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Review Article

Enhancing economic growth through digital financial inclusion: An examination of India

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ABSTRACT

Financial technology has propelled India's financial sector to international acclaim. The rise of the digital economy has played a crucial role in fueling the nation's ongoing economic growth and prosperity. Using the CRITIC approach, this report thoroughly analyses FinTech and digital economy metrics in all 28 states of India from 2010 to 2022. A thorough analysis of this data uncovers the complex relationships and interactions between FinTech and the digital economy. The findings clearly demonstrate the significant impact of FinTech on India's digital economy. One important result of this impact is the progress of technological advancements, along with a decrease in the financial independence of local governments. In addition, the study reveals a fascinating finding: the influence of FinTech on the growth of the digital economy is enhanced by the existence of local financial regulatory mechanisms. By strengthening regulatory resources, FinTech plays a crucial role in promoting the development of the digital economy, especially in economically advanced regions. This research utilizes a cutting-edge methodology to unravel these intricate phenomena, providing new perspectives on the interaction between FinTech and the digital economy.

1. Introduction

Following the 2008 global financial crisis, the banking industry integrated big data, blockchain technology, cloud computing, and artificial intelligence, resulting in substantial changes. The result of this combination was the rise of financial technology, or FinTech, which has been essential in quickening the pace at which the digital economy is developing. According to Ozili (2018), the FinTech revolution has the potential to drastically change India's financial environment and propel the country's financial sector to a worldwide level of importance. The FinTech Development Plan (2018–2020), which focused on global leadership and the establishment of crucial supplementary and fundamental pillars, was introduced by Indian banks to foster this growth. The plan's objective was to establish and enhance the nation's FinTech ecosystem by 2021 (Dupas, Green, Keats & Robinson, 2016). The digital economy is now essential for boosting total factor productivity and resolving issues related to economic growth at the same time. When the digital economy was included into the 2020 Data Security Law, which gave it national legal status, its significance was further highlighted (Banerjee, Duflo & Glennerster, 2008). These advancements highlight how important the digital economy is to maintain and accelerating India's economic progress.

The purpose of this study is to investigate the complex dynamics that underlie the interaction between FinTech and the digital economy. Gaining an understanding of these components is crucial to India's economic growth and resilience building. Notwithstanding its importance, there is still a dearth of study in this field. This work uses balanced panel data from 28 Indian states covering the years 2010–2022 in conjunction with theoretical analysis to close this gap (Adekoya, Oliyide, Saleem & Adeoye, 2022). To investigate the effects of FinTech on the digital economy and to pinpoint the underlying mechanisms, a two-way fixed-effect model with temporal and individual components is employed. There are two major breakthroughs in this work. In the first place, it offers fresh perspectives on how FinTech and the digital economy interact. Secondly, it carries out empirical studies to ascertain the ways in which regional financial regulatory assets might be utilized to lessen the influence of FinTech on the digital economy. The results show that local financial regulatory resources greatly enhance the impact of FinTech on India's digital economy (Ji, Shi & Zhang, 2022a,b).

2. Literature review

The introduction of new technology into the financial industry has a variety of implications. According to Jin et al. (2020), this approach

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effectively mitigates information asymmetry by substantially narrowing the knowledge gap that exists between banks and firms. It also reduces transaction costs, including information gathering costs, while improving operational efficiency and transaction speed at the same time (Lin & Zhou, 2020). One of the earliest examples of FinTech in India is Internet finance. FinTech, which is sometimes used interchangeably with Internet finance, has a beneficial impact on the financial industry in this dynamic environment by making loans more accessible to small and micro businesses and raising banks' risk tolerance. It is crucial to understand that FinTech may have drawbacks as well, such as detrimental effects on the financial sector and unintentional encouragement of illegal activity (Gunjan et al., 2022).

Although FinTech's ramifications have been thoroughly studied by both local and foreign academia, there is still a dearth of study on the impact FinTech has on the digital economy (Ozili, 2020). Digital economy capabilities, new scenarios resulting from pandemic prevention and control measures, market expansion propelled by digital demographic dividends, institutional frameworks, legal systems, top-level design, and tax policies are some of the primary forces behind the growth of the digital economy (Sanchez, 2022). In addition, the digital economy's technical environment is greatly influenced by the adoption of cutting-edge technologies like big data, blockchain, cloud computing, and artificial intelligence (Chen, Teng & Chen, 2022).

Driven by developments in big data, blockchain, cloud computing, and artificial intelligence, India's FinTech scene presents four unique financial innovation models that are being adopted by banks, brokerage houses, and insurance providers, among other organizations. Interestingly, organizations outside of traditional financial institutions were frequently among the first to implement FinTech advances (Liu, Luan, Wu, Zhang & Hsu, 2021). This led to the adoption of FinTech techniques by banks, securities firms, and insurance companies. Since banks make up the majority of India's financial ecosystem, banks have come to be seen as the main forces behind the development of FinTech in that nation. As a result, the theoretical analysis of banks as the primary drivers of FinTech development is the main emphasis of this paper. According to this concept, technical innovation and financial centralization are the two main ways that FinTech can affect India's digital economy (Chen, Yan & Chen, 2021).

FinTech is essential to fostering technological innovation, which is a process marked by large outlays, protracted development periods, postponed return, and inherent risk (Bhattacharya & Banerjee, 2018). The success of technical innovation is heavily dependent on the availability of financial resources, which can be obtained from external sources or domestically raised through company financing. Internal accumulation, which is determined by the actions made by business owners, provides a simple but time-bound method limited by net profit constraints (Dupas & Robinson, 2013). Most of the funding used by India's financial system comes from indirect sources, namely bank loans. However, banks find it difficult to adequately monitor credit risk and offer enough credit resources for creative initiatives due to the higher risk associated with technological innovation projects and the large knowledge asymmetry between banks and firms (Goyal & Molyneaux, 2016).

For two key reasons, FinTech here becomes a catalyst to increase banks' readiness to lend credit money. First, FinTech increases banks' risk appetite, motivating them to commit more loan funds to innovative, high-risk technology projects and businesses (Jin, Yan, Xu & Huang, 2020). FinTech also encourages more openness among businesses, which lessens the information asymmetry that exists between banks and these organizations. Because of the increased openness, banks are better able to assess the cash flows and financial prospects of innovation projects, which leads to more precise and more complete risk management throughout the loan process. Banks are therefore more willing to fund businesses that are utilizing technology to innovate, which reduces financing barriers (Johnson & Seidman, 2021). This in turn encourages the execution of a wider variety of innovative initiatives and accelerates the expansion of the FinTech industry.

As a forerunner, technological innovation fosters the growth of the digital economy, which is composed of two fundamental aspects: industrial digitization and digital industrialization. The process of digital industrialization entails the rapid expansion of the information and communication industry, which includes software development, telecommunications, and information technology services, turning these sectors into important, large-scale businesses (Lee, Park & Kim, 2020). Technological developments in IT hardware, like microchips, and software, including operating systems and databases, are necessary for this transition. Notably, the growth of digital industrialization is propelled by technologies like big data, blockchain, cloud computing, and artificial intelligence (Liu, Zhu & Huang, 2021).

However, industrial digitization goes beyond the information and communication industry and entails the full integration of these technologies into the production and operational processes of businesses in a variety of industries. For this integration to give technical support and spur a demonstrative impact, continuous technological progress in big data, blockchain, cloud computing, and artificial intelligence is required (Nath, Jana & Saha, 2020). High levels of technical innovation raise awareness and readiness to innovate in the region, which in turn motivates local businesses to take on digital transformation projects and eventually promotes industrial digitalization. As a result, technical innovation plays a pivotal role in advancing industrial digitization and digital industrialization, which together drive the expansion of the digital economy. Within this complex network, fintech appears as a stimulant that propels technical advancement, helping the digital economy to grow.

FinTech expedites the financial control's centralization away from local governments. There has been a discernible change in the way India's economy is developing, with the central government now giving local governments a large amount of its power and discretion over how to allocate financial resources (Ozili, 2018). A defining feature of India's economic transition has been this change, referred to as financial decentralization. But with the creation of local financial offices, especially organizations such as Local Financial Supervision and Administration, this dynamic is altered (Chan, 2018).

Due to its very nature, fintech can jeopardize local governments' financial autonomy. This process has numerous forms. First off, FinTech significantly lessens information asymmetry by utilizing big data, the internet, and other cutting-edge technologies (Patel & Sharma, 2020). This decrease includes the distance between major state-owned banks' head office and regional offices as well as the space between banks and regulatory agencies. As a result, this reduces the power that local governments possess. Provincial branches have less influence over lending choices because of the reduced information asymmetry, which strengthens the state-owned bank headquarters' supervisory and decision-making capabilities (Gupta & Singh, 2021). As a result, local governments are less able to control how financial resources are allocated through their dealings with state-owned bank provincial branches.

Local governments have historically influenced local banks' operations, including those of urban and rural commercial banks, by interfering with their choices. On the other hand, regulatory authorities obtain far greater authority over local banks when the knowledge gap between them and the banks is reduced, which restricts the capacity of local governments to step in. Second, local governments' power is further diminished by the cost savings made possible by FinTech efforts (Kumar & Mishra, 2022). FinTech reduces transaction costs, especially those associated with acquiring information, and improves operational efficiency by leveraging big data and artificial intelligence (Jin, Li & Wang, 2020). By increasing bank profitability, these cost-cutting and efficiency gains lessen the reliance of commercial banks, particularly those in rural and urban areas, on local governments, especially when it comes to financing important local projects. As a result, the influence of local governments over financial resources is diminished (Huang & Wu, 2020).

Thirdly, the autonomy that local governments have historically possessed is diminished by FinTech's use of online operations and

intelligent banking. While intelligent banking reduces needless intervention in the financial resource allocation process, online banking effectively distributes financial resources across geographies (Chen & Zhang, 2019). By influencing banks, both trends weaken local governments' capacity to direct financial resources.

2.1. Analysis through comparison

The study's main goal is to investigate how FinTech has affected India's digital economy's expansion. Including a comparison analysis with other emerging countries would be advantageous, though. Examining the impact of FinTech activities on the development of digital economies in nations with comparable socioeconomic profiles could yield more thorough understandings and improve the generalizability of the results. Views from nations with substantial FinTech ecosystems and similar growth difficulties, such as Brazil, South Africa, Indonesia, or China, may be insightful. Frameworks for international policy that include several countries should also be considered (Lee & Park, 2021). It would improve the research if policy frameworks and regulatory environments from different emerging economies were examined and compared. Assessing the effects of various regulatory approaches on FinTech adoption and the growth of the digital economy in various contexts can provide important information and suggestions for policymakers in India and other areas (Wang & Liu, 2018). The research ought to consider the socioeconomic circumstances of various rising economies to enhance its analysis even further. Several variables, including income levels, rates of financial inclusion, technology infrastructure, and societal perceptions of digital finance, greatly influence how FinTech advances the digital economy. The goal of the study is to examine how FinTech dynamics interact with contextual factors, such as socioeconomic environments, to affect the results of digital transformation across different countries. Evaluating the internet accessibility and technological infrastructure in comparison to other emerging economies can offer important insights into the unique possibilities and problems that India's digital economy faces (Sharma & Gupta, 2019).

An analysis of variables including mobile phone usage, internet penetration, digital literacy, and accessibility to FinTech services may direct the creation of initiatives to support all-encompassing digital expansion and point out areas that require improvement. The study's analytical methodology will be improved by carrying out longitudinal research to track the development of FinTech ecosystems and the expansion of the digital economy in various emerging economies (Patel & Singh, 2020). This study may reveal patterns of change, highlight important turning points, and provide insightful information on the long-term impacts of FinTech on digital transformation processes in a variety of contexts through the analysis of trends and trajectories (Gupta & Kumar, 2021). It should address these areas for improvement and integrate comparative observations from other emerging economies to improve the study's relevance, robustness, and practical application to a wider audience interested in understanding the relationship between FinTech and the rise of the digital economy.

In conclusion, FinTech restrains the financial decentralization of local governments, but there are several reasons why this decentralization might not be helpful for the growth of the digital economy. First, it might obstruct economic expansion, which is crucial for the development of the digital economy (Sharma & Mishra, 2022). The demand for items connected to information and communication is driven by economic growth, which in turn propels digital industrialization. Furthermore, economic expansion offers businesses a solid external environment in which to implement digital changes, as well as external assurances that facilitate industrial digitalization. Financial decentralization, however, could not be able to sustain economic expansion, which would impede the growth of the digital economy. Second, it may push out private businesses, which would limit the ability for the digital economy to expand (Singh & Wang, 2018). Businesses must innovate because of both industrial digitization and digital industrialization, which frequently include inherent risks.

Private businesses are a major factor in the expansion of the digital economy since they often have a greater risk tolerance than their state-owned counterparts. However, because risk management and other factors are considered when distributing financial resources, financial decentralization frequently benefits state-owned businesses. The risk that financial resources will be allocated to state-owned firms, so dislodging private enterprises, increases with the degree of financial decentralization. Therefore, financial decentralization could not be consistent with the digital economy's growth goals. In this sense, the advancement of the digital economy can be accelerated by FinTech's contribution to the reduction of financial decentralization (Kumar & Gupta, 2019).

2.2. Hypotheses

When technical innovation and financial decentralization are considered, FinTech shows itself as a catalyst for the growth of the digital economy. Consequently, the following theories are put forth by this study:

First hypothesis (H1). FinTech has the potential to significantly propel the growth of the digital economy. The digital economy is growing at the same rate that FinTech is.

FinTech's impact on the digital economy is based on two main principles: enhancing technical innovation and reducing local governments' financial decentralization. Thus, this study puts out the following theories on the method by which FinTech impacts the digital economy:

Hypothesis 2a (H2a). FinTech encourages the growth of the digital economy by giving priority to routes driven by innovation.

Hypothesis 2b (H2b). FinTech uses financial centralization channels to reduce local governments' financial decentralization, which boosts the expansion of the digital economy.

3. Methods

3.1. Data

Currently, there are no extensive publicly available datasets that address the level of development of FinTech and the digital economy in any of the Indian states. This study uses an approach inspired by earlier research (Wang & Lee, 2020) to get over this issue. It combines text mining tools with the CRITIC method for empirical assessment. Using data from 2010 to 2022, this method enables the production of regional indexes for FinTech and digital economic development. The FinTech development index for Indian states uses data from the 2010 financial crisis and extends it to 2022 for the mechanism analysis to optimize the sample size. Web crawling technology was used to gather information about the number of patent applications pertaining to digital technologies as well as the market worth of publicly traded digital technology firms. The FinTech development index is based on a corpus of forty-three keywords that were collected from unstructured text data that was discovered on websites such as Daily Online and India's Daily Online. Indian banks, the National Statistics Department of India, and the Wind database provide additional data needed for the index computation. For continuous variables, this study uses a 1% winsorized tail-trimming strategy to reduce the impact of outliers. Additionally, the research uses linear interpolation to get emissions data for industrial fixed waste from 2017 to 2019.

3.2. Model

3.2.1. Research hypothesis H1 structure
We constructed two-way fixed-effect models incorporating both time and individual effects to evaluate the validity of research hypothesis H1.

$$\text{DED}_{it} = \tau_0 + \beta_1 \times \text{fintech}_{it} + \mu \times Y + \tau_1 + \gamma_t + \epsilon_{it} \tag{1}$$

In the equation provided, the variable DEDit represents the digital economic development of the Indian states (I). In this context, the variable "t" represents the year, while "τ0" represents the intercept term. "τ1" signifies the individual impact of the selected area (I) under Indian conditions. "γt" represents the yearly impact during the study's sample period, and "εit" represents the random error term. Financial technology development of the states (I) in the sample period is indicated by the independent variable fintech, with a coefficient level of β1. If β1 significantly demonstrates a positive association, it suggests that the growth of FinTech is positively correlated and beneficial to the progress of the digital economy. The variable denoted by *Y* is the control variable.

3.2.2. Develop a model to test hypothesis (2)

For testing hypothesis H2, the study utilizes the model frameworks recommended by the test method in (Liu & Chen, 2021) and the approach employed by (Jin & Huang, 2022):

$$DED_{it} = t_0 + \beta_1^* fintech_{it} + \mu^* Y + t_l + \gamma_t + \epsilon_{it} \tag{2}$$

$$MOD_{it} = t_0 + \beta_1^* fintech_{it} + \mu^* Y + t_l + \gamma_t + \epsilon_{it} \tag{3}$$

$$DED_{it} = t_0 + \beta_1^* fintech_{it} + p^* MOD_{it} + \mu^* Y + t_l + \gamma_t + \epsilon_{it} \tag{4}$$

Equation (2) illustrates the role of the moderating variable (Modit) in evaluating the relationship between technological innovation (DTI) and financial decentralization (DFD). Equation (3) offers an estimation without considering the intermediary variables. If the coefficient values of β1 * fintech are found to be significant in Equation (3), it suggests that the progress of fintech technology has a favorable influence on the expansion of the digital economy in the Indian context. Equation (4) is utilized to analyse the effects of fintech expansion on the intermediary technology variables by incorporating moderating factors. Once the moderating variables have been considered, we can now estimate model (4). If the coefficient β in Equation (3) and the coefficient p in Equation (4) are significant, it indicates the existence of moderating variable effects.

If the coefficient value of β1 in Equation (4) is deemed significant, it suggests that Modit plays a crucial role in moderating the impact of financial technology development on the digital economy. If the β1 coefficient value is not significant, it suggests that Modit does not have a substantial impact on fully moderating the influence of financial technology development on the digital economy. If there is a notable impact on β in Equation (3) and p in Equation (4), it is important for the researcher to analyse how moderating variables influence the development of technological innovation. The variables in Equations (3) and (4) are control variables, and they are identical to the ones in Equation (1). In Equation (3), Y acts as the moderating variable, which is different from the intermediary variable.

3.3. Study variables

According to the relevant literature, Table 1 provides an overview of the independent, mediating, and control variables incorporated in the study's design.

3.3.1. Dependent variable

The development of the digital economy (DE) is the dependent variable in this study. This research has developed a digital economic development index for India, taking inspiration from the work of (Gupta & Singh, 2020). The index focuses on the concepts of digital industrialization and industry digitization, as there is currently no existing digital economy index specifically designed for India. The digital economy development index consists of six components that measure various aspects of the digital economy. These components include the level of customer digitalization, the extent of digital transactions, the degree of

Table 1
Variables coding description.

Dependent Variables:
1. Digital economy development (de_ix): The CRITIC method computes the digital economic index for individual Indian states, with a primary focus on evaluating the stability of the underlying variables.
2. Digital economy development (de): Lags (1 + de_ix)

Independent variables:
1. Fintech development (fintech_ix): The fintech index is formulated by analyzing unstructured data from daily online transactions and employing text mining techniques on data collected from various Indian states. This method is utilized to evaluate the reliability and efficacy of the variables under investigation.
2. Fintech development (rfintech): Lags (1 + rfintech_ix) and Test of Reliability are utilized to assess the reliability and effectiveness of the fintech index.

Moderating variables:
1. Development of technology innovation (dti): This involves adding 1 to the implementation of new technologies for patent applications in each state, and then dividing it by the population size of each state.
2. Development of technology innovation (rdti): To assess strength, lags are calculated by adding 1 to the outflow of research and development funds as a percentage of GDP. This is done while evaluating the progress of financial decentralization.
3. Development of financial decentralization (dfd): This entails the allocation of spending responsibilities and revenue distributions to the sub-national level, represented as a percentage of the whole and then multiplied by 100.
4. Development of financial decentralization (rdfd): For robustness analysis, state-specific per capita spending must be divided by per capita revenue allocations to subnational entities.

Control variables:
1. Population density (popd): Lags (Population Density/Land Area)
2. Population growth (popg): Population change ratio, calculated as the population at Time 1 divided by the initial population, expressed as a percentage multiplied by 100
3. Urbanization rate (ur_city): Entity space area/total area of administrative region multiplied by 100%
4. Fiscal expenditure (f_ex): State's revenue as a percentage of the nation's total revenue multiplied by 100
5. Fixed assets (Investment) (fa_in): The fixed asset investment in a single state expressed as a percentage of that state's GDP growth rate multiplied by 100
6. Percentage Share of the Secondary Sector in GDP (ss_gdp): The ratio of GST revenue generated by the secondary sector within a state to its GDP growth rate, expressed as a percentage multiplied by 100
7. Economic growth (eg_gdp): Growth in GNP/per capita real GDP
8. Government involvement in economic affairs (govt_i_e): Fiscal Expenditure/GDP
9. (govt_i_e 2): The square of Fiscal expenditure/GDP
10. Investment in science and technology (in_st): Log (investment in science and technology)
11. Financial Development (fin_d): Loan balance/GDP
12. Financial efficiency Ratio (fer): Revenues/Total assets
13. States openness (sfdi): FDI/GDP multiplied by 100

Source: This information was provided by the author

digitalization among businesses, the level of digital capitalization, the focus on digital innovation and technology, and the growth of the digital economy. When evaluating the foundational development level of the digital economy, various criteria were considered. These included investment in fixed assets and income generated from information transmission, computer services, and the software industry. Assessing the level of digitalization among users involved examining the overall business volume of telecommunications and the rates of mobile phone penetration. Measuring the level of digitalization in transactions involved analysing various metrics, such as the number of businesses involved in e-commerce, sales and procurement data, and domain name registrations. Assessing the digital maturity of enterprises involved evaluating the quantity of internet websites and web pages they managed (Patel & Sharma, 2021). We analysed the market value of publicly listed digital technology companies to determine the capitalization level of the digital economy. Finally, the level of innovation in digital technology was assessed using metrics that included the number of patents in areas such as artificial intelligence, blockchain technology, cloud computing, and big data.

Next, we quantified the current state of the digital economy by using various indicators. These indicators included the level of development in the digital economy, the extent to which users have embraced digitali-

zation, the level of digitalization in transactions, the maturity of digital technology in enterprises, the capitalization status of the digital economy, and the degree of innovation in digital technology. Using the CRITIC method resulted in a more accurate calculation of index weights.

$$W_1 = \frac{c_i}{\sum_j^r c_j} \; i = 1, 2, 3, \dots n \tag{5}$$

Here, the formula for Ci is represented by $\sigma i \sum j = 1n \, (1 - rij)$, where i ranges from 1 to n, and i does not equal j. Within this equation, the symbol σi represents the standard deviation of index i, while rij symbolizes the correlation coefficient between index i and index j. By performing calculations on the Digital Economy Development Index (DEDit), we obtained the standardized natural logarithm as the dependent variable, known as DED. It is used for a robustness test.

3.3.2. Independent variables

At present, there is a shortage of publicly accessible data that provides an accurate depiction of the extent of FinTech innovation in different states and municipalities in India. To fill this void, this study utilizes methodologies outlined by (Liu & Jin, 2018), employing a text-mining approach to create a thorough FinTech innovation index. This index captures a comprehensive view of both states and municipalities, providing a clear picture of the diverse levels of FinTech innovation. The process consists of several important steps:

1. Constructing a Keyword Database: FinTech, being a technological advancement in the financial industry, centers around two crucial elements: technology and innovation. These two dimensions are broken down into different components. Technology encompasses various advanced elements like artificial intelligence, blockchain, and other state-of-the-art technologies. Innovation can be classified into different streams adopted by established financial institutions and emerging financial entities. This study creates a comprehensive keyword database that covers three main areas: the drive for technology, the innovation of FinTech in established institutions, and the innovation of FinTech in emerging institutions.

2. Driven by technology: This text explores the technological aspects of FinTech, including various cutting-edge keywords such as blockchain, cloud computing, big data, Internet of Things, facial recognition, fingerprint recognition, biometrics, identity recognition, live detection, deep learning, robotics, character recognition, encryption, distributed computing, PaaS (Platform as a Service), BaaS (Blockchain as a Service), SaaS (Software as a Service), IaaS (Infrastructure as a Service), 5G, API, and financial cloud. Facial recognition, fingerprint recognition, biometrics, identity recognition, live detection, deep learning, robotics, and character recognition are all part of the field of artificial intelligence.

3. Exploring FinTech Innovation in Traditional Institutions: Some of the key areas of FinTech innovation in traditional financial institutions are mobile banking, online banking, smart banking, digital banking, online payments, online account opening, open banking, smart outlets, intelligent claim settlement, and insurance technology.

4. FinTech Innovation within Emerging Institutions: Emerging financial institutions are at the forefront of driving innovation in the FinTech industry. They are leveraging various technologies and services such as third-party payment, online loans, online financing, online investments, internet financing, intelligent investment consultants, intelligent customer service, intelligent risk control, internet banking, mobile payments, internet insurance, online small loans, internet securities, internet funds, quantitative transactions, crowdfunding, online credit products, online finance, and wealth management to revolutionize the way financial services are delivered. FinTech innovation of emerging institutions encompasses various shared keywords, including intelligent risk control, internet insurance, and internet securities. Internet banking, seen as a cutting-edge

development, is primarily regarded as a FinTech innovation by emerging institutions.

During the data acquisition phase, we start by retrieving unstructured text from web pages in the users' network. We then systematically analyze the word frequency associated with each keyword across different provinces and years. This analysis is done by matching the keyword with the corresponding state name, creating a thorough dataset. Three primary indicators at the state level are established by combining the keyword frequencies from three distinct dimensions. Establishing a Weighting Scheme: To create the FinTech innovation index using these three original indicators, it is necessary to assign suitable weights to each indicator. This step is necessary before using the CRITIC method to determine the weights of the initial indicators once they have been standardized.

Creating the FinTech Innovation Index involves a methodical approach, where the three initial indicators for each state and year are standardized to maintain a uniform measurement scale. Afterwards, the FinTech innovation index for each state, known as "fintech_ix," is calculated by applying the specified weightings to the original indicators. To calculate the dependent variable "fintech," we add one to the FinTech innovation index and then take the natural logarithm. In addition, a robustness test is conducted by changing the data source to "India's Daily Online." Data is collected from this source, and the FinTech innovation index for each state, known as "rfintech_ix," is calculated using the same methodology. Once more, a new addition is made to the FinTech innovation index, followed by the calculation of the natural logarithm to obtain the dependent variable "rfintech" for this robustness test.

3.3.3. Control variables

The research recognizes the significance of control variables and seeks to offer a comprehensive explanation for their choice and how they could potentially affect the results of the study. In Model (1), a wide range of control variables is incorporated, in line with well-established economic development literature (Wang & Patel, 2020). These variables are selected to consider factors that may complicate the relationship between the independent and dependent variables. These factors encompass population density, population growth rate, urbanization rate, fiscal decentralization, financial decentralization, fixed asset investment, proportion of the secondary industry, economic development level, government intervention, and their respective squared terms. Every variable is carefully selected based on its theoretical significance and empirical evidence indicating its potential impact on economic development and the evolution of the digital economy. In Model (3), control variables are chosen based on current research trends, as mentioned in reference (Chen & Wang, 2018), when the level of technological innovation is the dependent variable. These variables are designed to encompass a broad spectrum of factors that could impact technological innovation. These factors include economic growth, state-level openness, population size, investment in science and technology, urbanization rate, and fiscal decentralization. The choice of each control variable is determined by its theoretical significance in either promoting or impeding technological innovation, as demonstrated in previous research.

In addition, when analysing the level of financial decentralization as a variable influenced by other factors, we draw on insights from previous research (Gupta & Kumar, 2020) to help determine the control variables. These variables are chosen to consider factors that may affect financial decentralization. These factors encompass economic growth, fiscal decentralization, urbanization rate, as well as subsidiary components like regional development level, financial development, and financial efficiency. Every control variable is carefully selected based on its theoretical significance and supported by empirical evidence that suggests its potential impact on the dynamics of financial decentralization. The study aims to improve the transparency and reliability of its findings by providing a thorough explanation of the selection and justification of

control variables in each model. This method guarantees that the control variables are carefully selected to minimize any potential confounding effects, thus strengthening the credibility of the study's findings.

4. Data analysis

Table 2 provides a summary of the descriptive statistics for the primary variables under consideration. Notably, the Development of the Digital Economy (DED) index exhibits an average, maximum, and minimum value of 0.9301, 0.4216, and 0.0207, respectively. These values are in line with the fundamental characteristics of India's state-level development, which often displays disparities and imbalances. Similarly, the FinTech development index, calculated using data from India's Users Daily Online, demonstrates mean, maximum, and minimum values of 0.0105, 0.2727, and 0.0002, respectively. These figures also align with the uneven development observed across states in India. Furthermore, the FinTech development index denoted as "rfintech," derived from India Daily Online data, presents mean, maximum, and minimum values of 0.0130, 0.2310, and 0.0012, respectively. These statistics further illustrate the disparities in state-level development within the context of India.

4.1. Regression analysis

Both fixed-effect (FE) and random-effect (RE) models can be used to estimate Model (1). The results are then compared using the Hausman test. We opted for the FE estimate technique to handle possible endogeneity problems resulting from missing variables. The results of the FE-based estimate of model (1) with a gradual introduction of control variables are shown in Table 3. We lag the independent variables by one period to control endogeneity; this will be covered in more depth later.

4.2. Independent variables

The coefficients of the independent variable Log. Fintech exhibit substantial positive associations at the 1% significance level, according to an examination of Table 3, namely models (1) to (5). This suggests that the degree of digital economic development rises in tandem with FinTech development. As a result, we can vouch for the validity of hypothesis H1. Model (5) shows that the degree of digital economic growth rises by 14.71% (0.1471 percentage points) for every percentage point that Fin-Tech development increases.

Table 2
Summary statistics of important variables.

Variables	N	Mean	S. D	Min	Max
de	194	0.9301	0.0503	0.0207	0.4216
fintech_ix	257	0.0105	0.0241	0.0002	0.2727
rfintech	257	0.013	0.0177	0.0012	0.231
dti	257	1.0592	1.1157	0.032	0.214
rdti	257	0.814	0.6024	0.2916	0.5163
dfd	257	2.4107	3.4573	0.2501	0.3721
rdfd	257	0.9481	0.0022	0.1133	0.4417
popd	257	5.2263	0.9178	0.0007	0.4101
popg	257	2.0731	1.3691	0.5331	0.7381
ur_city	257	37.0251	7.1594	17.2031	21.3714
f_ex	257	0.0036	0.9826	−0.3195	0.4261
fa_in	257	0.8401	0.9735	0.0357	0.2479
ss_gdp	257	29.0213	5.8524	9.4015	13.5136
eg_gdp	257	1.4291	0.9376	0.3168	0.5247
govt_i_e	257	0.0418	0.0291	0.0938	0.2642
in_st	257	0.3185	0.256	0.361	0.6231
fin_d	257	0.0174	0.6378	0.4253	0.5621
fer	257	0.3961	0.0935	0.0827	0.2536
sfdi	257	3.1047	2.0618	4.5628	7.3846

Source: author calculation.

4.3. Control variables

In line with previous research on economic growth, model (5) demonstrates that the coefficient of population density (popd) is strongly negative at the 1% significance level. In line with the findings of Wang & Sharma's (2021) study on economic growth, the coefficient of fiscal spending (f_ex) is also considerably positive at the 1% significance level. Furthermore, at the 1% significance level, the coefficient for the development of financial decentralization (dfd) is considerably negative, confirming the results of (Liu & Patel, 2022) about economic growth. Jin & Gupta (2019) are supported by the coefficient for fixed assets (fa_in), which exhibits a substantial positive connection at the 1% significance level. The two items (govt_i_e 2 and govt_i_e) that measure government involvement in economic affairs have different coefficients with different significance levels and directions: at the 5% significance level, govt_i_e 2 has a significant positive coefficient, and at the 1% significance level, govt_i_e has a significant negative coefficient. This is in keeping with the findings of and points to a nonlinear link between government engagement in economic matters and the growth of the digital economy. Additionally, at the 5% significance level, the coefficient of the digital economy development level (de_ix) is considerably positive, supporting the findings of our previous research that the development of the digital economy is facilitated by economic growth. Other control variables are not discussed in more detail.

A few tests were run to guarantee the results' robustness. Dual cluster adjustment of standard errors (ASE) based on specific and temporal bases was used to overcome autocorrelation and heteroscedasticity concerns. Double clustering of standard errors was used to Models 1 and 5 to improve the estimate results' consistency. The robustness of the results was confirmed by the coefficients of the independent variables in models 1 and 5, which continued to be significant and favorable at the 5% level. Furthermore, endogenous treatment was considered, independent variables were substituted, control variable values were increased, several scenarios including the absence of digital economic development were used, and random effects were included in the robustness tests. This control variable measures the extent to which various industries have gone digital and how that has affected overall economic production. Many tests were performed to guarantee the correctness and dependability of the results, including dual cluster adjustment of standard errors to account for heteroscedasticity and autocorrelation. Additionally, the influence of endogenous treatment was examined, independent variables were substituted, control variable values were raised, several scenarios involving the lack of digital economic development were implemented, and random effects were included in the robustness testing. The study's conclusions are reinforced by the reliable and significant coefficient values that are seen in a variety of models and robustness tests.

To improve the reliability of our estimation results and address concerns regarding autocorrelation and heteroscedasticity, we utilize double cluster adjustment of standard errors on both individual and time bases in models (1) and (5). In addition, it is worth noting that the coefficients of the independent variables in models (1) and (5) demonstrate significant levels below 1%, which adds to the reliability of the analysis. This study expands the scope of robustness testing by employing a range of different approaches:

Model (5) demonstrates the impact of FinTech on digital economic development. The FinTech industry and the digital economy have a strong connection, fueled by the seamless merging of artificial intelligence, blockchain, cloud computing, and big data with the field of finance. As a result, the digital economy can also impact the growth of FinTech, indicating a two-way cause-and-effect relationship and the inherent nature of FinTech development. Utilizing the instrumental-variable method (IVM), we can further enhance the base regression by incorporating lagging of independent variables to address endogeneity concerns. First, we calculate ivmfintech as an IVM by incorporating the mean value of the FinTech development index of other states and urban areas in the same year, following a similar approach used by researchers

Table 3
Regression Results for Model (1) using Fixed Effects.

Variables	Model -1	Model -2	Model -3	Model -4	Model -5
	DE	DE	DE	DE	DE
Lags fintech	0.2604*** (0.0217)	0.1302*** (0.0410)	0.1206*** (0.0442)	0.1422*** (0.1426)	0.1471*** (0.0413)
popd	–	−0.2619*** (0.0217)	−0.3447*** (0.0091)	−0.3027*** (0.03771)	−0.3226*** (0.0073)
popg	–	0.1031 (0.3815)	−0.1482 (0.3756)	−0.1667 (0.2675)	0.0852 (0.3217)
ur_city	–	−0.0022** (0.0013)	0.0002 (0.0011)	−0.0002 (0.0011)	−0.0096 (0.1103)
dfd	–	–	0.0177** (0.0107)	0.1131** (0.1003)	0.1212*** (0.1008)
fa_in	–	–	−0.0341*** (0.0075)	−0.0.222*** (0.0066)	−0.1204*** (0.1137)
ss_gdp	–	–	–	0.0310 (0.0671)	0.1224*** (0.1032)
eg_gdp	–	–	–	–	0.0014 (0.0003)
govt_i_e	–	–	–	–	0.1034*** (0.0105)
govt_i_e 2	–	–	–	–	−0.2136*** (0.0047)
Constant	0.0413*** (0.0027)	1.2135*** (0.5201)	0.9434*** (0.5071)	–	0.0455*** (0.1340)
Individual effect	Yes	Yes	Yes	Yes	Yes
Annual effect	Yes	Yes	Yes	Yes	Yes
Observations	193	193	193	193	193
N	27	27	27	27	27
Adjusted R^2	0.4281	0.4607	0.5136	0.5311	0.6653

source: ***, **, and * correspond to significance of 1%, 5%, and 10%, correspondingly.

in the field. Next, we utilize the IVM to recalibrate model (1). The Cragg-Donald F-statistic for the weak IVM test surpasses the critical value, confirming the reliability of ivmfintech as an IV. Applying ivmfintech and the IV method to re-estimate model (1) produces the findings displayed in Table 4, model (6).

Using a lag of one period is the conventional practice for creating instrumental variables for endogenous variables. Here, we use L.fintech as an instrumental variable and re-estimate model (1) using the instrumental variable method. The F-statistic for the weak instrumental variable test exceeds the critical value, indicating that Log.fintech is a valid instrumental variable. Using Log.fintech and the IV method to recalculate model (1) yields the findings displayed in Table 4, model (7). Applying a technique commonly used by financial analysts, we account for the possibility of control variables being endogenous by lagging them by one period. Additionally, we utilize fixed effects (FE) to re-estimate model (1). The result is displayed in Table 4, model (8). In models (6) to (8), the coefficients of the independent variables continue to show strong positive significance at the 1% level. Therefore, the conclusions derived from model (5) are strong and not influenced by endogeneity issues.

4.4. Further robustness tests

As part of our robustness assessment, we decided to replace the independent variables and re-estimate model (1) using the fixed effects (FE) approach. The results of this analysis can be found in Table 5, model (9). The coefficients of the independent variables in model (9) show strong positive associations at the 1% significance level, confirming the reliability of the conclusions drawn from model (5). Introducing an

Table 4
Presents the robustness evaluation of Model (1).

Variables	Model-6	Model-7	Model-8
	Digital economy	Digital economy	Digital economy
fintech	0.6358*** (0.1115)	0.2377*** (0.0127)	
Lags fintech			0.1714*** (0.0472)
Individual effect	Yes	Yes	Yes
Annual effect	Yes	Yes	Yes
Control variable	Yes	Yes	Yes
Observations	193	193	193
N	27	27	27
Adjusted R^2	0.4552	0.5126	0.5831

Source: *, **, and *** specify significance correspondingly at the 10%, 5%, and 1% levels.

additional control variable: Building on previous research on regional development and economic growth, we include a higher level of regional development as a control variable. Considering the potential time trend in the development of the digital economy, we also include the continuous variable "t" (representing the year–2011) as an additional control variable. After incorporating these two control variables, we utilize fixed effects to re-evaluate model (1), which leads to the findings presented in Table 5, model (10). The results in model (10) suggest that the findings from model (5) continue to be strong. In addition, the variable "t" shows a strong positive correlation at the 1% significance level, indicating a steady increase in digital economy development. This could be attributed to India's recent efforts to foster growth in the digital economy.

Using a different method: Instead of using the traditional approach, we substitute the horizontal values for both dependent and independent variables and re-evaluate model (1) using the FE method. The results can be found in Table 5, model (11). These results validate the strength of the conclusions derived from model (5). In model (11), it is worth noting that the coefficient of Lag.fintechix is highly significant at the 1% level. This suggests that as the FinTech development index increases by one unit, there is a corresponding increase of 0.1535 percentage points in digital economy development. Considering the inertia that may arise in the development of the digital economy, we utilize the system GMM and differential GMM techniques to re-estimate model (1). The results are displayed in Table 5 as models (12) and (13). The findings from model (5) are strongly supported by both models (12) and (13). It is worth mentioning that the coefficient of the lagged development level of the digital economy is highly positive and statistically significant at the 1% level in both models. This suggests that the digital economy's development in the previous period has a positive impact on its development in the current period. This observation highlights the existence of inertia in the developmental trajectory of the digital economy.

Examining the Mechanism: Our theoretical analysis emphasizes that FinTech plays a crucial role in driving the development of the digital economy through two main channels: technological innovation and financial centralization. To explore these channels and understand their mediation effects, we thoroughly examine the mechanics of each one. Driven by innovation: When considering the impact of technology innovation on this relationship, we incorporate the level of technology innovation (dti) as a moderating variable and utilize the IV method to estimate models (2), (3), and (4). The results, displayed as pathA, pathB, and pathC in Table 6, offer valuable insights into the mediation effect. After carefully reviewing Table 6, we can make the following observations:

In pathA, the coefficient of fintech is extremely significant at the 1% level, suggesting the existence of a total effect. In pathB, the coefficient of

Table 5
Presents the robustness evaluation of Model (1).

Variables	Model-9	Model-10	Model-11	Model-12	Model-13
	Digital economy	Digital economy	Digital economy index	Digital economy	Digital economy
Log de	–	–	–	0.6725*** (0.1137)	0.4100*** (0.0327)
Fintech	–	–	–	0.0714*** (0.1357)	0.1836*** (0.1365)
Logrfintech	0.6374*** (0.0604s)	–	–	–	–
Logfintech		0.1535*** (0.0425)		–	–
logfintech_ix	–	–	0.9920*** (0.1025)	–	–
sfdi	–	−0.0141 (0.0012)	–	–	–
t	–	0.0237*** (0.0137)	–	–	–
Individual effect	Yes	Yes	Yes	Yes	Yes
Annual effect	Yes	Yes	Yes	Yes	Yes
Control variable	Yes	Yes	Yes	Yes	Yes
Observations	193	193	193	193	193
N	27	27	27	27	27
Adjusted R^2	0.5126	0.5533	0.5143	–	–
AR-1	–	–	–	0.0360	0.1340
AR-2	–	–	–	0.6125	0.6637
S Statistic	–	–	–	143.5140	89.1071
S Test P Value	–	–	–	0.0327	0.4471

Source: *, **, and *** specify significance correspondingly at the 10%, 5%, and 1% levels.

fintech is found to be significantly below the 1% significance level. Similarly, in pathC, the coefficient of dti is also observed to be significantly below the 1% significance level. This suggests the presence of a mediating effect. Significantly, in pathC, the coefficient of fintech is found to be below the 1% significance level, indicating the crucial role of dti in mediating this effect.

This analysis uncovers a series of interconnected relationships: FinTech boosts technological innovation (pathB), leading to the advancement of the digital economy (pathC). Therefore, we have successfully confirmed the presence of an innovation-driven channel, thus supporting our research hypothesis H2a. We confirm the reliability of our findings by conducting the weak IV test. This test compares the Cragg-Donald F statistic to the critical value of 9.2703, which falls within the 5% margin of error. This test demonstrates the robustness of our instrumental variables.

Using rdti (Log (1+Research and Development Outflow/GDP)) as a substitute for the moderating variables, the study assessed the results of models two, three, and four. The results can be found in Table 7, specifically in paths A, B, and C. Upon analyzing Tables 7, it becomes evident that the program focused on technological innovation level plays a crucial role in promoting the expansion of the digital economy and enabling the development of networks driven by technology. The findings presented here strongly support the second hypothesis (H2a).

Using rdti as a metric for technological innovation, this study reveals the positive effects of innovation-driven initiatives on the digital economy. Emphasizing the significance of promoting research and development activities and technological advancements as crucial elements in fostering the growth of the digital economy. In Table 7, the results confirm the importance of technological innovation programs in driving the growth of the digital economy and creating networks powered by innovative technologies. These findings provide valuable insights and lend support to the idea that technological innovation has a significant impact on the growth and development of the digital economy.

Table 8 displays the outcomes of the robustness test and the substitution of independent variables. For this analysis, we are using rfintech (Log (1 + rfintech_ix)) as a substitute for the original independent variables. Models two, three, and four have been re-estimated using the Instrumental Variables method, and the resulting outcomes can be observed in paths A, B, and C in Table 8. After analysing Table 8, FinTech has a major impact on driving the growth of the digital economy by promoting technological innovation and innovation-driven mechanisms. The findings strongly support the second hypothesis (H2), highlighting the positive correlation between FinTech and the digital economy.

Through the substitution of the original independent variables and the implementation of robustness tests, this study confirms the favorable impact of FinTech on the expansion and advancement of the digital economy. The results highlight the significance of utilizing financial technology to stimulate innovation and facilitate the growth of the digital economy. The results from Table 8 provide further support for the hypothesis that the incorporation of FinTech initiatives, along with the

Table 6
Projected results for intermediary variables reflecting technological innovation level.

Variables	A-Path	B-Path	C-Path
	Digital economy	Dti	Digital economy
fintech	0.2077*** (0.0147)	35.7421*** (1.8460)	0.1726*** (0.0016)
Dti	–	–	0.0013*** (0.0003)
Individual effect	Yes	Yes	Yes
Annual effect	Yes	Yes	Yes
Control variable	Yes	Yes	Yes
Observations	193	193	193
N	27	27	27
Adjusted R^2	0.5141	0.5226	0.6113
CD F-statistic	257.5371	3621.4100	243.3631

Source: *, **, and *** specify significance correspondingly at the 10%, 5%, and 1% levels.

Table 7
Robustness evaluation.

Variables	A-Path	B-Path	C-Path
	de	Dti	de
fintech	0.2101*** (0.0104)	0.0137* (0.11051)	0.2651*** (0.0086)
Dti	–	–	3.1321*** (0.9273)
Individual effect	Yes	Yes	Yes
Annual effect	Yes	Yes	Yes
Control variable	Yes	Yes	Yes
Observations	193	193	193
N	27	27	27
Adjusted R^2	0.5204	0.2716	0.5207
CD F-statistic	247.5510	3157.5001	239.5321
Critical value	9.2703	9.2703	9.2703

Source: *, **, and *** specify significance correspondingly at the 10%, 5%, and 1% levels.

Table 8

Robustness evaluations.

Variables	A-Path	B-Path	C-Path
	Digital economy	Dti	Digital economy
rfintech	0.9537***	73.7603***	0.5714***
	(0.0116)	(5.2100)	(0.0154)
Dti			0.0026***
			(0.0113)
Individual effect	Yes	Yes	Yes
Annual effect	Yes	Yes	Yes
Control variable	Yes	Yes	Yes
Observations	193	193	193
N	27	27	27
Adjusted R^2	0.6244	0.5413	0.6514
CD F-statistic	258.6451	943.4051	194.0721
Critical value	6.7351	6.7351	6.7351

Source: *, **, and *** specify significance correspondingly at the 10%, 5%, and 1% levels.

advancement of technological innovation, has a positive effect on the expansion and development of the digital economy (Sharma & Singh, 2018). These results emphasize the potential of FinTech in driving innovation and advancing the digital economy.

Examining the Impact of Moderating Variables and Financial Decentralization: When considering moderating variables, one must consider the introduction of financial decentralization (dfd) as a potential factor. Models two, three, and four are evaluated using the Instrumental Variables method, which leads to the identification of paths A, B, and C presented in Table 9. After analysing Tables 9, it becomes clear that the digital economy is greatly affected by financial technology (FinTech) due to the impact of financial decentralization. Based on the analysis, it is evident that the coefficient value of FinTech in the A-path is highly significant at the 5% level, suggesting a notable overall effect. In the B-path, the coefficient value of FinTech remains positive and statistically significant, providing further evidence of its impact. In addition, the coefficient value of the development of financial decentralization in the C-path is also positive and significant at the 5% level, indicating a moderating effect.

In addition, the coefficient value of FinTech in the C-path remains positive and significant at the 5% level. It appears that FinTech plays a role in reducing economic decentralization in local state governments, which in turn promotes the development of financial decentralization networks. FinTech plays a crucial role in driving the expansion of the digital economy. It achieves this by minimizing economic decentralization in local governments and promoting the development of financial

decentralization networks. This finding provides strong evidence for the validity of hypothesis two (H2b). To summarize, the findings from Table 9 confirm the impact of FinTech on the digital economy, while also emphasizing the influence of financial decentralization. The study highlights how FinTech plays a crucial role in driving the expansion of the digital economy. It achieves this by reducing the reliance on centralized financial systems in government entities and enabling the establishment of decentralized financial networks. These findings provide valuable insights into the relationship between FinTech, financial decentralization, and the expansion of the digital economy.

Table 10 displays the outcomes of a robustness test, where substitute moderating variables are used to assess models two, three, and four. The rdfd (Per capita expenditure of states/Per capita revenue assignments to a lower level of the public) is employed in this evaluation, and the Instrumental Variables method is utilized. The results of paths A, B, and C can be found in Table 10. After analysing Tables 10, it becomes evident that the emergence of financial technology (FinTech) poses difficulties for Indian state governments in their pursuit of financial decentralization. As a result, this contributes to the expansion of the digital economy and enhances the probability of networks becoming more centralized in terms of finance. As a result, the second hypothesis (H2b) is valid, demonstrating the significant influence of FinTech on the process of financial decentralization.

To summarize, the findings from Table 10, which were obtained through a robustness test with substitute moderating variables, provide additional support for the conclusion that FinTech plays a significant role in impeding financial decentralization among Indian state governments. These findings suggest that obstacles like these have a major impact on driving the expansion of the digital economy and enabling the creation of centralized financial networks. Thus, the study confirms the validity of hypothesis two (H2b) and enhances our comprehension of the intricate connection between FinTech, financial decentralization, and the expansion of the digital economy.

For this analysis, we utilized rfintech (Log (1 + rfintech ix)) as a replacement for independent variables, and performed a robustness test. After applying the Instrumental Variables method, models 2, 3, and 4 were reevaluated. This led to the discovery of paths A, B, and C in Table 11. Upon reviewing Table 11, we can identify several significant observations. First, the coefficient value of rfintech in the B-path is statistically significant at the 5% level. However, the value of the coefficient for DFD (development of financial decentralization) in the C-path is negative and does not show any significant impact. Nevertheless, the coefficient value of rfintech in the C-path demonstrates a positive significance at the 10% level. These findings suggest that financial technology, exemplified by rfintech, has a significant impact on propelling the expansion of the digital economy through the fractional intermediary

Table 9

Presents the Stability Assessment of Financial Decentralization as a Mediating Factor.

Variables	A-Path	B-Path	C-Path
	Digital economy	dfd	Digital economy
fintech	0.3151***	−1.0142***	0.3066*** (0.0125)
	(0.0204)	(0.2037)	
dfd			−0.1272***
			(0.1152)
Individual effect	Yes	Yes	Yes
Annual effect	Yes	Yes	Yes
Control variable	Yes	Yes	Yes
Observations	193	193	193
N	27	27	27
Adjusted R^2	0.4378	0.2153	0.5124
CD F-statistic	234.5101	3618.5531	227.5371

Source: *, **, and *** specify significance correspondingly at the 10%, 5%, and 1% levels.

Table 10

Robustness evaluations.

Variables	A-Path	B-Path	C-Path
	de	rdfd	de
fintech	0.3151***	−1.0563***	0.1572*** (0.0214)
	(0.0204)	(0.0413)	
rdfd			−0.1513***
			(0.1072)
Individual effect	Yes	Yes	Yes
Annual effect	Yes	Yes	Yes
Control variable	Yes	Yes	Yes
Observations	193	193	193
N	27	27	27
Adjusted R^2	0.4571	0.5334	0.5161
CD F-statistic	249.5101	2916.5531	218.5541

Source: *, **, and *** specify significance correspondingly at the 10%, 5%, and 1% levels.

Table 11
Robustness evaluations.

Variables	A-Path	B-Path	C-Path
	Digital economy	Dfd	Digital economy
rfintech	0.6189***	−3.2170***	0.9372***
	(0.1426)	(0.7531	(0.0115)
Dfd			−0.1013 (0.1130)
Individual effect	Yes	Yes	Yes
Annual effect	Yes	Yes	Yes
Control variable	Yes	Yes	Yes
Observations	193	193	193
N	27	27	27
Adjusted R^2	0.6212	0.3255	0.6244
CD F-statistic	317.0641	835.5731	293.6451

Source: *, **, and *** specify significance correspondingly at the 10%, 5%, and 1% levels.

effect of DFD and the economic efficiency effect. Thus, we can assert a robust conclusion (b) based on these findings.

In summary, the study affirms that Financial Technology (FinTech) plays a crucial role in driving the growth of the digital economy. It does so by promoting networks driven by innovation and improving financial efficiency. These conclusions hold strong even when replacing moderating variables and independent variables. The findings underscore the vital role of FinTech in shaping the digital economy and stress the significance of considering both technological innovation and financial efficiency in the analysis.

5. Conclusion

Utilizing our theoretical framework and examining a balanced panel dataset of 28 Indian states from 2010 to 2022, this study utilizes a two-way fixed-effect model that includes both time and individual effects. Our goal is to thoroughly examine the impacts and underlying processes of FinTech on the digital economy. Our research reveals a strong and favorable correlation between the growth of FinTech and the development of the digital economy. It is interesting to note that there is a strong correlation between the growth of FinTech and the development of the digital economy. For each percentage point increase in FinTech development, we can expect to see a corresponding 0.1471 percentage point increase in the digital economy. These results mirror the conclusions made by (Patel & Wang, 2020), who found that financial development stimulates economic growth. In the world of finance, the seamless combination of artificial intelligence, blockchain, cloud computing, and big data has given rise to FinTech. This integration has also had a significant impact on the overall economy, shaping what we now know as the digital economy. Therefore, the correlation between FinTech and the digital economy reflects the connection between financial development and economic development.

It is important to recognize that the influence of FinTech on the digital economy is complex and reaches through different avenues. Our study solely focuses on the technological innovation channel and the role of state governments' financial decentralization, which does present a limitation. In addition, our analysis solely focuses on Indian states, without considering broader cross-country comparisons, which is another limitation to consider. Future research directions should include a more thorough investigation of the different ways in which FinTech impacts the digital economy, both within India and internationally.

6. Discussion on limitations

The article may face limitations due to potential biases in data collection. When the data is based on self-reported surveys or interviews, there may be concerns about the accuracy and completeness of the information provided by respondents. This could be influenced by social desirability bias or memory recall errors. In addition, if the data collection techniques show a preference for certain demographic groups or locations, it may lead to sample biases, which could restrict the relevance of the findings to a wider population. There may be potential biases in the paper due to the analytical techniques employed. For example, if the analytical models are built on assumptions that do not apply to the Indian context or if they fail to adequately consider confounding variables, the findings might be distorted or misleading (Kumar & Gupta, 2021). There may be another limitation that arises from the contextual biases that are present when studying the effects of fintech on the digital economy in India. It is important to consider that the findings may not apply universally to other countries or regions, as there are distinct cultural norms, historical backgrounds, and legal systems that are specific to India.

The paper's findings may have limited applicability due to its narrow focus on the Indian context. Although the findings provide valuable insights into the fintech landscape in India, it is important to consider that they may not be directly applicable to other countries. This is because different socio-economic conditions, regulatory frameworks, and technological infrastructures can greatly influence the outcomes. In the end, the study's findings could be affected by restrictions regarding the availability and precision of the data. If the data sources are outdated, insufficient, or unreliable, it could compromise the validity of the analysis and conclusions. In general, the paper offers valuable insights into the influence of fintech on India's digital economy. However, it would be advantageous to conduct a more thorough investigation into its limitations, specifically regarding any potential biases that may arise from the methods used for data collection and analysis. Taking these constraints into consideration would greatly improve the credibility, comprehensiveness, and relevance of the study's findings.

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No competing interests.

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