IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Digital Financial Inclusion and Sustainable Development Goals: A systematic study on their interrelationship with special reference to India

Dr. Sarmita Guha Ray, Faculty, Department of MBA (Finance & Operation), University of Calcutta

Souvik Mukherjee, Research Scholar, HRDC(Economics), University of North Bengal

ABSTRACT

The world is experiencing a digital revolution. Digital financial inclusion is a digital approach to providing formal financial services to previously excluded and underserved populations. Inclusive digital financial services empower low-income individuals to save and accumulate funds, manage unexpected economic shocks, access social benefits more affordably, and invest in economic opportunities that can help them to escape poverty. Sustainable Development Goals (SDGs) are crucial for every country worldwide. In this context, a stable global financial system is necessary today to fulfill its duty of boosting private capital mobilization and achieving sustainable development goals for steady-state economic growth. Although none of the objectives of the United Nations Agenda 2030 is devoted to finance, can financial instruments play a role in attaining some of the Sustainable Development Goals? Can financial instruments contribute to reducing hunger and poverty, ensuring healthy lives, gender equality, and decent jobs? The ballooning of micro, small, and medium-sized enterprises reduces inequalities and enhances an effective fight against corruption.

Furthermore, are they increasing the mobilization of additional financial resources? This article aims to investigate the linkage between digital financial inclusion and the Sustainable Development Goals (SDGs) in a global context. The evidence presented in this epitome highlights how digital financial inclusion can accelerate progress toward the SDGs and create lasting social and economic impact for millions worldwide, including in India.

INTRODUCTION

The Sustainable Development Goals (SDGs) were embraced in September 2015 as a collective aim for the 193 participating countries in the United Nations to eradicate poverty, conserve the planet, and secure prosperity for all. Scheyvens et al. (2016) emphasized the long-term demand for pushing sustainable and inclusive economic growth in the SDGs and the 2030 Agenda, as outlined in the Sustainable Development Report. Furthermore, the G20 Sustainable Finance Study Group (SFSG) (2018) emphasizes that, in addition to the environmental perspective, other aspects of sustainable development must also be considered to reap benefits from private capital mobilization in pursuit of sustainable development and financial system stability. Therefore, sustainable finance should be adopted more broadly (Allen et al., 2016). The report indicates that, through direct and indirect support of the SDG framework, sustainable finance can be widely recognized as a funding source, as well as related institutional and market arrangements, that combine to achieve solid, stable, healthy, and inclusive growth. This movement aimed to achieve the beneficial influences of investments for social and economic gains, such as job creation, technical innovation, poverty alleviation, and social integration (Allen et al., 2018). A significant problem in today's global financial environment is mobilizing private capital to stimulate economic growth and stabilize the finance sector. Digitalization, particularly its intersection with finance (digital finance or financial technology), encompasses a diverse range of technological innovations, including artificial intelligence (AI), big data, blockchain, the Internet of Things (IoT), and

mobile platforms. Digital transformation is not a recent feature of the financial system. For the past twenty years, automated technologies and transformation have significantly increased performance in the financial industry (Collste et al., 2017; Hinson et al., 2019). Digital finance is increasingly demonstrating its potential to address obstacles relevant to the growth of finance for sustainable development.

The COVID-19 pandemic has revolutionized digital financial services; therefore, digital financial inclusion is essential to ensure that everyone can access these services, promoting sustainable economic growth. The development and activities for promoting digital financial inclusion must align and help attain the 2030 Sustainable Development Goals (SDGs). Observers expect the pandemic to improve the use of digital financial services; it has also presented challenges for certain countries. Hence, a systematic literature review investigates the impact of digital financial inclusion across countries. This research revealed that developing countries, particularly in Asia, are embracing and upgrading digital financial inclusion to help alleviate poverty. However, the results show that in developing countries, a persistent divide exists between gender, the wealthy, and the poverty-stricken, as well as between urban and rural regions regarding access to and utilization of digital financial services. After observing different studies, several recommendations can be made regarding digital infrastructure, complex banking procedures, financial education, and the seamless integration of digital financial inclusion across countries. Digital Financial Inclusion (DFI) is making essential financial services (EFS) accessible to people experiencing poverty at an affordable cost (Kandpal, 2020). FI, being multi-faceted, is the access provided to all persons to formal financial services. These financial services (FS) are reasonably priced and cost-reasonable when compared to informal FS, which have a deterring impact on low-income slab groups (Inoue, 2019).
Regarding the case study of Nigeria, DFI has significant constructive implications for sustainable development (Ade Soyemi et al., 2020). Through the extension of credits, DFI impacts the achievement of the United Nations' Sustainable Development Goals. There is also empirical evidence that gender and educational levels impact FI, especially in developing economies. Whereby financially excluded classes pay higher interest rates on informal credits, further affecting their financial conditions and the achievement of the SDGs (Kara et al., 2021).

It is essential to analyze which Sustainable Development Goals (SDGs) are most closely linked to digital financial inclusion and to identify the financial instruments that have the most significant impact on this goal. The following table highlights the relationships among the Sustainable Development Goals (SDGs), their targets, and finance. Additionally, the table includes SDG 17, based on the partnership of civil society, governments, the private sector, the UN, and non-governmental organizations (NGOs) for implementing the other sixteen SDGs, also thanks to the mobilization of financial resources.

SDG	Target	Focus
1. No poverty	1.4	The importance of every person having access to Financial services, including microfinance.
2. Zero hunger	2.3	It connects the doubling of agricultural productivity and income of small-scale food producers, amid many Other factors, to enter the financial services.
3. Good health and well-being	3.8	Medical insurance can alleviate the risks related to Health.
5. Gender equality	5. A	It focuses on the high-priority need to launch reforms to grant women equal rights, including access to financial services.
8. Decent work and economic growth	8.3	It ties access to financial services to the promotion of development-oriented policies, the generation of decent work and the growth of micro, small, and medium-sized enterprises (MSMEs).
	8.1	Strengthening the volume of financial institutions to promote entrance to insurance, banking, and financial services for all. In this regard, there are three references. indicators: the count of branches of commercial banks per 100,000 adults, the count of ATMs for every 100,000 adults, and the percentage of adults with a current account or a mobile-based payment system.
9. Industry, innovation and infrastructure	9.3	The access of small industries and other business enterprises, especially in the developing countries, to financial services, including credit at pocket-friendly prices, should be improved as a matter of emergency. It considers the share of small business enterprises that have access to lines of credit or loans.
10. Reduced inequalities	10.5	Reaffirming the need to improve the control and regulation over global financial markets and institutions. Financial soundness is used as an indicator (United Nations, DESA).
16. Peace, justice and strong institutions	16.4	Reducing illicit financial flows by 2030.
	16.5	Reducing bribery and corruption.
17. Partnerships for the goals	17.1	Domestic resource mobilization, including through non-domestic support to developing countries to upgrade domestic capacity for tax and other revenue collection.
	17.3	Mobilizing supplementary financial resources for developing countries from multiple sources.

Finance is fundamental in achieving at least nine out of seventeen Sustainable Development Goals (SDGs). In particular, it significantly impacts those linked to living conditions (hunger, poverty, and health), economic growth and development, and the correct functioning of society (transparency and international aid).

LITERATURE REVIEW

Han and Melecky (2013) have defined DFI as the people and businesses in society that have access to beneficial and affordable financial services and products. They meet the needs of transactions, payments, savings, credit, and insurance in a trustworthy and sustainable manner. DFI is the parameter of a segment that uses financial services or owns a bank account. It assumes access to and use of essential financial services at affordable rates and with transparency (Boateng, 2017; Rastogi et al., 2021). Financial exclusion directly leads to poverty, while DFI supports a nation in its path toward progress. It ensures convenient access to financial resources for ordinary people.

Niaz (2022) stated that digital financial inclusion has a substantial and significant influence on the realization of sustainable development in the long run. The study also provides insights into gender and demographic-based findings, indicating that underprivileged urban areas have benefited more than their rural counterparts. This demographic divide in the differing degrees of benefit realization, as documented in the literature, is complemented by other studies that highlight the role of digital financial inclusion in alleviating poverty and improving food security.

Tay et al. (2022) highlighted the glaring divide in using financial inclusion through digital media in developing economies on several fronts. These economies are using it to combat poverty, especially in Asia. Nepal and Neupane (2022) conducted a study in multiple districts of Bihar, India, providing insights into the linkage between digital financial inclusion (DFI) and SDG 2. This study has identified a significant and positive relationship between FI and food security.

Purwiyanta et al. (2022) confirmed a unidirectional relationship and connection between financial inclusion (FI) and economic growth, a constituent of sustainable development. They stated that financial inclusion positively influences economic growth, but the reverse is invalid. On the other hand, Kim et al. (2018) employed the panel causality test for OIC countries to examine the mutual causal relationships between the two variables. According to a study examining the case studies of several Indian states, sustainable development is significantly impacted and necessitates financial inclusion, strategic economic growth, and IT development (Pradhan et al., 2021). All the aspects of financial stability significantly influence poverty alleviation, reduction in inequality, and economic growth. The same does not hold when the assessment of multiple Asian nations is done, considering the partial impact of FI (Ratnawati, 2020).

Hussain et al. (2021), in a study on multiple Asian nations, concluded that financial inclusion is associated with higher carbon pollution levels. Financial inclusion enhances the expansion of enterprises' production capacity and the purchasing power of those who are financially included. This study stated the negative implications of digital financial inclusion (DFI) on sustainable development. Zaidi et al. (2021) also suggested in a survey that policy formulation programs must align financial inclusion and consumption patterns that impact the environment. On the other hand, Dai et al. (2022) conducted a study that took the RCEP economies into account during a sixteen-year timeframe. According to the report, financial inclusion benefits the environment by stimulating the adoption of renewable energy sources. The findings of this literature differ from those of others, which claim that financial inclusion has harmed the environment due to an increase in demand and customer base.

Neaime and Gaysset (2018) developed new insights in a study on MENA nations. The results confirmed that financial inclusion has a substantial influence on reducing income inequality but does not significantly influence poverty. This study thereby links financial inclusion with two different constituents of sustainable development.

Siddik (2017) examined the role of financial inclusion (FI) in enhancing women's overall economic condition and quality of life. The study emphasized the significance of financial inclusion in enhancing women's living standards, particularly in rural areas, and reducing their reliance on informal lending institutions. George and Thomachan (2018) also confirm the same findings in another study. Kandari et al. (2021) established a connection between the nexus of technology usage and financial inclusion (FI). Insights are drawn into gender-based vulnerability regarding access to technology and credit, and the resultant disability to inclusion.

Anh Tu et al. (2019) conducted a study that highlights the use of financial inclusion to help mid-income economies improve their economic conditions. This literature review examines the relationship between certain aspects of sustainable development and financial levels, which is influenced by the variable of financial inclusion in this study. Nguyen and Ha (2021) strongly emphasized the quality of financial institutions in the context of ASIAN countries to protect those financially included from potential breaches and other dangers.

Ratna et al. (2015) assert that more than half of the poorest 40% of inhabitants in developing economies lack formal accounts, whereas 35% of start-up companies struggle to access credit from formal financial institutions. Additionally, considerable

gaps in access to formal digital financial products exist between the rich and the poor in both urban and rural communities, as well as between females and males (Ratna et al., 2015). These studies present that gaps still exist in sub-Saharan Africa despite efforts to promote financial deepening and inclusive growth. This is also alarming because Africa ranks lower than other developing countries, with only 23% of the adult population having an account in a formal financial institution. This percentage is significantly below the acceptable global cut-off of 50% (Dabla-Norris et al., 2015; Demirgüç-Kunt & Klapper, 2013), as cited in Ajide (2017).

Koppensteiner and Olukorede (2016) investigated the impact of mobile money adoption by households in Tanzania on poverty, consumption smoothing, and human capital investments. The results show that while per-capita total spending is not leveled within recommended specifications, the per-capita expenditure pattern for impoverished families is significantly leveled in the era of adverse idiosyncratic shocks for families that use mobile money. The study indicates that households that use mobile money conveniently shield themselves against sliding into transient extreme poverty. At the same time, there is an increase in the number of households living on less than US$1.25 per day among non-adopter households. Isibor et al. (2018) investigated the impact of electronic banking on banks' performance, customer satisfaction, and economic growth. They found that electronic banking has improved clients' contentment and economic development in Nigeria. Forgelli and Rubino (2016) probed how mobile banking can increase financial inclusion and improve the welfare and wealth of individuals in developing countries. It found a slightly positive relationship between mobile phone banking and inclusive finance inclusions, in like manner. Achugamonu et al. (2016) studied the relationship between agent banking and financial inclusion in Nigeria. The study revealed that a high level of illiteracy among the unbanked population constitutes a significant constraint to achieving high financial inclusion growth in Nigeria. Amoo (2018) posits that SSA ranked behind other regions in developmental strides, primarily using Millennium Development Goal indicators, such as improved public health, a reduction in maternal mortality rates, and the elimination of poverty and hunger. The SDGs are goals designed to address fundamental issues, including poverty allevation, achieving a environmentally and healthy friendly society, and reducing maternal mortality. The purpose is to conserve the planet, eliminate poverty, and ensure that inhabitants enjoy prosperous, peaceful, and harmonious coexistence now and in the future (Morton et al., 2017).

Mlachila et al. (2016) discuss SSA as a sizable but sparse population, noting that traditional bank intermediaries do not reach remote areas. The cost of their services tends to be too steep for low-income households and small enterprises. They argue that a substantial increase in mobile phone subscriptions has enabled the recent surge in mobile money in several Sub-Saharan African (SSA) countries. This is reinforced by expanding network coverage and technology to support financial services. Additionally, the declining prices of mobile phones and an increasing variety of mobile payments and banking innovations have also contributed to the expansion of fintech-driven financial inclusion. Sy et al.'s (2019) study on fintech in Sub-Saharan African countries illustrates that by 2015, mobile money accounts surpassed traditional deposit accounts in seventeen countries, including some of the largest economies such as South Africa, Tanzania, and Kenya.

OBJECTIVE OF THE STUDY

In this paper, we have endeavored to investigate the impact of the SDGs on digital financial inclusion across India's states using spatial analysis. We have taken E-Transaction Share from the Electronic Transaction Aggregation and Analysis Layer (E-Taal) to quantify the success of digital financial inclusion. The objective of this study can be manifested as follows.

1) Checking spatial autocorrelation of E-Transaction Shares and SDGs.
2) Building a spatial regression model to calculate the impact of SDGs on E-transaction shares.

RESEARCH METHODOLOGY

i) DATA SOURCES

The dataset used in this study comprises two datasets. One is the Sustainable Development Goals index, and the other is Etaal-State Wise Transaction Per Service. Both datasets have been collected from the National Data and Analytics Platform (NDAP). The National Data and Analytics Platform (NDAP) is NITI Aayog's flagship initiative aimed at enhancing access to and utilization of government data. NDAP is a user-friendly, web-based platform that aggregates and hosts datasets across India's vast statistical infrastructure.

The Sustainable Development Goals (SDG) index contains information on goal scores, which are computed by aggregating scores under each SDG, and composite scores, obtained by averaging all goal scores across all states. Based on the performance scores of states, they were classified into four categories: states with scores of 0 to 49 are aspirants, those with scores of 50 to 64 are performers, those with scores of 65 to 99 are front-runners, and those with scores of 100 are achievers. The Sustainable Development Goals (SDGs) Index, launched in 2015 by the United Nations General Assembly (UN-GA), is an assemblage of 17 interlinked global goals developed to act as a "blueprint for achieving a better and more sustainable future for all." Using a globally

acknowledged and robust methodology, the Index measures the progress reached at the country and State/Union Territory levels, offering precious insights to policymakers and decision-makers on the remaining distance to travel, gaps, and data and statistical challenges.

E-Taal stands for Electronic Transaction Aggregation and Analysis Layer. It is an online platform developed by the National e-Governance Division (NeGD) under India's Ministry of Electronics and Information Technology (MeitY). E-Taal aims to provide transparency and accountability in electronic transactions conducted by various government departments and agencies across the nation. E-Taal State-Wise Transaction per Services refers to the data compiled and presented on E-Taal regarding the volume of electronic transactions for specific e-Governance services in different states of India. It provides insights into citizens' adoption and utilization of digital services across various regions. The platform tracks and monitors electronic transactions related to e-Governance services from different government entities. These transactions may include online services such as applying for documents, making payments, submitting forms, and accessing government portals.

ii) PERIOD AND GRANULARITY

The Composite score of the SDG India Index has been derived from the SDG INDIA Index & Dashboard 2020-21. It contains data on SDG indices of 28 states and eight union territories. The Etaal-State Wise Transaction Per Service dataset spans from 2012 to 2023, providing daily data. These two datasets have been merged within the NDAP Platform for our analysis by aggregating the Etaal dataset at the state/UT levels. Since these two datasets have different time dimensions, the time/year dimension has been excluded from the merged dataset, thereby making the datasets comparable.

iii) RESEARCH METHOD

The spatial analysis process begins with the shape file of Indian states and union territories. For our study, the shape file was obtained from the online map portal of the Ministry of Science and Technology, Government of India. The data for the composite score of the SDG India Index was derived from NDAP. After the collection of the shape file of Indian states and union territories and SDG indices data, the following steps have been followed to perform the whole analysis: -

1) Merging of the shape file and dataset based on a common attribute, i.e., state.
2) Spatial plots of the relevant SDG indices have been done to visualize the variation of such indices across the selected geographical space.
3) The centroid of the states and union territories has been calculated and plotted.
4) The spatial weight matrix has been calculated based on the derived centroids to define neighbor connectivity and neighbor weight (i.e., who is your neighbor, and how much does your neighbor matter?)
5) Moran's I calculation for all SDG Indices. Moran's I calculations rely on a weighted matrix, with units i and j. Moran's I is a correlation coefficient that calculates the overall spatial autocorrelation of a variable. In other words, it measures how one object is homogenous to the others objects surrounding it. Spatial autocorrelation is multidimensional and multidirectional, making it particularly helpful in identifying patterns in complex datasets. Like correlation coefficients, it has a value from -1 to 1. -1 is the perfect clustering of dissimilar values (perfect dispersion). 0 is no autocorrelation (perfect randomness). +1 indicates perfect clustering of similar values (the opposite of dispersion).

Similarities between units are computed as the product of the differences between y_j and y_i with the overall mean.

$$\text{Similarity} = (y_i - \bar{y})(y_j - \bar{y}), \text{ where } \bar{y} = \Sigma^n_{i=1}\, y_i/n$$

Calculation of Moran's statistic is done using the basic expression, which is divided by the sample variance: $s^2 = (\Sigma(y_i - \bar{y})^2)/n)$.

$$I = \frac{1}{s^2} \frac{\sum_i \sum_j (y_i - \bar{y})(y_j - \bar{y})}{\sum_i \sum_j w_{ij}}$$

After calculating Moran's I, we can identify the SDG index with the highest spatial non-autocorrelation or dispersion probability.

6) Making a Moran scatter plot. This plot shows an association between a variable and its neighbors' values of the same variable. It has four quadrants. The upper right and lower left quadrants imply positive spatial autocorrelation, and the lower right and upper left quadrants imply negative spatial autocorrelation.

7) An Ordinary Least Squares model is built by considering the SDG index from Step 5 as the dependent variable and other SDG indices as independent variables.

8) Finalise the OLS model from step 7 by dropping insignificant variables from the model.

9) Calculating Global Moran's I for regression residuals to see whether there is any residual spatial dependence.

10) Perform the Lagrange Multiplier Test to select an appropriate model. The flow chart in Fig. 1 below illustrates the process for selecting a model.

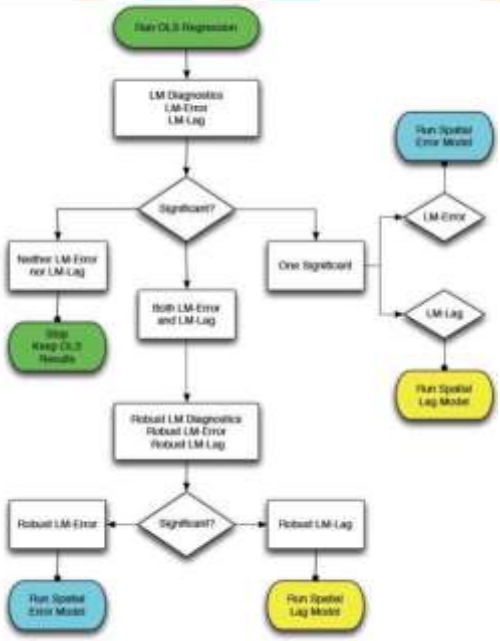

Fig 1

Source: Anselin (1988), Burkey (2018)

11) Building Spatial cross-regressive models to check whether neighboring regions' independent values affect Outcome values.

iv) RESEARCH FINDINGS

Our analysis begins with calculating Moran's I on SDG and E-Transaction share indices, as available from NDAP. Based on the calculated result, we have found that E-Transaction shares have no spatial autocorrelation. Some of the SGDs exhibit spatial autocorrelation, while others do not. We have calculated Moran's I based on inverse distance weights under randomization and Monte Carlo simulation. The inference may be different. Moran I has a null hypothesis that the variable is randomly disbursed, and the alternative hypothesis is that the variable is spatially clustered. We have considered $\alpha = 0.001$ and accordingly accepted the null or alternative hypothesis. Below is the presentation of all three types of Moran's I calculation.

SDG Variables	Observed Value	Expected Value	Standard Deviation	P Value	Comments
E-Transaction Share	0.0423	-0.0286	0.0291	0.0153	Zero Spatial Autocorrelation
SDG.India.Index..No.Poverty	0.0838	-0.0286	0.0350	0.0013	Zero Spatial Autocorrelation
SDG.India.Index.Zero.Hunger	0.0870	-0.0286	0.0349	0.0009	Spatial Autocorrelation
SDG.India.Index..Good.Health.and.Well.being	0.0776	-0.0286	0.0351	0.0025	Zero Spatial Autocorrelation
SDG.India.Index..Quality.Education	0.1007	-0.0286	0.0351	0.0000	Spatial Autocorrelation
SDG.India.Index..Gender.Equality	0.0930	-0.0286	0.0349	0.0005	Spatial Autocorrelation
SDG.India.Index..Clean.water.and.sanitation	0.0514	-0.0286	0.0352	0.0196	Zero Spatial Autocorrelation
SDG.India.Index..Affordable.and.clean.energy	0.0530	-0.0286	0.0334	0.0138	Zero Spatial Autocorrelation
SDG.India.Index..Decent.work.and.economic.growth	0.1484	-0.0286	0.0348	0.0000	Spatial Autocorrelation
SDG.India.Index..Industry..Innovation.and.Infrastructure	0.2083	-0.0286	0.0354	0.0000	Spatial Autocorrelation
SDG.India.Index..Reduced.Inequality	-0.0127	-0.0286	0.0341	0.6435	Zero Spatial Autocorrelation
SDG.India.Index..Sustainable.cities.and.communities	0.1829	-0.0286	0.0350	0.0000	Spatial Autocorrelation
SDG.India.Index..Responsible.consumption.and.production	0.0338	-0.0286	0.0350	0.0858	Zero Spatial Autocorrelation
SDG.India.Index..Climate.Action	-0.0171	-0.0286	0.0347	0.7421	Zero Spatial Autocorrelation
SDG.India.Index..Life.on.Land	-0.0338	-0.0286	0.0346	0.8797	Zero Spatial Autocorrelation
SDG.India.Index..Peace..justice.and.strong.institutions	-0.0372	-0.0286	0.0338	0.7984	Zero Spatial Autocorrelation
				α	0.001

Table 1

	Moran I test under randomisation					
SDG Variables	Moran I statistic standard deviate	p-value	Moran I statistic	Expectation	Variance	Comments
E-Transaction Share	4.3939	0.0000	0.1899	-0.0286	0.0025	Spatial Autocorrelation
SDG.India.Index..No.Poverty	2.3967	0.0083	0.0911	-0.0286	0.0025	Zero Spatial Autocorrelation
SDG.India.Index.Zero.Hunger	2.7254	0.0032	0.1072	-0.0286	0.0025	Zero Spatial Autocorrelation
SDG.India.Index..Good.Health.and.Well.being	2.9347	0.0017	0.1184	-0.0286	0.0025	Zero Spatial Autocorrelation
SDG.India.Index..Quality.Education	4.7178	0.0000	0.2079	-0.0286	0.0025	Spatial Autocorrelation
SDG.India.Index..Gender.Equality	3.5547	0.0002	0.1485	-0.0286	0.0025	Spatial Autocorrelation
SDG.India.Index..Clean.water.and.sanitation	3.1471	0.0008	0.1253	-0.0286	0.0024	Spatial Autocorrelation
SDG.India.Index..Affordable.and.clean.energy	3.0732	0.0011	0.1185	-0.0286	0.0023	Zero Spatial Autocorrelation
SDG.India.Index..Decent.work.and.economic.growth	4.3939	0.0000	0.1899	-0.0286	0.0025	Spatial Autocorrelation
SDG.India.Index..Industry..Innovation.and.Infrastructure	6.9814	0.0000	0.3246	-0.0286	0.0026	Spatial Autocorrelation
SDG.India.Index..Reduced.Inequality	-0.8468	0.8014	-0.0699	-0.0286	0.0024	Zero Spatial Autocorrelation
SDG.India.Index..Sustainable.cities.and.communities	5.9317	0.0000	0.2683	-0.0286	0.0025	Spatial Autocorrelation
SDG.India.Index..Responsible.consumption.and.production	0.4387	0.3305	-0.0066	-0.0286	0.0025	Zero Spatial Autocorrelation
SDG.India.Index..Climate.Action	0.2695	0.3938	-0.0152	-0.0286	0.0025	Zero Spatial Autocorrelation
SDG.India.Index..Life.on.Land	0.1455	0.4422	-0.0214	-0.0286	0.0025	Zero Spatial Autocorrelation
SDG.India.Index..Peace..justice.and.strong.institutions	-1.1622	0.8774	-0.0847	-0.0286	0.0023	Zero Spatial Autocorrelation
				α	0.001	

Table 2

	Monte-Carlo simulation of Moran I			
SDG Variables	statistic	observed rank	p-value	Comments
E-Transaction Share	0.0552	953	0.0470	Zero Spatial Autocorrelation
SDG.India.Index..No.Poverty	0.0911	965	0.0350	Zero Spatial Autocorrelation
SDG.India.Index.Zero.Hunger	0.1072	978	0.0220	Zero Spatial Autocorrelation
SDG.India.Index..Good.Health.and.Well.being	0.1184	991	0.0090	Zero Spatial Autocorrelation
SDG.India.Index..Quality.Education	0.2079	1000	0.0010	Zero Spatial Autocorrelation
SDG.India.Index..Gender.Equality	0.1485	998	0.0020	Zero Spatial Autocorrelation
SDG.India.Index..Clean.water.and.sanitation	0.1253	985	0.0150	Zero Spatial Autocorrelation
SDG.India.Index..Affordable.and.clean.energy	0.1185	989	0.0110	Zero Spatial Autocorrelation
SDG.India.Index..Decent.work.and.economic.growth	0.1899	998	0.0020	Zero Spatial Autocorrelation
SDG.India.Index..Industry..Innovation.and.Infrastructure	0.3246	1000	0.0010	Zero Spatial Autocorrelation
SDG.India.Index..Reduced.Inequality	-0.0699	184	0.8160	Zero Spatial Autocorrelation
SDG.India.Index..Sustainable.cities.and.communities	0.2683	1000	0.0010	Zero Spatial Autocorrelation
SDG.India.Index..Responsible.consumption.and.production	-0.0066	731	0.2690	Zero Spatial Autocorrelation
SDG.India.Index..Climate.Action	-0.0152	691	0.3090	Zero Spatial Autocorrelation
SDG.India.Index..Life.on.Land	-0.0214	634	0.3660	Zero Spatial Autocorrelation
SDG.India.Index..Peace..justice.and.strong.institutions	-0.0847	77	0.9230	Zero Spatial Autocorrelation
		α	0.001	

Table 3

SDG Variables	Moran.I based on inverse distance v	Moran I test under randomisation	Monte-Carlo simulation of Moran I
E-Transaction Share	Zero Spatial Autocorrelation	Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..No.Poverty	Zero Spatial Autocorrelation	Zero Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index.Zero.Hunger	Spatial Autocorrelation	Zero Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Good.Health.and.Well.being	Zero Spatial Autocorrelation	Zero Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Quality.Education	Spatial Autocorrelation	Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Gender.Equality	Spatial Autocorrelation	Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Clean.water.and.sanitation	Zero Spatial Autocorrelation	Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Affordable.and.clean.energy	Zero Spatial Autocorrelation	Zero Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Decent.work.and.economic.growth	Spatial Autocorrelation	Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Industry..Innovation.and.Infrastructure	Spatial Autocorrelation	Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Reduced.Inequality	Zero Spatial Autocorrelation	Zero Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Sustainable.cities.and.communities	Spatial Autocorrelation	Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Responsible.consumption.and.production	Zero Spatial Autocorrelation	Zero Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Climate.Action	Zero Spatial Autocorrelation	Zero Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Life.on.Land	Zero Spatial Autocorrelation	Zero Spatial Autocorrelation	Zero Spatial Autocorrelation
SDG.India.Index..Peace..justice.and.strong.institutions	Zero Spatial Autocorrelation	Zero Spatial Autocorrelation	Zero Spatial Autocorrelation

Table 4

Table 4 summarizes comments from all three methods of calculating Moran's I.

In the above three calculations of Moran's I, we observe that the E-Transaction Share has been demonstrated to be spatially non-autocorrelated using inverse distance weights and the Monte Carlo simulation method for Moran's I. In contrast, the randomization technique of Moran's I has demonstrated that it is spatially autocorrelated. Additionally, Moran`s I value is positive in all three techniques. In Moran's I, based on inverse distance weights, the value is 0.04206366; in the Moran's I test under randomization, it is 0.18986638, and in the Monte Carlo simulation of Moran's I, it is reported as 0.055179. Since

-1 of Moran's I is assumed to represent perfect dispersion, and +1 is considered ideal clustering, we can infer that the E-Transaction Share is moderately clustered or dispersed.

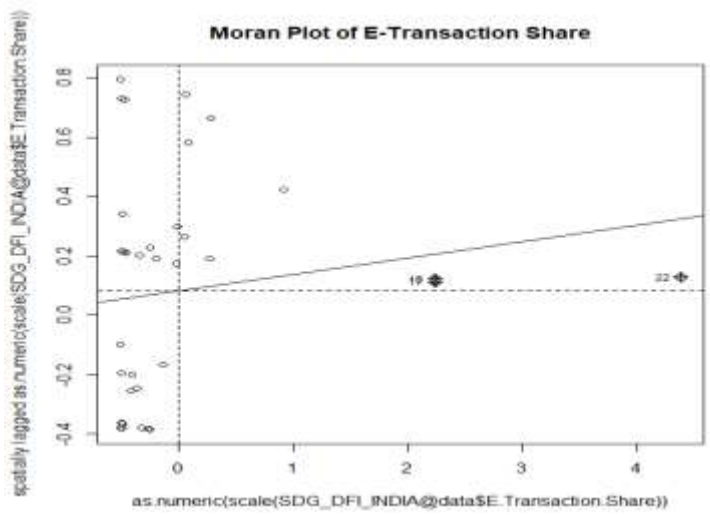

Fig 2

Figure 2 plots E-transaction share against its spatially lagged values, augmented by reporting the summary of influence estimates for the linear relationship between the data and the lag. The trendline inside the plot validated a positive Moran`s I value.

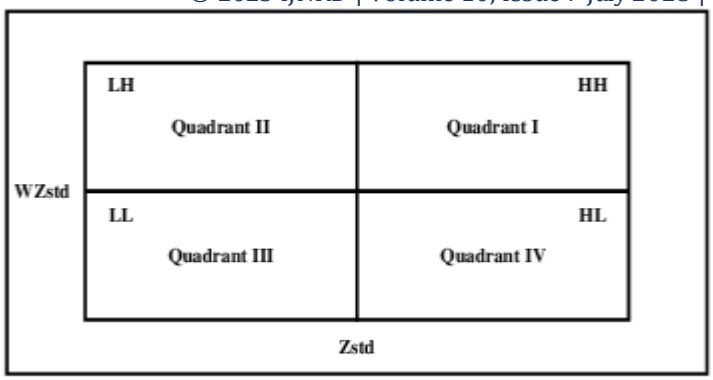

Fig 3

Moran's Scatterplot Index Quadrant I, or HH (High-High), indicates areas with high observation values that are surrounded by other areas with high values. Quadrant II is called LH (Low-High), meaning that this quadrant shows areas with low observation values but is surrounded by areas with high observation values. Quadrant III, also called LL (Low-Low), is a quadrant of an area with low observation values surrounded by areas with low observation values. Quadrant IV, also known as HL (High-Low), indicates areas with high observation values that are surrounded by areas with low observation values.

Figure 2 shows that the data points are mainly concentrated in quadrants II and III. Considering Fig. 3, we can infer a neural association with the neighbor's E-transaction share.

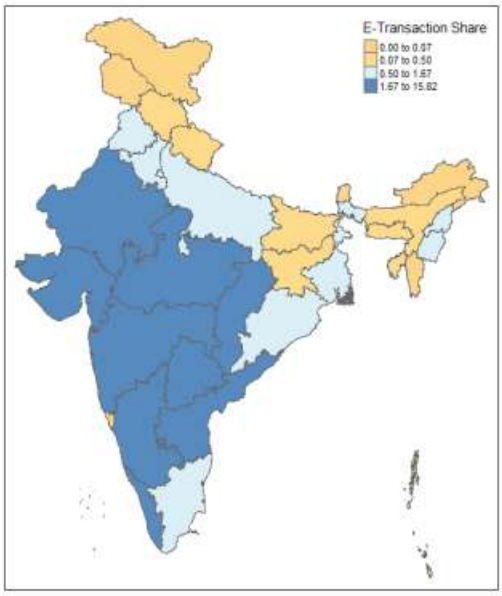

Fig 4

Figure 4 is the choropleth map of E-transaction shares. The data has been plotted on the map in quartiles. This map shows that western and some northern states and Union Territories have achieved higher percentages of E-transaction shares than other states and Union Territories. However, northern and upper northern states lag considerably in making E-transactions popular daily.

To develop a spatial regression model, we first developed an OLS (Ordinary Least Squares) model. In the OLS model, we have taken E-Transaction shares as the dependent variable and SDG Indices reported by Niti Aayog as independent variables.

Residuals:

Min	1Q	Median	3Q	Max
-3.9652	-1.4073	-0.0158	1.1699	4.1683

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	-24.9821	9.99539	-2.499	0.02126	*
Sdg.India.Index..Decent.Work.And.Economic.Growth	0.06457	0.09746	0.663	0.5152	
Sdg.India.Index..Responsible.Consumption.And.Production	-0.08498	0.05371	-1.582	0.12929	
Sdg.India.Index..Good.Health.And.Well.Being	0.04806	0.09251	0.52	0.60911	
Sdg.India.Index.Zero.Hunger	-0.08617	0.04721	-1.825	0.08292	.
Sdg.India.Index..Life.On.Land	0.05229	0.04288	1.22	0.23682	
Sdg.India.Index..Clean.Water.And.Sanitation	0.09489	0.05884	1.613	0.12248	
Sdg.India.Index..Climate.Action	0.12634	0.0442	2.859	0.00971	**
Sdg.India.Index..Gender.Equality	-0.12781	0.08436	-1.515	0.14537	
Sdg.India.Index..Quality.Education	-0.12495	0.07471	-1.672	0.11002	
Sdg.India.Index..Sustainable.Cities.And.Communities	0.07419	0.04618	1.607	0.12378	
Sdg.India.Index..Industry..Innovation.And.Infrastructure	0.01465	0.06256	0.234	0.81719	
Sdg.India.Index..Reduced.Inequality	-0.04306	0.05895	-0.731	0.47352	
Sdg.India.Index..Peace..Justice.And.Strong.Institutions	0.1915	0.07713	2.483	0.02203	*
Sdg.India.Index..No.Poverty	0.02926	0.05943	0.492	0.62777	
Sdg.India.Index..Affordable.And.Clean.Energy	0.07401	0.06171	1.199	0.2444	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.596 on 20 degrees of freedom

Multiple R-squared: 0.6297, Adjusted R-squared: 0.352

Table 5

Table 5 represents the OLS model. We have considered all SDG indices in this model to quantify their effect on E-transaction shares. However, only the Zero Hunger, Climate Action, Peace Justice, and Strong Institutions indices have proven statistically significant. Additionally, the R-squared value, as well as R-squared valuethe adjusted $R^{2,}$ is relatively low (35.2%).

We have checked the spatial pattern of the OLS model's residuals using Global Moran' I and found that the residuals are randomly distributed. The null hypothesis of Global Moran's I statistic says that the attribute being examined is randomly dispersed among the features in the study area. The alternative hypothesis says that the attribute is spatially clustered. The Global Moran I for regression residuals result is shown in Table 6 below.

Global Moran I for regression residuals	
Moran I statistic standard deviate	0.6487
p-value	0.5165
Observed Moran I	-0.0244
Expectation	-0.0478
Variance	0.0013

Table 6

The spatial regression model has four types: OLS, spatial cross-regressive model, Spatial lag model, and spatial error model.

The Lagrange Multiplier Test (LM test) was performed to determine whether any spatial lag or spatial error models are suitable for the OLS model. The LM test results are as follows in Table 7.

Lagrange multiplier diagnostics for spatial dependence		
LMerr	Lmerr_df	Lmerr_p-value
0.14162	1	0.7067
LMlag	Lmlag_df	Lmlag_p-value
0.13544	1	0.7129
RLMerr	RLMerr_df	RLMerr_p-value
1.6153	1	0.2037
RLMlag	RLMlag_df	RLMlag_p-value
1.6092	1	0.2046
SARMA	SARMA_df	SARMA_p-value
1.7508	2	0.4167

Table 7

Considering Table 7 and Figure 1, we conclude that the OLS model is the most suitable of all the proposed and built models.

Additionally, we have developed a spatial cross-regressive model (Table 8), which identifies the independent values of neighboring regions that influence outcome values.

Table 8

We have two sets of results. The first set consists of our region's independent variables (X), while set 2 (the lag set) defines the X values of the neighboring area. Here, the results can be interpreted as the typical OLS model. However, all the independent variables have insignificant effects, both direct and indirect. The adjusted R-squared value has been significantly improved in the spatial cross-regressive model (56.68%) compared to the ordinary least squares (OLS) model (35.2%).

CONCLUDING REMARKS

Our analysis begins with the calculation of Moran's I on SDG indices and E-transaction shares across states and Union territories. According to Table 1, there is no spatial autocorrelation between the E-transaction and the nine SDG indices, indicating a geographically dispersed distribution. In contrast, the other six SDG indices are spatially autocorrelated, indicating a geographically clustered distribution. That means policy implications have not been practical and progressive enough to achieve SDG goals on a pan-Indian basis, and more progressive schemes are yet to be adopted to make electronic transactions a popular and convenient method for money flow across all strata of society.

OLS was built in this study with due consideration of Fig. 1. OLS is a non-spatial regression model that does not consider geographical boundaries. Table 5 shows that Peace, Justice, and Strong Institutions have a positive impact on the prosperity of E-transaction initiatives. Other positively impactful SDG indices include climate action, sustainable cities and communities, sanitation and clean water, decent work and economic growth, clean and affordable energy, life on land, good health and well-being, no poverty, and industry, innovation, and infrastructure.

Additionally, we have developed a spatial cross-regressive model to quantify the impact of our own area and neighboring areas on SDG scores and E-transaction shares, as shown in Table 8. Here, we observe that seven SDG indices have a positive impact on E-transaction shares, considering their impact on a particular state or union territory. These are Industry innovation and infrastructure, gender equality, justice, peace, strong institutions, sustainable cities and communities, responsible consumption and production, zero hunger, and reduced inequality. For the neighboring area impact, we see the same SDG indices contributing to the effect on E-transaction shares. Still, the magnitude of positive impact is mostly higher than the impact on one's area.

FURTHER RECOMMENDATIONS AND POLICY IMPLICATIONS

Undoubtedly, India has made significant progress in bringing the underprivileged segments of the economy into digital financial inclusion. The digital divide, on the other hand, is far too broad, and several bottlenecks and obstacles require a rapid response:

- It is more challenging for emerging private business entities to establish a level of confidence and loyalty that will encourage customers to transfer their funds into such digital accounts, due to the legacies of government-owned banks.
- Digital finance supplier companies expanding to relatively low-income regions will face challenges due to low literacy and the limited capacity to understand the principles and implications of digital financial products.
- Consumers prefer cash, and sellers also like to transact in cash, so staying in a cash system makes more sense. One of the main reasons for the non-adoption of digital payments is a lack of demand.
- Some shopkeepers and merchants believe that transitioning from a cash-based economy to a digital one will require small enterprises and individuals to pay taxes they are not currently obligated to pay.
- Many people in remote and rural areas still lack access to the network and digital infrastructure needed to foster confidence and frequently use digital services.
- Rural economies remain predominantly cash-based, notwithstanding the modest early proliferation of digital finance in remote and rural areas. Poorer people are more responsive to data prices, and access to sources is a primary challenge in connecting rural people to digital financial inclusion.
- Most digital financial products are available in English, and some are also available in Hindi. However, most rural people feel reluctant to use other languages due to illiteracy and unfamiliarity, and they prefer digital financial products in their local language.
- The shortfall of relevant financial products is one of the most common hurdles to digital financial inclusion.

Financial inclusion is critical to economic growth because it encourages people to save, which creates a base for financial system resources. Financial inclusion protects the financial wealth and other resources of low-income individuals by bringing them into the formal banking system. It also saves the poor people from exploitation by moneylenders in remote areas. With the support from the government, this growth has driven digital financial inclusion drive across all regions of the country, including the isolated areas. Digital financial inclusion has become a key focus for the RBI, the government, and other relevant authorities over the years, with various actions taken and significant progress made. Major initiatives and efforts made by the government and development sector, such as Jan-Dhan Yojana, Aadhaar, direct benefit transfer, Rupay, demonetization & GST, licensing to new banking institutions, payments banks, small finance, and microfinance banks, penetration of internet smartphones and fintech has played a role as a milestone in the success way of DFI. on the other hand, there are several bottleneck and challenges found in the way of proliferation of DFI such as trust, illiteracy and unfamiliarity, cash dominated economy especially in rural and remote areas, insufficient digital infrastructure, local languages, deficiency of suitable digital services and shortage of skill. There are considerable hindrances, such as a lack of infrastructure and inadequate services, that hinder accessibility to the underserved and hinder their improvement in standard of living. The primary goal of digital financial services is to connect low-income individuals with their peers and various providers. In financial inclusion, the infrastructures required for DFI are as follows: Governments and authorities should encourage rural areas to expedite and coordinate the growth of the e-models that are aligned with the requirements of micro-enterprises at the bottom of the economic pyramid by enhancing connectivity and infrastructure, maintain appropriate regulations, and to encourage remote areas to expedite and coordinate digital financial services. Assist with transitioning from cash to digital processes. Support the integration of micro-merchants towards formal e-commerce platforms by increasing demand. Digital skills and training programs should be provided. The benefits of economic progress can be amplified through digital financial inclusion. It will lower the costs of financial services and solve issues about data security and accuracy in financial transactions.

References

1) Han, Rui, and Martin Melecky. 2013. Financial Inclusion for Stability: Access to Bank Deposits and the Deposit Growth during the global Financial Crisis Financial Inclusion for Financial Stability. MPRA. Available online: https://mpra.ub.uni-muenchen.de/
48339/ (accessed on 16 July 2013).

2) Niaz, M. U. (2022). Socio-economic development and sustainable development goals: A roadmap from vulnerability to sustainability through financial inclusion. Ekonomska Istrazivanja, 35(1), 3243–3275.

3) Tay, L. Y., Tai, H. T., & Tan, G. S. (2022). Digital financial inclusion: A gateway to sustainable development. Heliyon, 8, 1–10. https://doi.org/10.1016/j.heliyon.2022.e09766.

4) Purwiyanta, P., Pujiharjanto, A., Astuti, R. D., & Kijkasiwat, P.(2022). The causality of financial inclusion and economic growth in Indonesia. Jurnal Analisis Bisnis Ekonomi, 20(1),18–30. https://doi.org/10.31603/bisnisekonomi.v20i1.6453.

5) Hussain, S., Jawad, S., & Shahzad, H. (2021). Financial inclusion and CO2 emissions in Asia: Implications for environmental sustainability. Research Square, 5, 1–17 https://doi.org/10.21203/rs.3.rs-245990/v1.

6) Neaime, S., & Gaysset, I. (2018). Financial inclusion and stability in MENA: Evidence from poverty and inequality. Finance Research Letters, 24(2), 230–237. https://doi.org/10.1016/j.frl.2017.09.007.

7) Siddik, M. N. A. (2017). Does financial inclusion promote women's empowerment? Evidence from Bangladesh. Applied Economics and Finance, 4(4), 1-9. https://doi.org/10.11114/aef.v4i4.2514

8) Anh Tu, C., Thi Minh Phi, N., Quoc Tuan, L., Yoshino, N., Sarker,T., & Taghizadeh-Hesary, F. (2019). Remittance inflows,financial inclusion, and economic development: An empirical analysis of the world.

9) Ratna, Martin, Diaye, Barajas, Mitra, Kyobe, & Mooi. (2015). Financial inclusion: Can it meet multiple macroeconomic goals? Monetary and Capital Markets Department with inputs from Strategy and Policy Review Department and other departments.

10) Koppensteiner, F., & Olukorede, A. (2016). Financial inclusion, shocks and welfare: Evidence from the expansion of mobile money in Tanzania. Research Gate.

11) Mlachila, M., Jidoud, A., Newiak, M., Radzewicz-Bak, B., & Takebe, M. (2016). Financial Development in Sub-Saharan Africa: Promoting Inclusive and Sustainable Growth, Departmental Paper No. 16/1, International Monetary Fund, Available online:
https://www.imf.org/en/Publications/Departmental-Papers-PolicyPapers/Issues/2016/12/31/Financial-Development-in-Sub-Saharan-Africa-PromotingInclusive-and-Sustainable-Growth-44220 [Accessed 08/04/21]

12) Kandpal, V., & Mehrotra, R. (2019). Financial inclusion: The role of Fintech and digital financial services in India. Indian Journal of Economics & Business, 19(1), 85-93.

13) Ravikumar, T. (2019). Digital financial inclusion: A payoff of financial technology and digital finance uprising in India. International Journal of Scientific & Technology Research, 8(11), 3434-3438.

14) Ahmad, M., Majeed, A., Khan, M. A., Sohaib, M., & Shehzad, K. (2021). Digital financial inclusion and economic growth: Provincial data analysis of China. China Economic Journal, 14(3), 291-310.

15) Malladi, C. M., Soni, R. K., & Srinivasan, S. (2021). Digital financial inclusion: next frontiers—challenges and opportunities. CSI Transactions on ICT, 9(2), 127-134.

16) Bachas, P., Gertler, P., Higgins, S., & Seira, E. (2018, May). Digital financial services go a long way: Transaction costs and financial inclusion. In AEA Papers and Proceedings (Vol. 108, pp. 444-48).

17) Ozili, P. K. (2018). Impact of digital finance on financial inclusion and stability. Borsa Istanbul Review, 18(4), 329–340.