade openness also exhibits a negative and significant effect on sustainable development, supporting earlier findings that trade expansion without adequate environmental and social safeguards may adversely affect sustainability outcomes in developing economies (Cole, 2004; Salahuddin et al., 2015). Inflation shows positive and marginally significant impact, suggesting that moderate inflations may support sustainable development through short-term economic growth and increased investments activity (Green

Policy Journal of Social Science Review
Online ISSN 3006-4635
Print ISSN 3006-4627
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et al., 2020). GDP demonstrated positive and statistically significant relationship with sustainable development, consistent with literature emphasizing the role of economic growth in financing social and environmental investments (Levine, 2005; Beck et al., 2004).Governments spendings displays a negative but statistically insignificant effect indicating possible inefficiencies in fiscal allocation and weak policy implementation in developing countries, are also highlighted in previous studies (OECD, 2015; Salahuddin et al., 2015). Overall, the model is statistically significant, and the explanatory power is acceptable for fixed effects framework focusing on within-country variations over time.

4.5 Fixed Effect (FE) with sustainable development, FinTech, Financial Deployment, Trade Openness, GDP, Inflation, Governments spending

Table 4.5: ***Results of Fixed Effects (EF)***

Sustainable Development	***Coef.***	***St. Err.***	***t-value***	***p-value***	***[95% Conf***	***Interval]***	***Sig***
fintech	-.116	.045	-2.56	.013	-.206	-.026	**
FD	-.154	.089	-1.73	.088	-.331	.023	*
Trdop	-7.334	2.629	-2.79	.007	-12.575	-2.094	***
Inf	.794	.339	2.34	.022	.118	1.471	**
GDP	.497	.224	2.22	.03	.05	.944	**
Govsp	-.442	1.304	-0.34	.736	-3.041	2.158	
Constant	1.355	.541	2.50	.015	.276	2.433	**
Mean dependent var	0.000		SD dependent var		1.000		
R-squared	0.204		Number of Obs		84		
F-test	3.072		Prob > F		0.002		
Akaike crit. (AIC)	64.326		Bayesian crit. (BIC)		81.341		

*** p<.01, ** p<.05, * p<.1

Table 4.5 reports the results indicate that financial technology has negative and statistically significant effect on sustainable development suggesting that fintech growth in the sampled countries is currently more focused on economic and financial expansion rather than environmental and social sustainability.

Financial development also shows a negative and weakly significant at the 10 percent level. This implies that financial devilment does not strongly promote sustainable development and may support activities that increase environmental pressure. Among the control variable, trade openness has strong negative and highly significant effects on sustainable development indicating that increased trade may lead to higher industrial activity and environmental stress when sustainability regulations are weak. In contrast, inflations and GDP have positive and statistically significant effects on sustainable development, suggesting that moderate inflation and economic growth support sustainability outcomes. Governments spending shows a negative but insignificant effects indicating that public expenditure does not play a meaningful role in enhancing sustainable development in this model. Overall, the model is statistically significant and explains 20.4 percent of the variation in sustainable development.

These findings differ from much of the existing literature, which generally reports a positive relationship between financial technology and sustainable development (Bhuyan & Thakker, 2024; Arner et al., 2020; Mhlanga,2022). The negative role of financial development is consistent with studies highlighting adverse effects in developing economies (Salahudin et al., 2015; Cole, 2004), while trade openness shows a negative impact in line with literature emphasizing weak environmental safeguards. The positive effects of inflations and GDP align

with prior studies suggesting that stable economic growth supports sustainable development (Levine, 2005; Beck et al., 2004; Green et al., 2020). Governments spending remines insignificant, consistent with evidence from developing countries where inefficient allocation limits its effectiveness (OECD, 2015

4.5 Conclusion

This study examined the Impact of financial technology on sustainable development in selected Asian countries, with financial development as moderating variable, using panel data from 2010 to 2023. The results reveal the financial technology his negative and statistically significant effect on sustainable development, while financial development shows a weak and negative moderating role. These findings suggest that fintech expansion in developing Asian economies is not yet fully aligned with environmental and social sustainability objectives. Trade openness negatively affects sustainable development, were inflations and GDP contribute positively, while government spending remines insignificant. The study addresses an important research gap by providing empirical evidence on the fintech-sustainable development relationship in Asian countries, where existing literature remines limited and inconclusive. Future research may extend this analysis by incorporating institutional quality, regulatory frameworks, and country specific dynamic to better understand how fintech can support sustainable development.

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