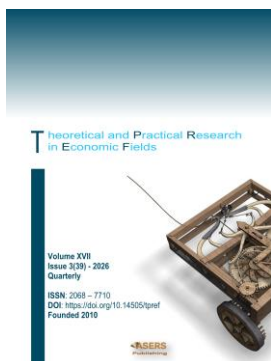


Digital Transformation and Economic Growth: A Case Study of India



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Abstract: The relationship between Digital Transformation (DT) and economic growth is a subject of intense debate. Defined broadly, DT means the development (or integration) of digital technologies with other economic activities, intended to improve productivity, efficiency and governance. In the last decade, Indian economy witnessed a paradigm shift in the development and diffusion of DT, driven by a series of policy initiatives viz. Aadhar, DigiLocker and BharatNet. Further, at a macro level, emergence and convergence of new technologies in the form of Artificial Intelligence (AI), Blockchains, cloud computing, Internet of Things (IoT) etc., are not only reshaping the industrial structure but also creating new business models of production, information, consumer preferences or the delivery system (like online payment, e-commerce and E-Governance). The very foundation of 4IR (4th Industrial Revolution) rests on the DT directly and indirectly. Given the unprecedented growth and development of DT, the paper attempts to understand the theoretical relationship between DT and economic growth by identifying various channels and mechanisms through which the relationship works. The theory is further corroborated by empirical evidence from advanced countries across different time periods. Given this, the study delves deeper into drawing inferences about the relationship in case of the Indian economy, the fastest emerging economies in the world. The time period considered is since 1991, i.e. the period of economic reforms leading to the emergence of DT.

Keywords: digital transformation; growth; productivity.

JEL Classification: O14; O3; O36; O40; O43; O49.

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Introduction

There is no universal definition of Digital Transformation (DT). It means different things to different people, groups, or organizations. Broadly speaking, it connotes the integration of digital technologies into economic activities to improve productivity, efficiency, and governance, thereby reducing (or eliminating) transaction costs. In the last two decades, economies around the world have witnessed a paradigm shift in the growth, scale or composition of the digital economy. According to the World Bank (2025), the size of the digital economy stood at 15 per cent of Global GDP in 2024, amounting to US\$16 trillion out of US\$118 trillion in Global GDP. AI, an integral part of DT, offers unprecedented potential to expand access to services, enhance workers' and businesses' capabilities, boost productivity, and open new economic pathways towards growth and economic development.

India is at the forefront in the adoption and development of the DT. For instance, the contribution of the digital economy has increased exponentially from 11.74 per cent of GDP in 2022-23 to 13.42 per cent in 2024-25 (GOI, 2026). Or, in comparative sense, as high as the contribution of agriculture sector in total GDP of the country. Among others, the leading carriers of DT includes: internet connections (it was 25.14 crore in 2014 and reached 96.96 crore in 2024); UPI transactions (1867.7 crore in number, amounting to Rs. 24.77 lakh crore in April 2025); and high-speed internet connected with 2.18 lakh Gram Panchayats, the report further added. New technologies

viz. AI, IoT, blockchain, and cloud computing, etc. are fast emerging as the backbone of DT; these are not only reshaping the industrial landscape but also creating new business models for information, production, consumption, and delivery systems (such as online payments, e-commerce, e-governance, etc.). Eventually, the very foundation of 4IR (4th Industrial Revolution) rests on DT. From the theories and empirical evidence, various key channels and mechanisms are identified that explain why and how the rise in DT contributes to economic growth of an economy. Reduction in transaction costs, containing asymmetric information are among the important channels leading to higher productivity and balanced regional development of a country. For developing countries like India, studies are, however, far fewer in number.

The paper attempts to fill the gap by establishing the fact that rise in DT goes hand in hand with economic growth by fostering various backward and forward linkages. It begins with the review of literature, referring to established empirical studies on the role DT plays in economic growth. After it, the research methodology is given. Thereafter, the paper gives the growth trends of the constituents of DT in Indian economic growth. It follows by discussion, which is mainly based on the importance, limitation, and scope for further research. And, finally, the conclusion on how DT is important for Indian economic growth.

1. Literature Review

DT refers to the creation of information systems, which leads to reduced, minimal, or no transaction costs for firms, providing them with a competitive advantage (Zheng, X., Zhang, X., and Fan, D., 2023). For instance, in manufacturing, DT creates new or upgrades old industrial structures and industrial chains (Prokhoruk, *et. al.*, 2025). Another unique feature of the DT is that it promotes the integration of the manufacturing and service sectors, or the creation of more service-oriented manufacturing sectors. For instance, DT has fundamentally redefined automotive industrial production processes, shifting from traditional labor-intensive methods to intelligent, connected, and highly automated assembly lines powered by AI, IoT, and robotics. The evolution has shifted the value chain from heavy hardware manufacturing to a software-defined ecosystem, increasing operational efficiency and enabling mass customization. For instance, technology is growing in scale and size, leading to lower production costs by enabling digital transformation and skilled labor (Cherba, Vita, *et. al.*, 2025).

DT of the economy catalyze immense opportunities in various areas; innovations, health and education, management, lifestyle (Mühleisen, 2018). The world has gone massive digital shift in data, i.e. less than 1% of the technological processed information was in digital form in the 1980, it reached more than 99% in 2012 (Hilbert 2020). Humanity now generates more new knowledge every 2.5-3 years than it was before the dawn of new civilization (UNCTAD, 2019). Digitalization acts as a significant catalyst for economic growth but its actual influence varies as per research, methodology and geographical context (Molinari, Torres, 2018; Solomon, van Klyton, 2020). Some studies indicate that this trend significantly alters the labor market, driving down the demand for routine work and low skilled workers (Peetz, 2019). Digitalization significantly alters the business models, management customers relations, which further improve the business efficiency (Ritter, T., and Pedersen, C., 2020). To understand the economic impact of digitalization, in a special survey of leading Eurozone companies, which highlights the urgent need to adapt a statistical system to the rapid technological changes (Elding, C., and Morris, R., 2018). DT in the economy signify a comprehensive process reshaping organizational and economic system through the strategic integration of digital technologies, which is not limited to adopting new tools but also involves holistic shift in business models, strategies, long run competitions terms with a digital connect of ecosystems (Cichosz *et al.*, 2020). In a digital transformed economy, digitalization is reinforced by financial and economic integration through digital communications, accelerate money- commodity relations, lowers transaction costs, and increases security and efficiency of financial exchanges (Li *et al.*, 2022). DT boosts operational efficiency and agility through streamline the workflow, automation process, and optimizing supply chains. This reduces transaction costs and enhances responsiveness to the dynamic market conditions (Omol, 2024). Further there is a series of empirical studies that conclude on the positive role of technology (DT) in economic growth (Grinin and Grinin, 2021; Schaller *et.al.* 2022; David, *et.al.* 2025; and Hermawan, *et. al.* 2025).

2. Digital Transformation and Economic Growth: Theory, Channels and Mechanisms

Towards the relationship between DT and economic growth in India, secondary data sources are used. Among other, it mainly includes, Annual Survey of Industries, commonly known as ASI, PROWESS database of CMIE (Centre for Monitoring the Indian Economy), Economic Survey, WDR (World Bank Reports), etc. Labor productivity is measured as output (GDP) employment ratio. Given the definition of DT, its various constituents included are: tele-density, internet-density, ICT intensity, FDI in ICT sector, E-Commerce, E-Governance, etc. The following is the basis of the relationship between DT and economic growth in India.

2.1 Periods of Kondratiev Wave (K-Waves)

The main inspiration of the research is drawn from Kondratiev Wave (K-Waves), which lasts for 40-60 years. Intrinsically, each upturn in the 'K Wave' is marked by the adoption of transformative technologies such as the Steam Engine, Electricity, ICTs (Information and Communication Technologies), followed by its maturation (or stagnation) until the next technological revolution takes place. Post-ICTs, AI led DT forms the K-Waves. Table 1 illustrate 6 cycles of rise and depression over the period from 1790 to 2030. DT is an integral part of the Cycle 6.

Table 1. Periods of Kondratiev Wave (K-Waves)

Cycle	Wave	Periods
Cycle 1	Ascending Wave	1780 to 1810-17
	Descending Wave	1810-17 to 1844-51
Cycle 2	Ascending Wave	1844-51 to 1870-75
	Descending Wave	1870-75 to 1890-96
Cycle 3	Ascending Wave	1890-96 to 1914-20
	Possible Descending Wave	1914-20 to 1928-33
Cycle 4	Ascending Wave	1928-33 to 1925-65
	Descending Wave	1925-65 to 1971-75
Cycle 5	Ascending Wave	1971-75 to 2007-08
	Descending Wave	2007-08 to 2014-15
Cycle 6	Ascending Wave	2014-15 to 2025-30
	Possible Descending Wave	2025-30

Source: Dudin, M., Levina, E., Alferov, V., & Zasko, V. 2020. ND Kondratiev's long wave theory and modernity: the digital age. *Revista Inclusiones*, 380-394.

2.2 Theories and Relevance for DT and Growth

As we know, a number of theories exist on how DT affects growth. The theories are listed and summarized below in Table 2. For the research on India, eight such theories are identified that form the basis of the impact of DT on economic growth in India.

Table 2. DT and Economic Growth: Various Theories

No.	Theory and Growth Model	Relevance to DT and Growth
1	Schumpeter 'Kondratieff Wave' of	Rise of tele-density, internet density, etc. means high productivity led growth
2	Innovation Cycle Theory	DT Productivity led growth
3	Endogenous Growth Model	Digital Innovation Drives Long Term Growth
4	Resource Based View	DT as a Key Economic Resource
5	Network Effect	Value Creation via Expanding Digital Platforms
6	Structural Transformation	Shift Industrial Structure to Higher Value Activities
7	Ecosystem/Cluster Approach	Shifts Industrial Structure to higher-value activities
8	Sustainable Development	Growth with social and environmental outcomes

Source: Wang, Fengyi. 2025. Digital Transformation and Economic Development: A Comparative Study of Emerging and Developed Economies. *Development Economics of China* 9 (1), 100-104.

2.3 DT and Economic Growth: Channels and Mechanism

These theories in turn give rise to different mechanism or channel, which assign different role to technology as a source of productivity (or growth). In the paper, eight such channels and mechanisms are identified, through which DT translates into higher economic growth. It mainly includes infrastructure, productivity, financial inclusion and investment, etc. The complete list of the channels and mechanisms, along with their likely economic impacts is given in Table 03 below.

3. DT and Economic Growth: Channels and Mechanisms

No.	Channels	Mechanism	Economic Impact
1	Infrastructure and Connectivity	Expansion of broadband, mobile penetration and cloud services.	- Broadband, mobile penetration and cloud infrastructure are backbone of digital transformation. - Without a reliable connectivity, advanced technologies (AI, IoT, blockchain) cannot scale. Reduces transaction costs, integrates rural and urban economies, boosts GDP growth.
2	Increase productivity	Automation, AI, IoT, and Data Analytics Streamline Process	- Cloud computing advanced networking enables firms to adopt automation, data analysts and work in remote areas. - All these are infrastructure base which enable real time supply management and reducing inefficiencies. - Higher output per worker, improved competitiveness, costs savings
3	Financial Inclusion	Mobile Banking, Digital Fintech Solutions, etc.	Digital payments and fintech (UPI in India), internet connectivity, mobile penetration expands banking services in remote areas which further expands consumption and investment.
4	Governance & Public Services	E-Governance, Digital IDs, Online Delivery, etc.	- Digital infrastructure helps government to provide fast and good governance and services through digital IDs, e governance portals and online deliveries; these services help to provide financial helps to the needy without any linkages. - For example: in India Bharat Net Project aims to connected 250,000 Grampanchayats with fibre optic broadband, enabling rural digital inclusion
5	Trade and Global Integration	E-Commerce, Digital Supply Chains (DSCs)	- Digital infrastructure integrates SMEs in to global value chain through e-commerce platform. - It invites FDI in digital industries and creates development and growth
6	Sustainability and Green Growth	Smart Grids, Digital Monitoring	Digital infrastructure helps to optimize the resources use through digital energy management which further helps in green growth.
7	Human Development	Online Education and Skills	Improve skills, inclusive finance and job quality
8	Investment and Capital Deepening	Increase in ICT intensity, Automation, Robotization, etc.	Boosts fixed assets, private enterprises and ICT infrastructure, with 10% broadband penetration yielding 1.59% GDP per capita growth

Source: Own formulation using Kaggwa et al., 2023; and Wang, 2025.

3. Research Methodology and Data Source

To establish, how DT affects economic growth in India, the secondary data sources are used. It mainly includes, Annual Survey of Industries (ASI), PROWESS database of CMIE (Centre for Monitoring the Indian Economy), Economic Survey of the Government of India (GOI), WDR (World Bank Reports), among others. Labor productivity is measured by the ratio of gross output (Gross Domestic Product) and employment. Given the definition of DT, its various constituents viz: tele-density, internet-density, ICT intensity, FDI in ICT sector, E-Commerce, E-Governance, etc. The time period taken into account is 2000-2025, i.e. the post economic reforms period.

$$Q = f(DTI) \quad (1)$$

$$Q_t = \alpha_0 + \alpha_1 DTI_t + u_t \quad (2)$$

Q_t stands for gross GDP for any given point of time (t) and DTI_t is the Digital Transformation Index at time t; it consists tele-density, internet-density, ICT intensity, E-Commerce, FDI in telecommunication, and E-Governance. All the variables taken into account are given equal weightage (1/6) i.e. (1/6*6=1). By definition, the summation of weights is equal to one.

4. Results

SUMMARY OUTPUT								
Regression Statistics								
Multiple R		0.92304603						
R Square		0.85201397						
Adjusted R Square		0.84584789						
Standard Error		48.6077812						
Observations		26						
ANOVA								
	df	SS	MS	F	Significance F			
Regression	1	326474.178	326474.178	138.177472	1.9137E-11			
Residual	24	56705.1934	2362.71639					
Total	25	383179.371						
	Coefficient	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	178.402824	11.6256262	15.3456529	6.604E-14	154.408711	202.396937	154.408711	202.396937
DTI	0.067081	5.7067E-05	11.7548914	1.9137E-11	0.00055303	0.00078859	0.00055303	0.00078859

The regression co-efficient value (0.06), indicating the direction and size of relationship between DTI and GDP, means if the DTI goes up by 100 points, the GDP increases by 0.06 point. Given the t-value and P values, the results are found to be statistically significant; and fitting perfectly in line with theory or empirical studies on the relationship between DT and growth in case of the advanced countries. Given this, it can be concluded that DT has affected the Indian economic growth positively during the reference period (2000-25). The results have direct policy implications, it is highly required to enhance the value of DT, through enhanced investment in DT infrastructure, required to achieve targeted economic growth.

5. DT Policies and Performance of the India Economy

Given no universal definition of DT, a number of parameters are taken as constituents of the DT in India. Among others, it majorly includes tele-density, Internet density, ICT intensity, FDI in ICT, E-Commerce and E-Governance. Over the years, the Indian government have come up with various initiatives, which directly and indirectly helped in the promotion of DT (through tele-density and E-Commerce and E-Governance) in the country. The detail of such initiatives is provided below in Table 4.

Table 4. The Digital Transformation (DT) Policies in India

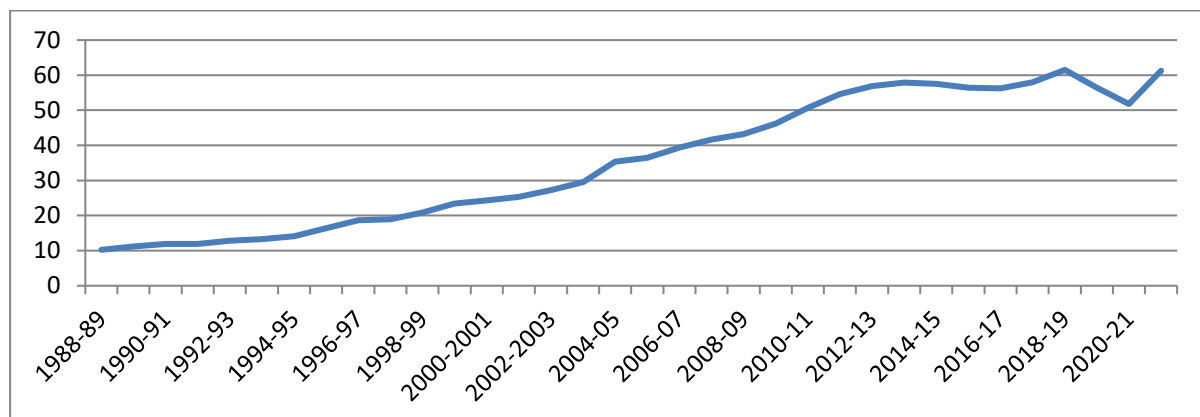
No.	Initiatives	Description	Current Status
1	Aadhar Number	Launched in 2009 to give all Indian citizen with a unique identity called as Aadhar number.	As per the records of (UIDAI) Unique Identification Authority of India on September 2025 more than 1.425 billion citizens are possessing Aadhar number.
2	Digilocker	Introduced in 2015 to create a cloud-based platform to deliver, exchange and verify important documents/certificates.	According to records on September 2025, India has 59.72 crore registered Digilocker users.
3	MyGov	Brought in 2009 by the government to engage citizens in policymaking through an interface (online form) for inviting their ideas.	By September 2025, MyGov has more than 30 million registered members.
4	Bharat Net	Launched in 2012 and renamed in 2015 to connect 2.5 lakh Gram Panchayats and give them 100 Mbps Internet facility.	By May 2025, 2,14,325 Gram Panchayats were connected under Bharat Net projects.
5	Smart Cities Mission	It was introduced in 2015 aimed to transform cities in to smart cities with the initiatives of various technologies.	As of July 2025, 91% of project is completed with 100 cities having significant progress.
6	Common Service Center (CSC)	CSCs aimed to established a self -sustained network for Gram Panchayats under Digital India initiative. It was initiated by the Department of Electronics and Information Technology.	On February 2025, there were 5,82,121 active centres.
7	Digitalization of Post Offices	Under Digital India scheme, government is aiming to transform approximately 15,000 post offices into multiservice.	By September 2025, India Post Payment Bank (IPPB) having over 12 crore) customer operations under 1.64 post offices and 190 lakh postmen. It is operating with billions of transactions to increase financial inclusion.
8	Universal Access to mobile	It was introduced to give mobile connectivity villages in India	By September 2025, more than 6.29 lakh villages were covered with mobile and internet connectivity.
9	Public Wi-Fi Hotspots	It was meant to develop Wi-Fi hotspots to allow people to use internet without mobile data.	By September 2025 in India, public Wi-Fi hotspots were 3,73,000 which was less than the target of 10 million in 2022 and 50 million by 2030.
10	India Stacks	India Stacks as introduced to aim at paperless and cashless digital services through using Aadhar.	JAM (Jan Dhan Aadhar Mobile) is being used to provide direct benefits transfer services.
11	PM Sakshrata Abhiyan	It was introduced in 2017 to provide digital literacy in rural area with the aim to cover more than 6 crore people in rural area by March 2020 with the target of one person from each eligible household.	By March 2025, the number of beneficiaries were recorded were 7,35,71,963.
12	E- Health	It was initiated to give effective and timely health related services like online registration, paying bills, receive reports, and ask any query.	By October 2025, it created more than 85 crore Ayushman Bharat Health Accounts.
13	E-Education	It was introduced to give education in remot and rural areas through online platform by the use of new technologies like apps, smart phones.	In May 2020, E-VIDYA, program was launched for multimode access of online education. As on October 2025, 565.12 cr. Learning sessions were imparted through DIKSHA. It is having 18.33 cr. enrolments and 14.62 cr. course competition.

Source: India Brand Equity Foundation, GOI, 2025.

6. Research Results

As mentioned above, DT and economic growth go hand in hand. It becomes imperative to analyse how DT drives economic growth in the Indian economy. Let us try to understand it with the following illustrations. Starting with labour productivity, as shown in Figure 1, it has increased manyfold since 1990. It was estimated at Rs. 10 lakh per annum in 1989-90, rising to over Rs. 60 lakhs in 2020-21, i.e., a six-fold increase. It is remarkable by any standard of growth and productivity. However, it is cumbersome to disentangle (or quantify) the impact of DT on economic growth.

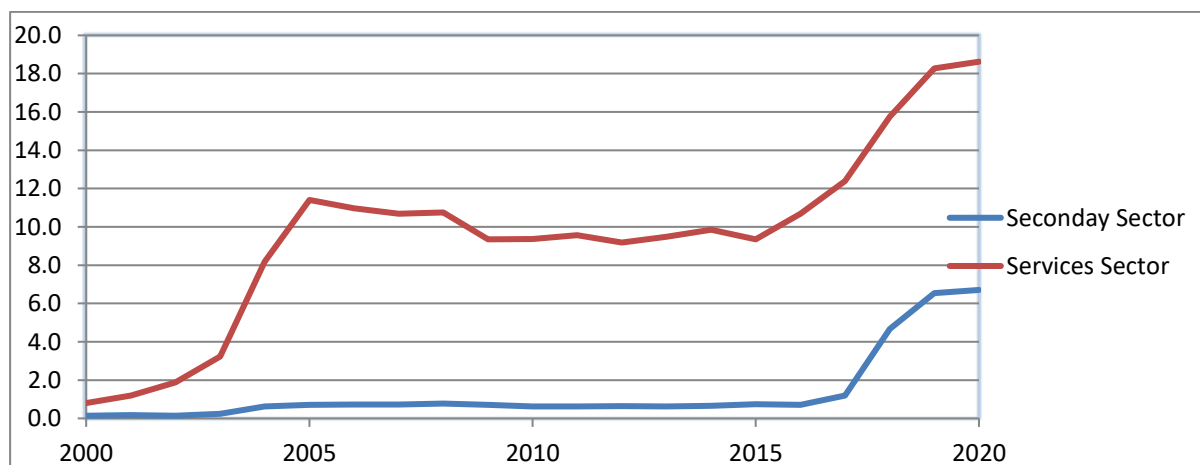
Figure 1. Labor Productivity (Output per unit of Labor) in the Organized Sector in the Country (Rs. Lakh).



Source: Own Computation using the ASI database from GOI, 2025.

ICT intensity (ICT as a percentage of non-ICT capital), an important and integral component of DT, has exhibited a remarkable upward trend since 2000 across both the secondary and services sectors of the economy. It rose from a humble level of nearly 1 per cent to around 20 per cent in 2020. In the services sector, it was far higher than in manufacturing. See Figure 2 for more details. There are numerous empirical studies that conclude that ICT plays a positive and significant role in growth and productivity in advanced countries and in India (Kumar and Kumar, 2020).

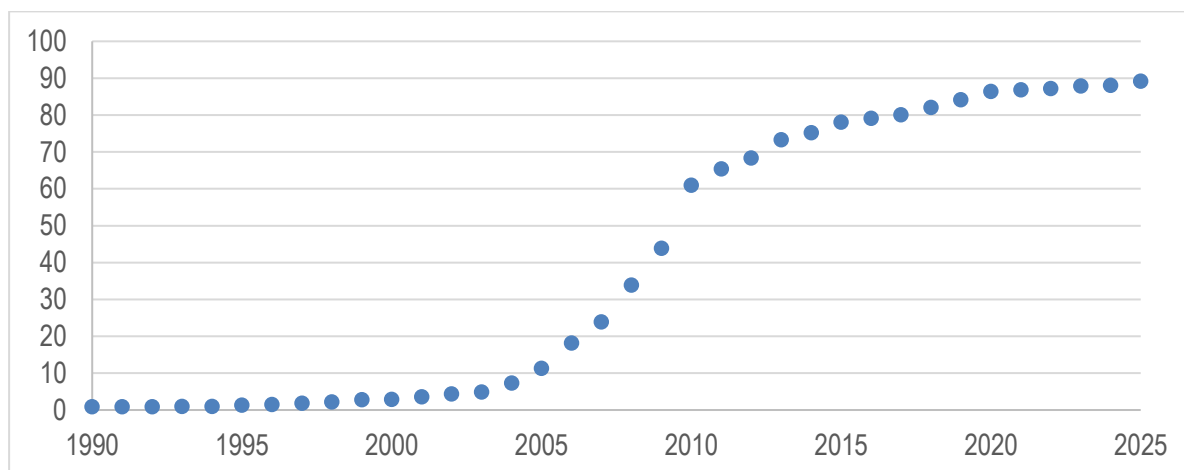
Figure 2. Change in ICT Intensity (ICT as % of Non-ICT Capital) in Secondary and Services Sectors in India during 2000-2020



Source: Own Computation using the PROWESS database of CMIE, various years.

Tele-density (the number of telephones per 100 population) is another important component of DT. The higher the tele-density, the more the DT. As shown in Figure 3, tele-density has increased exponentially from a nearly zero level to as high as 90, and even close to 130 in urban areas.

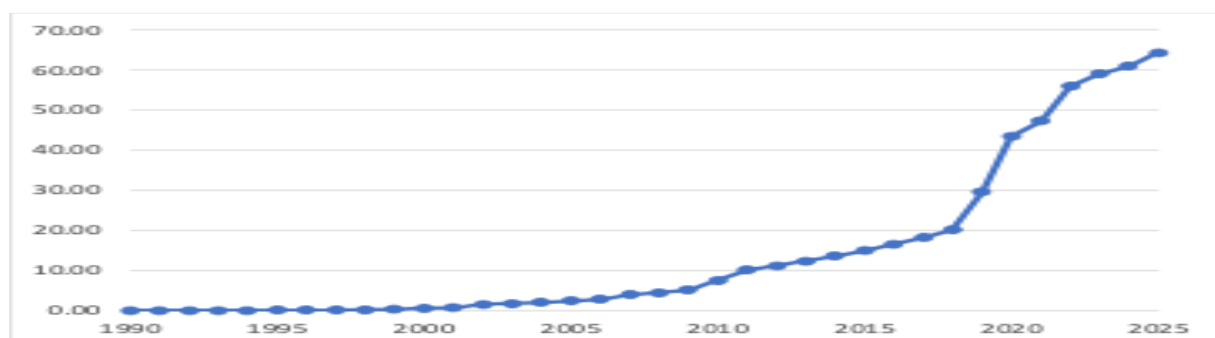
Figure 3. Tele-density in India (1990-2025).



Source: TRAI Report, GOI, 2023-24.

The rise in internet density is therefore regarded as the leading cause of the increase in DT in India. As shown in Figure 4, internet density (number of internet connections, wired and wireless, per 100 population) has increased exponentially for the country as a whole, something remarkable for a developing country like India. Again, numerous studies discuss its positive, significant role in productivity-led growth in developed and developing countries, including India. Another important question is how internet density, an important constituent, helps the DT affect productivity and growth in India.

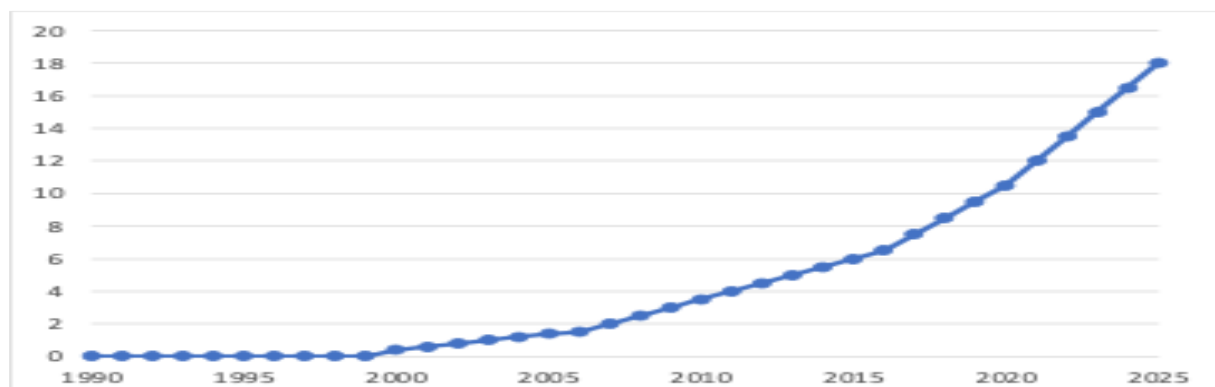
Figure 4. Internet-density in India (1990-2025).



Source: Government of India (GOI). 2023-24.

Attracting more and more FDI has been an integral part of the economic reforms process since 1991. It is well documented FDI is an important channel for technology transfer through machinery, ideas, automation, and Fintech, among other areas; and hence an important source of economic growth for any developing countries like India.

Figure 5. FDI (US\$) in India (1990-2025).



Source: UNCTAD. 2024.

As evident in Figure 5, the Indian economy witnessed an increasing trend in FDI inflows into the ICT sector, rising from nearly zero in 1990 to nearly USD 18 billion. It is contributing significantly to DT in the country.

The other factors contributing to DT are the rise in E-Commerce and E-Governance; the details are given in Fig. 06 and Figure 7, respectively. For instance, from 1990 to 2012, the size of E-Commerce was nearly negligible but rose to USD 140 billion in 2025, maintaining a consistent rise over the years. Post-2012, it increased by leaps and bounds, thereby contributing significantly to DT's growth nationwide. Coming next to E-Governance, in terms of the E-Governance Index (EGI), India has maintained a consistent rise; particularly post-2012, it has increased from 0.40 to 0.67 in 2025. It is entirely due to proactive government policies as mentioned above.

Figure 6. Size of E-Commerce in India (1990-2025), in US\$.



Source: E-commerce in India.

Figure 7. E-Governance Index in India (2003-2024).



Source: UN E-Government Knowledgebase, 2024.

7. Discussions

Given the functioning of various channels and mechanisms, there now exists a well-established theoretical construct, how DT and economic growth are related. Empirically, N.D. Kondratiev analyzed various economic indicators from European countries in the 1920s and developed the theory on long-term economic fluctuations (duration 40-60 years), ascribing technology as one of the key factors of fluctuations. Following suit, emerging economies, viz. India, caught pace with developed countries both in terms of technology (tele-density, internet, ICT, etc.) productivity and growth, i.e. so-called catching-up theory of development (Piketti, 2022). In addition to this, the empirical studies established the deterministic role of DT in the process of growth and development, following the channels and mechanisms mentioned above. Today, India, after maintaining a consistent high growth rate, has emerged as the fourth largest economies of the world after US, China and Germany. All the constituents of DT exhibit remarkable progress over the period of time (2000-25), be it tele-density, internet-density, ICT density, E-governance and E-commerce, all the variables and eventually the DTI rose exponentially. The pertinent question, how it affects economic growth, is taken up as an empirical study for the Indian economy. The results, i.e. regression co-efficient of the DTI, positive and significant (0.06) means the impact of DT on economic growth is not only falling in line with 'theory' but also in 'practice' i.e. proved empirically in studies for the developed countries. On the policy front, the results would be integral to and one of the guiding principles for the 4IR, i.e. India cannot afford to ignore the growing importance of DT in the 4IR.

Conclusions

Over the last two decades, ICT-driven DT has emerged as a catalyst for social and economic changes. No single policy drives economic growth; rather, it is a comprehensive, coordinated approach that fosters innovation and future-ready conditions. While advanced countries (OECD members) are already benefiting from appropriate policies that enhance their productivity factor and business environments to fully exploit the potential of DT. On the same line, India introduced series of sweeping reforms to develop and gain from the DT. Empirical evidence largely mark convergence to conclude on the 'positive and significant' impact of DT on the productivity led growth by the development of digital markets leading to least (or no) transaction costs and bridging asymmetric information, the very foundation of imperfect market behavior. However, studies at the firm level establish that DT is not a 'standalone solution' for development but also requires comprehensive changes in how firms, industries, or the country as a whole work in a cohesive way.

In case of the Indian economy, the trends on growth, productivity and the various DT constituents, allow one to draw the following conclusions. First, the size of the digital economy has increased exponentially, but given the size and scale of the economy, there exists enormous potential from DT. Second, given the rise in tele-density and internet density, DT (E-commerce) has huge scope of growth in semi-urban and rural areas. Third, ICT intensity has though increased significantly over the years, again there lies a huge scope of growth in SMEs (Small and Medium Enterprises) firms, leading to increased productivity. Fourth, similarly, E-Governance, an important and integral part of DT, has enormous scope and potential to grow further, given the futuristic and proactive government approach (policies) leading to a series of public services poised to go online (not yet covered). Fifth, DT promotes financial inclusion (by area, region, gender, class, caste, and religion), imperative for sustainable DT-led growth and development. Sixth, technological changes in the form of AI, ML, IoT, etc., driving the DT (or the founding pillars of 4IR), are not only steering the global order but also making emerging countries viz. India has a huge potential of gain.

Declarations

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Credit Authorship Contribution Statement:

Anita: Conceptualization, Methodology, Software, Formal Analysis, Writing-original draft, Data curation, Validation, Writing-review and editing, Visualization.

Manju Dahiya: Conceptualization, Methodology, Software, Formal Analysis, Writing-original draft, Supervision, Data curation, Validation, Writing-review and editing, Visualization.

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

Declaration of use of generative AI and AI-assisted technologies: The authors declare that they have not used generative AI.

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