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Does Digital Financial Inclusion Affect Economic Development and the Environment Differently? Evidence from India using Robust Least Square Model

By Rayees Ahmad Hajam & Dr. Abdul Azeez N. P.

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I. Introduction

Digital financial inclusion increases access to financial services, which is crucial for fostering economic activity and prosperity. It has a positive short-term impact for South Asian economic growth, especially in India, according to empirical research (Thathsarani et al., 2021). Financial inclusion (FI), which focusses on the most impoverished segments of society, guarantees equitable access to necessary financial services that they might not otherwise have. As a result, FI is considered a key concept in worldwide development plans. Recognising the vital role an effective financial system plays in lowering extreme poverty and generating opportunities for all is the main driving force for this endeavour (Wang et al. 2022). Consequently, FI has garnered significant attention from scholars and policymakers due to its effectiveness in accomplishing the Sustainable Development Goals (SDGs), which were set forth by the United Nations in 2015, promoting social justice in certain nations, bringing poverty down to a manageable level, and generating a range of socioeconomic advantages (Ozili 2021). At the present time, governments are investing a lot of money in programs that try to lessen financial marginalisation. Thanks to the incredible advancements in mobile phones and the internet since the start of the twenty-first century, global financial inclusion is now more feasible than ever. The frequency and convenience of these transactions have significantly increased due to the widespread use of financial services technology, or FinTech (Ouma et al. 2017). Financial systems are now easy to access through digital internet platforms as a result of stakeholders' recent review of modern digital financial services as a viable route to FI. Therefore, the implementation and utilisation of digital services may influence and mould regular financial activities, thereby fostering economic development within a community. Thus, it would appear that the twin aims of fostering a wealthier community and reducing poverty are among the primary objectives of FI programs in many emerging nations (Koomson and Danquah 2021). Improved financial inclusion through digital channels (DFI), or the use of reasonably priced digital technology to empower financially excluded and disadvantaged individuals, is now more important than ever due to the COVID-19 pandemic and its aftermath (World Bank 2022).

In this context, the effects of (FI) on numerous determinants have been extensively studied. For instance, Shahbaz et al. (2022) investigated the impact of FI on China's attempts to reduce carbon emissions and pollution. Additionally, Hu et al. (2021) looked at how China's agriculture sector has improved its total factor productivity. Chen et al. (2018) also suggested that FI might lead to a decrease in non-performing loans. The Middle East and North Africa region served as the backdrop for Rojas Cama and Emara's (2022) investigation of the FI phenomena. According to Von Fintel and Orthofer's (2020) claims, FI can reduce income and wealth disparities. Scholars have recently focused a lot of attention on the connection between economic growth and equitable financial development (Kassi et al. 2021).

However, the concept of digital financial inclusion, or DFI, is relatively new. DFI is one of the most well-known areas of international development metrics at the moment, claim Duvendack and Mader (2019). Increased financial inclusion, the capacity to provide economically disadvantaged communities with convenient, safe, and reasonably priced banking services, and the potential for GDP development in

Author α: Research Scholar, Dept. of Economics, AMU, Aligarh.
e-mail: rayeesrashid07@gmail.com
Author σ: Assistant Professor, Dept. of Economics, AMU, Aligarh.
e-mail: abdulazeeznp@gmail.com

digitalised economies are only a few of the many benefits of digital finance (Peng and Mao, 2023). The still-largely-uncertain effects of digital financial inclusion on economic growth in emerging economies need to be thoroughly understood via both theoretical and empirical research (Liu et al., 2021; Ozili, 2018). Few studies provide insight at how DFI impacts economic growth, even though the body of current research has described the relationship between DFI and income (Kim et al. 2018; Neaime and Gaysset 2018; Sethi and Acharya 2018; ZHANG et al. 2019). Arner et al. (2020) examined the relationship between digital financial inclusion and economic advancement in China and discovered that, despite the region's comparatively low DFI levels, they had a favourable effect on economic growth.

Considering the vital role of FI, the urgent question facing empirical researchers and policymakers is how this phenomena will impact countries' economic growth paths. Financial inclusion is commonly defined as "the possession of some form of financial accessibility, such as maintaining an account at a formal financial institution that enables individuals to engage in borrowing, saving, and investing." Theoretically, both consumers (individuals and enterprises) and financial service providers (banks and other financial institutions) gain from financial inclusion (Anand and Chhikara, 2013; Saydaliyev et al., 2020). It is a crucial way for people to get the money they need to buy necessities including consumer goods, healthcare, and education (Kim et al., 2018). Conversely, it is anticipated that the financial system will grow more stable as more people join it. As financial institutions strive for consistent revenue growth, this is fuelled by the development of new credit products and other business endeavours that facilitate the introduction of a broad range of financial services and products (Radcliffe and Voorhies, 2012). Additionally, FI can lessen the impact of some macroeconomic issues, such as poverty and economic inequality (Park and Mercado, 2015).

Despite the fact that many studies have shown how financial inclusion boosts economic growth, little is known about how it affects environmental quality (Khan and Ozturk, 2021; Le et al., 2021). Environmental quality may benefit or suffer from financial inclusion, depending on the theoretical framework. FI can lower CO_2 emissions by increasing the accessibility of financial services for individuals and companies seeking to invest in sustainable and eco-friendly technology. According to Ozturk and Ullah's (2022) research, for instance, DFI boosts economic growth but also degrades environmental quality by raising CO_2 emissions. Financial inclusion may therefore improve environmental quality and reduce its impact on climate change by establishing a framework that promotes accessibility, cost effectiveness, and the adoption of more ecologically friendly behaviours (Qin et al., 2021). Since farmers and agriculturalists might not have the funds or credit available to them to invest in renewable energy sources like solar energy, which is less expensive and emits less carbon dioxide, financial inclusivity is particularly crucial for financially disadvantaged groups (Nizam et al., 2020; Usman et al., 2021). However, advancements in the financial sector and financial inclusion could hasten the economy's manufacturing and industrialisation, which could result in higher greenhouse gas emissions and warmer temperatures (Jensen, 1996). Therefore, increased financial availability and funding for consumption-related projects may incentivise consumers to purchase more energy-intensive products, such as automobiles and household appliances. Additionally, an inclusive system may benefit economic expansion, which would increase the usage of non-renewable energy sources and worsen the state of the environment (Frankel and Romer, 1999).

To the best of our knowledge, we have embarked on a thorough investigation into the complex interrelationships among financial inclusion (FI), environmental factors, and economic growth, all within the complex context of the Indian economy. In the process, we have used the fascinating study carried out by Ozturk and Ullah in 2022 as a starting point for our further analysis. We came to the conclusion after carefully reviewing the abundance of existing literature that the important role that DFI plays in promoting environmental sustainability and economic advancement has not been fully explored, and the empirical results that have been obtained up to this point are, at best, ambiguous and inconclusive. The majority of study so far has been conducted mostly in advanced nations, where the impact of DFI on different macroeconomic variables is evaluated and examined. Additionally, to the best of the authors' knowledge, there are not many pertinent studies that particularly address India's particular situation in this area. As a result, it is imperative that the significant influence that DFI can have on the economic development and environmental sustainability of the dynamic Indian economy be fully investigated and analysed.

Although financial inclusion has the potential to boost a country's economy and lessen the harsh reality of extreme poverty and financial inequality, more research is needed to determine how it affects environmental quality (Ozturk & Ullah, 2022). This study is a step in that direction since we want to examine how financial inclusion affects India's economic development and environmental health, particularly in view of its growing ecological problems. India is one of the most polluted countries in the world, and its cities are frequently near the top of lists of the most polluted cities in the world. According to a 2018 WHO survey, 14 out of the 15 dirtiest cities in the world were located inside India. India is expected to surpass China in population by mid-2023, with a growing population approaching 1.4 billion people (UN Population, 2023). Fuelled by a vibrant and rapidly growing financial sector that has maintained an impressive growth rate of 6% over recent decades, India is the second-fastest growing trillion-dollar economy and the fifth largest economy in the world, with a nominal GDP of $2.94 trillion (Sehrawat et al., 2015). This South Asian superpower proudly holds the third position when comparing GDP to purchasing power parity ($11.33 trillion). In 2010, India accounted for 5.9% of global CO2 emissions, making it the third-largest contributor after the United States and China (Zafar et al., 2023). In addition to that, it is the fourth-largest greenhouse gas emitter in the world. But because of its enormous population, India continues to have one of the lowest per capita greenhouse emissions in the world (Alam et al., 2011). India also has a number of international accords that are geared towards protecting the environment. By 2030, the Indian government aims to reduce greenhouse gas emissions by more than 30% compared to 2005 levels. The country, on the other hand, keeps building new coal plants and importing more crude oil to meet its growing energy needs as its population becomes more affluent. Additionally, it is the fourth-largest energy consumer globally (Zafar et al., 2023). India is one of the biggest users of fossil fuels in South Asia, with fossil fuels providing a sizable and dominant portion of this energy need (Xue et al., 2021).

In order to perform a thorough and rigorous empirical analysis, we collected data from 2004 to 2023 and then used the Robust Least Square model, which is well-known for its ability to handle problems with outliers and heteroscedasticity in empirical data. The impetus behind this research is firmly anchored in the current and increasingly pertinent discussion of financial inclusion, especially given the dearth of empirical data that clarifies the intricate and crucial connections among financial inclusion, environmental sustainability, and the more general phenomenon of economic growth. The present study is specifically intended to fill this highlighted gap in the literature by providing a number of noteworthy additions that seek to deepen our comprehension of these interrelated fields. In particular, the study uses different analytical models that enable a nuanced investigation of these interactions in order to investigate how FI affects economic growth and environmental sustainability. Additionally, the study carefully takes into account the relevant problem of endogeneity in the models used, acknowledging its possible influence on the validity and trustworthiness of the results. In conclusion, the study offers insightful information to stakeholders and policymakers alike by outlining pertinent policy implications that are critical for advancing environmental sustainability and economic growth in the Indian context. Furthermore, this study is an essential tool for making well-informed decisions on the creation and application of financial inclusion policies that can produce favourable results.

Following on the work of Khanday et al. (2023), the current study makes use of annual time-series data related to India from 2004 to 2023. The constraints related to the accessibility of financial inclusion statistics were the primary factor in the selection of this particular time period. The World Bank's (WDI) database is the source of the information on GDP, carbon dioxide emissions, automated teller machines, debit transactions, internet penetration, industrialisation, foreign direct investment, and inflationary tendencies. Furthermore, the International Monetary Fund's (IMF) FAS provided the data on the dimensions of DFI, particularly with regard to ATMs and debit transactions.

The majority of the existing work on financial inclusion typically focusses on either the demand side or the supply side. Studies that simultaneously look at the supply and demand sides of FI are few in number. This study takes into account both the supply and demand side aspects of FI, which is consistent with the research done by Ozturk & Ullah (2022). The number of ATMs is chosen from a demand perspective, and the number of debit cards issued by financial institutions is the focus of a supply viewpoint. DFI is represented by this combination of dimensions.

Consistent with the enlightening work of Le et al. (2020) and the follow-up study by Zaidi et al. (2021), we have prudently chosen to include a number of control variables in our analysis, including a number of important variables like the number of internet users, the level of industrialisation, energy consumption, foreign direct investment, and inflation rates. While the data on industrialisation is measured as the value added by industries as a percentage of the Gross Domestic Product (GDP), which includes the construction industry, the internet user metric is expressed as (% of the total population), clearly illustrating digital access. In order to ensure a comprehensive understanding of the economic landscape, inflation is carefully evaluated through the lens of consumer price changes measured annually, and foreign direct investment is measured as the net flow of digital financial inclusion expressed as (% of GDP).

II. Review of Literature

In the literature and academic discourse, the effect of the financial system on economic growth, poverty alleviation, and income disparity has been the subject of significant investigation. Furthermore, the significance of financial development about CO2 emissions has garnered increased scholarly attention in recent years. Financial inclusion, a critical component of the financial system, remains a topic of ongoing scholarly debate. A substantial body of research has explored the ramifications of financial inclusion on poverty, capital accumulation, macroeconomic stability, financial efficiency, inequality, and economic growth

(Ji et al., 2021; Kim et al., 2018; Cabeza-Garcıa et al., 2019; Le et al., 2019; Makina & Walle, 2019; Naqvi et al., 2021; Park & Mercado, 2015 Rojas-Suarez & Amado, 2014; Sahay et al., 2015; Salazar-Cantu et al., 2015; Umar et al., 2021a, 2021b). Van et al. (2021) in the context of developing markets, Kim et al. (2018) concerning OIC nations, Makina and Walle (2019) focusing on African states, and Hajilee et al. (2017) in the case of emerging economies have corroborated the positive effect of FI on economic growth. Nevertheless, the correlation between FI and environmental performance has not received substantial scholarly focus until recent years. Although financial inclusion has been theoretically acknowledged as hurting environmental performance, empirical evidence supporting this assertion remains limited, particularly in the context of B.R.I.C.S. nations. A select few researchers have examined the relationship between financial inclusion and CO2 emissions (Usman et al., 2021; Le et al., 2020). The expansion of accessibility to financial services and products presents a considerable threat to environmental sustainability because of heightened energy consumption. Additionally, Le et al. (2020) found no empirical support for the relationship between financial inclusion and CO2 emissions in Asian countries. Conversely, Usman et al. (2021) demonstrated the detrimental effect of FI on CO2 emissions among the top 15 emitting nations. Nonetheless, a significant limitation of their study lies in the utilization of an inadequate proxy for financial inclusion. For instance, Usman et al. (2021) employed financial development as a proxy for financial inclusion, a choice that warrants substantial critique.

The correlation between financial development (FD) and energy consumption has been found to exert a positive impact on greenhouse gas (GHG) emissions (Sarkodie and Owusu 2016). An analysis was conducted regarding the impact of urbanization, FD, trade, and energy consumption on greenhouse emissions across thirty-four distinct nations. The findings regarding causal relationships revealed a unidirectional causality linking CO2 emissions to FD (Khan et al. 2017). In addition, the influences of FD, economic growth, and energy consumption on (CO2) were meticulously examined. Utilizing the Vector Autoregression (VAR) model, the results obtained from 24 economies within the Middle East and North Africa region elucidated that both energy consumption and economic growth (EG) exhibit a weak association with environmental preservation (Charfeddine and Kahia, 2019). A study by Dong et al. (2018) asserted that the utilization of renewable and clean energy sources effectively reduces CO2 emissions within BRICS nations. Employing a novel statistical methodology, the MMQR approach, Rehman et al. (2021) determined that renewable energy displays a significant and inverse correlation with greenhouse emissions.

Plethora of empirical literature has demonstrated that trade, urbanization, economic complexity, EG, and energy consumption contribute to environmental degradation (Ahmad et al. 2021; Hashmi et al. 2020; Hashmi et al. 2021; Shahzad et al. 2021Ikram et al. 2021), while renewable energy serves to diminish CO2 emissions and ecological footprints (EGF) (Akram et al. 2020; Apergis et al. 2018; Apergis 2019; Apergis & Payne 2014a, 2014b, 2014c; Fareed et al. 2021; Wang and Dong 2019; Saidi and Omri 2020). The interplay of energy consumption, FD, and trade contributes to the mitigation of environmental deterioration; however, the findings derived from the augmented mean group model indicated that conventional usage of energy and economic progress are primarily responsible for environmental pollution (Usman et al. 2021).

In the context of India, there exists a paucity of literature that scrutinizes the direct correlation between FI and economic growth. Initial literature has focused on the theoretical elucidations of how FI is consequential for economic growth (Dev, 2006; Srinivasan, 2007; Kapoor, 2014; Dasgupta, 2009). These studies have posited that increased engagement of formal credit institutions, such as SHGs and microfinance entities within the informal sector, can engender financial system a more inclusive. Notably, several empirical investigations have developed an index to measure financial inclusion (Sarma, 2008; Chattopadhyay, 2011; Sarma and Pais, 2011). Gupte et al. (2012) computed the Financial Inclusion Index (FII) utilizing the methodology of Mandira Sarma (2008) for the fiscal year 2008–2009, incorporating various variables that are significant. Laha and Kuri (2014), Ambarkhane et al. (2016), and Sethy (2016), separately derived the index of financial inclusion index that is based on the supply-side and demand-side metrics of financial services. CRISIL (2013) measured the financial inclusion index (FII) across districts of India, revealing an improvement in FI from 2009 to 2011, with deposit penetration identified as a principal catalyst for this enhancement. However, Chakravarty and Pal (2013) proposed that an axiomatic framework represents a more robust methodology for assessing FI. Several studies have investigated the relationship between financial inclusion and economic growth. Eastwood and Kohli (1999) established that programs focused on branch expansion and targeted financing have stimulated investment, hence enhancing industrial production in small-scale firms. They argued that a robust financial system can reduce the spread of informal lending sources, sometimes marked by exploitative activities. Binswanger and Khandker (1995) observed that India's rural expansion effort has significantly reduced rural poverty while simultaneously increasing non-agricultural employment levels. Bell and Rousseau (2001) discovered that financial service providers have significantly enhanced investment and production growth in India. Mehrotra et al. (2009) asserted that improved access to banking services motivates individuals to deposit their wealth in formal financial institutions, thereby promoting substantial economic development via the multiplier effect. Ghosh (2011) noted the impact of foreign investment on state-level per capita GDP. Sharma (2016) determined that variables like the number of loan accounts, deposit accounts, and the population distribution of ATMs demonstrate a unidirectional causal link with economic development. Lenka and Sharma (2017) examined the enduring relationship between financial inclusion (FI) and economic growth, integrating both supply-side and demand-side factors, and concluded that FI positively influences long-term economic growth. Iqbal and Sami (2017) demonstrated that financial inclusion favourably impacts economic development when utilising indicators that include the number of bank branches and the ratio of credit deposits to GDP as proxies for financial inclusion.

III. Data Source and Econometric Methodology

This analysis builds upon Khanday et al. (2023) and utilises annual time-series data from India spanning 2004 to 2023. The chosen era is mostly dictated by the limitations of data availability on financial inclusion. The information about GDP, CO2 emissions, ATMs, debit transactions, internet usage, industrial metrics, foreign direct investment (FDI), and inflation is sourced from the World Development Indicators (WDI) database maintained by the World Bank. The information about elements of digital financial inclusion, such as ATMs and debit transactions, has been sourced from the Financial Access Survey conducted by the IMF.

The majority of research on financial inclusion is on either the supply or demand side. Few studies examine both the demand and supply aspects of financial inclusion. We adhere to the study of Ozturk and Ullah (2022) to incorporate both supply and demand aspects of financial inclusion. We selected the quantity of ATMs from the demand perspective and the number of debit cards issued by the financial institution from the supply perspective. The amalgamation of these dimensions signifies DFI.

In accordance with the research conducted by Le et al. (2020) and Zaidi et al. (2021), we incorporated many control variables, including internet users, industrialisation, energy consumption, foreign direct investment, and inflation, into our model to mitigate potential omitted variable econometric bias. Internet users are quantified as a proportion of the population, whereas statistics on industrialisation is assessed as the value contributed by industry as a percentage of GDP, inclusive of construction. Foreign direct investment is measured as the net flow of FDI as a proportion of GDP, whereas inflation is represented by the yearly percentage change in consumer prices.

a) *Model Specification*

Robust Least Squares Regression is utilised in the analysis to assess the relationship between the variables. Robust least square regression addresses the shortcomings of traditional non-parametric and parametric methods by minimising the influence of potential outliers from the dependent variable (utilising the M-estimator; Huber, 1973), the independent variables (employing the S-estimator; Rousseauw and Yohai, 1984), and from both (applying the MM-estimator; Yohai, 1987). Two functional relationships-economic growth and environmental quality have been used in this study. We selected GDP and CO2 as indicators of economic development and environmental quality. Consequently, the enumerated models are:

$$gdp_t = \omega_0 + \omega_1 ATMs_t + \omega_2 lnDebits_t + \omega_3 Int + \omega_4 Ind_t + \omega_5 fdi_t + \omega_6 Inf_t + \epsilon_t \quad (1)$$

$$lnCo2_t = \omega_0 + \omega_1 ATMs_t + \omega_2 lnDebits_t + \omega_3 Int + \omega_4 Ind_t + \omega_5 fdi_t + \omega_6 Inf_t + \epsilon_t \quad (2)$$

Where, gdp measures the GDP growth (annual percentage), ATMs and Debits represent the demand and supply side of financial inclusion, Ind represents Industry value added (% of GDP), fdi represents foreign direct investment (net inflows percentage of GDP), Inf represents inflation, consumer prices (annual percentage) and e_t represents random error term, ω_0 represents constant term and ω_1 *to* ω_0 are the coefficients of the following variables in the model.

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Table 1: Descriptive Statistics

	lnCo2	gdp	ATMs	lnDebit	Int	Ind	fdi	Inf	C
Mean	14.417	6.368	13.690	5.916	17.832	28.127	1.798	6.572	1.000
Median	14.537	7.497	15.185	5.986	12.900	28.031	1.665	6.085	1.000
Maximum	14.715	9.690	24.960	6.798	46.320	31.137	3.621	11.989	1.000
Minimum	13.898	-5.778	2.186	4.523	1.976	24.591	0.766	3.328	1.000
Std. Dev.	0.265	3.270	8.462	0.838	15.816	2.295	0.628	2.562	0.000
Skewness	-0.738	-2.728	-0.151	-0.491	0.918	-0.058	1.055	0.642	
Kurtosis	2.154	10.717	1.372	1.815	2.396	1.557	4.878	2.308	
Jarque-Bera	2.414	74.437	2.284	1.974	3.114	1.745	6.652	1.774	
Probability	0.299	0.000	0.319	0.373	0.211	0.418	0.036	0.412	
Sum	288.344	127.3	273.80	118.317	356.64	562.5	35.96	131.4	20.00
Sum Sq. Dev.	1.332	203.1	1360.4	13.340	4752.4	100.1	7.485	124.70	0.000
Observations	20.00	20.00	20.00	20.00	2.00	20.00	20.00	20.00	20.00

Source: Authors Calculation

b) *Empirical Results*

Table 2: Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Inco2	1.000						
(2) ATMs	0.938	1.000					
(3) lnDebit	0.980	0.968	1.000				
(4) Ind	-0.797	-0.927	-0.860	1.000			
(5) Int	0.710	0.837	0.808	-0.847	1.000		
(6) fdi	-0.014	-0.139	-0.056	0.286	-0.123	1.000	
(7) Inf	-0.135	-0.361	-0.205	0.546	-0.250	0.345	1.000

Source: Authors Calculation

Table 2 displays relationship estimates for the variables. The results demonstrate that GDP, as a dependent variable, has a positive relationship with all independent variables except Int and Inf. In the same way, Inco2 is positively related to all independent variables except Inf.

Table 3: Augmented Dicky Fuller (ADF) and Phillips-Perron (PP) unit root tests

	ADF-test		PP-test	
Variables	at Level	First Difference	at level	First Difference
gdp	-4.212	-6.36	-4.253	-15.822
ln2	2.994	-1.457	-0.404	-3.681
ATMs	-3.132	-2.954	-1.6772	-2.963
lnDebit	-0.0137	-3.232	-0.013	-4.369
Int	-0.0805	-3.785	-1.3668	-2.062
Ind	-2.426	-1.247	-2.839	-3.8026
fdi	-3.139	-3.116	-3.1085	-5.0543
Inf	-4.494	-4.039	-2.0159	-4.0399

Source: Authors Calculation

The results of the ADF and PP-unit root tests are displayed in Table 3. After becoming stationary at their first difference, the data reveal that gdp is non-stationary at the level. Every one of the other variables—lnCo2, ATMs, lnDebits, Int, Inf, fdi, and Inf—shows first difference stationary behaviour. We utilised the first difference of the corresponding variables to breakdown the non-stationary series into stationary ones, as the overall results suggest that the variables change over time.

To analyse the long-run estimates between gdp, ATMs, lnDebit, Ind, and fdi, the study estimated the Johansen cointegration test after analysing the unit root estimates. This test confirmed one cointegration equation between the variables. Therefore, the trace and eigenvalue tests limited the need to estimate Vector Autoregressive (VAR), which is presented in Table 4.

Table 4: VAR Estimates

	gdp	ATMs	lnDebit	Int	fdi	Inf	Ind
gdp(-1)	1.084256	0.006773	0.000507	1.376281	0.004680	-0.009881	0.117894
	(0.47349)	(0.10210)	(0.01416)	(0.69703)	(0.15754)	(0.24391)	(0.10287)
	[2.28993]	[1.63346]	[0.03578]	[1.97449]	[0.02971]	[-0.04051]	[1.14608]
gdp(-2)	0.320316	0.407597	0.005266	0.081255	0.115619	-0.141496	0.149378
	(0.35673)	(0.07692)	(0.01067)	(0.52516)	(0.11869)	(0.18377)	(0.07750)
	[0.89791]	[5.29880]	[0.49376]	[0.15473]	[0.97410]	[-0.76998]	[1.92740]
ATMs(-1)	0.337484	0.699737	0.072620	0.055299	0.200850	-0.403336	0.205765
	(1.01269)	(0.21837)	(0.03028)	(1.49081)	(0.33694)	(0.52167)	(0.22001)
	[-0.33325]	[3.20441]	[2.39844]	[-0.03709]	[0.59609]	[-0.77316]	[-0.93524]
ATMs(-2)	0.835027	1.592692	0.041860	2.862247	0.225581	-0.940415	0.090924
	(1.69923)	(0.36641)	(0.05080)	(2.50147)	(0.56537)	(0.87533)	(0.36917)
	[0.49142]	[4.34681]	[0.82393]	[1.14423]	[0.39900]	[-1.07436]	[0.24629]
lnDebit (-1)	0.781461	9.658448	0.157187	21.24660	0.337698	9.811987	-2.481962
	(16.5615)	(3.57115)	(0.49516)	(24.3805)	(5.51034)	(8.53136)	(3.59806)
	[0.04719]	[2.70458]	[0.31744]	[0.87146]	[0.06128]	[1.15011]	[-0.68981]
lnDebit (-2)	11.31922	1.506014	0.370069	8.192909	2.757363	-0.060114	0.171280
	(11.9060)	(2.56728)	(0.35597)	(17.5270)	(3.96136)	(6.13316)	(2.58663)
	[0.95072]	[0.58662]	[1.03961]	[0.46744]	[0.69606]	[-0.00980]	[0.06622]
Int(-1)	1.619653	0.123034	0.020482	1.991289	0.193689	-0.050110	0.076793
	(0.52992)	(0.11427)	(0.01584)	(0.78011)	(0.17632)	(0.27298)	(0.11513)
	[3.05640]	[1.07672]	[1.29273]	[2.55258]	[1.09853]	[-0.18357]	[0.66702]
Int(-2)	1.467580	0.126209	-0.020899	1.158633	0.162763	0.150876	0.075376
	(0.49880)	(0.10756)	(0.01491)	(0.73429)	(0.16596)	(0.25695)	(0.10837)
	[2.94223]	[1.17343]	[-1.40136]	[1.57789]	[0.98073]	[0.58718]	[0.69557]

fdi(-1)	0.829706	0.084274	0.072301	2.686245	0.147560	0.938355	0.056057
	(1.53657)	(0.33133)	(0.04594)	(2.26202)	(0.51125)	(0.79154)	(0.33383)
	[0.53997]	[0.25435]	[1.57376]	[1.18754]	[0.28863]	[1.18548]	[0.16792]
fdi(-2)	2.424259	0.566609	0.037289	3.347592	0.347327	0.166351	1.168693
	(1.96083)	(0.42281)	(0.05863)	(2.88658)	(0.65241)	(1.01009)	(0.42600)
	[123634]	[1.34009]	[0.63605]	[1.15971]	[0.53238]	[0.16469]	[2.74340]
Inf(-1)	1.487749	0.480692	0.009458	0.339405	0.049404	0.267816	0.056560
	(0.76380)	(0.16470)	(0.02284)	(1.12441)	(0.25413)	(0.39346)	(0.16594)
	[1.94782]	[2.91861]	[0.41417]	[0.30185]	[0.19440]	[0.68067]	[0.34085]
Inf(-2)	1.185960	0.654072	0.022844	-1.844521	-0.137880	-0.246295	0.282968
	(0.77482)	(0.16707)	(0.02317)	(1.14062)	(0.25780)	(0.39913)	(0.16833)
	[1.53064]	[3.91487]	[0.98612]	[-1.61712]	[-0.53484]	[-0.61708]	[1.68101]
Ind(-1)	0.055796	1.001575	0.108324	0.722978	0.010050	-0.652106	0.051931
	(1.77908)	(0.38362)	(0.05319)	(2.61902)	(0.59194)	(0.91646)	(0.38651)
	[0.03136]	[2.61083]	[2.03648]	[0.27605]	[0.01698]	[-0.71155]	[0.13436]
Ind(-2)	5.961030	1.635784	0.084695	0.259707	1.078101	0.720338	-0.471563
	(2.69861)	(0.58190)	(0.08068)	(3.97268)	(0.89788)	(1.39014)	(0.58629)
	[2.20893]	[2.81110]	[1.04971]	[0.06537]	[1.20071]	[0.51818]	[-0.80432]
C	232.2851	30.58774	2.434603	114.5231	14.58298	-34.98629	56.58289
	(98.0977)	(21.1528)	(2.93297)	(144.412)	(32.6391)	(50.5334)	(21.3122)
	[2.36790]	[1.44604]	[0.83008]	[0.79303]	[0.44679]	[-0.69234]	[2.65495]
R-squared	0.945007	0.999527	0.998931	0.994399	0.776042	0.973755	0.994685
Adj. R-squared	0.688373	0.997319	0.993941	0.968260	-0.269093	0.851276	0.969883
Sum-sq. resids	10.87621	0.505704	0.009722	23.57025	1.204030	2.886136	0.513355
S.E. equation	1.904049	0.410570	0.056928	2.802989	0.633517	0.980839	0.413664
F-statistic	3.682319	452.7181	200.1914	38.04341	0.742528	7.950408	40.10438
Log-likelihood	-21.00675	6.608692	42.17229	-27.96741	-1.198613	-9.066814	6.473542
Akaike AIC	4.000750	0.932368	-3.019143	4.774157	1.799846	2.674090	0.947384
Schwarz SC	4.742726	1.674344	-2.277166	5.516134	2.541822	3.416067	1.689361
Mean dependent	6.195437	14.96280	6.069464	19.57088	1.906337	6.856637	27.98818
S.D. dependent	3.410836	7.929461	0.731345	15.73332	0.562356	2.543357	2.383641

Source: Authors calculation
Note: Standard errors in ( ) & t-statistics in [ ]

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The table presents the results of a Vector Autoregression (VAR) model analysing the relationships between various economic indicators, including gdp, ATMs, the logarithm of debit transactions lnDebit, interest rates Int, foreign direct investment fdi, inflation Inf, and industrial production Ind. Each variable's lagged values are included, showing how past values influence current outcomes. For instance, the coefficient for gdp(-1) is 1.084256, indicating a significant positive effect on current GDP, while ATMs(-1) has a coefficient of 0.337484, also showing a positive relationship. The statistical significance of these coefficients is assessed through t-statistics, with notable values such as 2.28993 for gdp(-1) and 3.20441 for ATMs(-1), suggesting strong relationships. The model's fit is indicated by an R-squared value of 0.945007 for the GDP equation, reflecting a strong explanatory power. Additionally, the sum of squared residuals for the GDP equation is 10.87621, which helps evaluate the model's accuracy. Overall, the table illustrates the dynamic interactions among these economic indicators over time, highlighting their lagged effects and significance in understanding economic behaviour.

Table 5: Robust Least Square estimates for the equation (1)

gdp	Coeff.	St.Er.	t-value	p-value	[95% Conf	Interval]	Sig
ATMs	.63	.077	2.28	.04	.032	1.229	**
lnDebit	3.812	.086	1.67	.009	-8.752	1.127	
Ind	1.192	.096	1.71	.001	-.312	2.696	
fdi	1.62	.055	2.15	.051	-3.25	.011	*
Inf	-.033	.042	-0.14	.003	-.556	.49	
Constant	4.732	2.629	0.43	.000	34.619	39.155	
Mean of dependent var	7.007		SD of dependent var		1.631		
R-squared	0.725		Number of obs		19		
F-test	1.919		Prob > F		0.000		

Source: Authors Calculation
*Note: ** p<.05, * p<.1*

The table displays the outcomes of a robust regression model intended to elucidate the correlation between many independent variables and GDP. Each coefficient signifies the projected alteration in GDP resulting from a one-unit increase in the respective independent variable while maintaining all other variables constant. The correlation for ATMs is 0.63, showing that an increase of one ATM unit correlates with a 0.63 unit rise in GDP, signifying a positive effect on economic growth. The standard error quantifies the variability of the coefficient estimations. A reduced standard error signifies more accurate projections. The standard error for lnDebit is 0.086, indicating a very modest number that suggests the estimate's reliability; the t-value evaluates the importance of each coefficient. An elevated absolute t-value signifies a more substantial association. The t-value for FDI is 2.15, indicating that the correlation between FDI and GDP is statistically significant. The 95% confidence interval delineates a region in which we may assert with 95% certainty that the real coefficient resides. The confidence interval for ATMs spans from 0.032 to 1.229, suggesting that the real impact of ATMs on GDP is both positive and substantial. An R-squared score of 0.725 signifies that around 72.5% of the variability in GDP is explicable by the model's independent variables.

Table 6: Robust Least Square estimates for the equation (2)

lnco2	Coeff.	St.Er.	t-value	p-value	[95% Conf	Interval]	Sig
ATMs	004	.007	0.60	.000	.02	.011	
lnDebit	.411	.062	6.64	.000	.278	.544	***
Ind	.026	.015	1.71	.001	-.007	.059	
fdi	.002	.018	0.10	.008	-.037	.041	
Inf	-.007	.006	-1.19	.254	-.021	.006	
Constant	11.344	.222	21.73	.000	10.224	12.464	***
Mean of dependent var	14.417		SD of dependent var		0.265		
R-squared	0.980		Number of obs		20		
F-test	135.273		Prob > F		0.000		

Source: Authors Calculation
*Note: *** p<.01, ** p<.05, * p<.*

The table presents the results of a robust regression analysis for equation (2), detailing the coefficients, standard errors, t-values, p-values, and confidence intervals for various independent variables affecting the dependent variable. The coefficient for ATMs is 0.004, indicating a positive but weak relationship, with a statistically significant p-value of 0.000, suggesting that ATMs have a measurable impact on the outcome. The InDebit variable shows a strong positive relationship with a coefficient of 0.411, a t-value of 6.64, and a p-value of 0.000, indicating high significance and reliability in its effect. In contrast, the Ind variable has a coefficient of 0.026, with a t-value of 1.71 and a p-value of 0.001, suggesting a positive but less certain effect. The fdi variable's coefficient is 0.002, with a t-value of 0.10 and a p-value of 0.008, indicating a weak positive relationship that may not be significant, as its confidence interval includes zero. The Inf variable shows a negative coefficient of -0.007, with a t-value of -1.19 and a p-value of 0.254, indicating no significant effect on the dependent variable. The constant term is 11.344, which is highly significant with a t-value of 21.73 and a p-value of 0.000. This indicates that there is a strong baseline value when all of the independent variables are zero. Overall, the model has a value of 0.980 for its R-squared, which indicates that it explains 98% of the variance in the dependent variable. Furthermore, the F-test confirms the model's overall significance with a p-value of 0.000, which highlights the model's robustness and reliability in explaining the relationships among the variables.

IV. Conclusion and Policy Implications

The study concludes that digital financial inclusion (FI) significantly influences economic development and environmental sustainability in India, highlighting a complex relationship between these variables. It emphasises that while FI can drive economic growth by enhancing access to financial services, it may also pose challenges to environmental sustainability due to increased consumption patterns. Therefore, policymakers are urged to adopt a balanced approach that promotes economic growth through digital FI while implementing measures to mitigate environmental impacts. This includes investing in technology and infrastructure to expand access to financial services, particularly in underserved areas, and ensuring that financial inclusion initiatives align with sustainable development goals. Additionally, continuous monitoring and evaluation of these policies are essential to adapt strategies effectively and achieve desired outcomes in both economic and environmental domains.

In summary, the study concludes that FI is a critical factor in driving economic growth and achieving environmental sustainability, particularly in the context of India's unique challenges and opportunities. The insights provided can guide future research and inform policy decisions aimed at fostering a more inclusive and sustainable economy.

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