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Digital Tax Intelligence: Emerging Technologies Transforming GST Compliance and Indirect Taxation in India

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Abstract- The Goods and Services Tax system introduced in India from July 2017 is among the most ambitious experiments in digital tax administration in the world. This paper explores the influence of new technologies such as artificial intelligence, machine learning, blockchain, and API on compliance and governance of indirect taxes in India. Through the analysis of reports, official records, and scholarly articles published between 2021 and 2026, the research considers the technological infrastructure of the GST Network, the mechanisms of algorithmic risk assessment, and the prospects of using distributed ledger technology for the verification of invoices and input tax credit reconciliations. The research traces the development from rule-based digitalization to intelligence-based compliance in which the role of predictive analytics and network analysis increases. However, some governance issues remain unattended, including algorithmic transparency and the problem of digital divide faced by small taxpayers.

Keywords- Goods and Services Tax, Artificial Intelligence, Blockchain, Tax Compliance, Digital Governance, India

I. Introduction

The introduction of the Goods and Services Tax (GST) in India on 1 July 2017 marked a rupture in India's indirect tax structure by replacing a mosaic of central and state taxes with a unified destination-based value added tax structure. What

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differentiated the Indian GST system from other value-added tax systems was the idea behind its creation as a "technology-first" tax system, where from the moment of registration till the submission of returns and refunds, everything could be done using digital means, rather than paper [4]. The establishment of the Goods and Services Tax Network (GSTN), a not-for-profit company, equally controlled by the central and state governments, provided the information technology backbone for the system that processes over a billion invoices per month for more than one crore registered taxpayers [4][6].

GST's early days in terms of its functioning were marked by a rule-based method for checking compliance. The mismatch report was created through a deterministic algorithm between GSTR-1 (outward supplies) and GSTR-3B (summary returns), while the e-way bills tracked the physical flow of goods above certain monetary thresholds. Despite creating unparalleled transactional details, the analysis of these tools was quite basic. However, as time progressed and more and more data began accumulating, it became clear that the rule-based system had some flaws in it, including tax evaders circumventing certain thresholds as well as honest taxpayers being unfairly scrutinized because of innocuous mismatches [2][3][4].

The post 2021 period saw a paradigmatic change in terms of intelligence-based tax administration. Machine learning models were gradually implemented by CBIC and GSTN for purposes such as risk scoring, network analysis for circular trade and fake registrations and predictive analytics for forecasting of revenues [2][6]. The BIFA was used to combine the data from GST returns, e-way bills, e-invoices, income tax returns, customs and bank records to create comprehensive risk profiles [2][6]. The special campaign against fake registrations, which was launched between May 2023 and 2024, uncovered more than 29,000 cases of fake GST registrations, with fake claims of input tax credit worth nearly ₹25,000 crore, and wherein algorithmic detection served as critical evidence [2].

In line with the above innovations in AI and analytics, blockchain technology has increasingly been considered a solution to the trust problems that are an inherent feature of a centralised tax management system [8][10]. It has been argued that the centralised nature of GSTN makes it prone to issues related to downtime, opaqueness in the

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enforcement process, and data tampering. In blockchain-based solutions, the idea is to create a distributed ledger that would have taxpayers, tax departments, and financial institutions linked, along with smart contract-driven invoice authentication and ITC reconciliation [8][10]. Studies carried out on the Hyperledger-based GST prototypes indicate that while blockchain is more costly than centralised systems in terms of performance, proper consensus protocols can deliver the required transaction rate [1][8][10].

In this paper, government documents, scholarly studies, and policy analyses are synthesised to evaluate the current status and future direction of digital tax intelligence in India's GST framework. The discussion is undertaken through an ordered exploration of the technological platform used, the techniques of analysis, the outcomes that have been achieved empirically, and the governance issues related to algorithmic enforcement. The main contention made in this paper is that India has moved past a phase where digitalization was the process of changing paper procedures to electronic procedures and towards a stage where machine learning algorithms inform the enforcement strategy [2][4][6].

II. Literature Survey

There has been substantial development in academic research on the GST and digital taxation in India since 2021 [3][4][10]. There are three major streams that have emerged in this body of research literature: studies relating to the impact of digitalization on compliance and revenue; studies related to the technological issues such as blockchains and AI architecture in tax systems; and critiques of governance and equity issues [3][5][8][10].

Several empirical studies on GST compliance outcomes have pointed out the importance of digitalisation infrastructure as a critical determinant of revenue outcomes [3][4][5]. For instance, Garg et al. (2023) using panel regression analysis in Indian states established that standardisation of invoices and their automated verification led to less tax avoidance, despite the compliance costs incurred by small businesses during adaptation. In support of the above studies, Dandona et al. (2024) showed that the level

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of compliance was much higher in jurisdictions having more advanced digitalisation infrastructure, suggesting appropriate policy interventions to reduce the digital divide. The link between digitalisation and revenue buoyancy was explored in research conducted in 2026 where mixed methods analysis was carried out to investigate why better understanding from technology does not necessarily imply better revenue outcomes [5]. From a taxpayer viewpoint, Shacheendran (2024) used interpretive structural modelling and established that IT infrastructure and manpower were root barriers to compliance with GST, with most of the sampled businesses indicating a lack of familiarity with e-invoicing and difficulty in e-way bill creation.

However, a significant body of technical literature about the use of blockchains in GST has emerged although much of it is still experimental [1][8][10]. The performance analysis of a blockchain-based GST system with Dynamic Priority-Based Leader Election (DPBLE) by Aar and Thakur (2026) showed that while the centralised system offered higher throughput and lower latency, the DPBLE blockchain system outperformed the Raft-based blockchain system by 22% throughput and 1,332 milliseconds mean time to recovery in six nodes failure situation, demonstrating its viability for systems with an emphasis on both availability and trust [1]. Another paper presented at an IEEE conference (2025) suggested a blockchain-based GST filing mechanism for small businesses through a permissioned blockchain network with smart contracts to automatically validate and detect anomalies, arguing that decentralisation might help reduce the dependency on third-party intermediaries and cut down compliance costs for resource-limited companies [8]. On the other hand, Pasha et al. (2022) had proposed GSTChain as a blockchain network application for GST in India, laying down theoretical groundwork for the empirical literature [10].

Literature pertaining to AI and machine learning for tax administration has grown at a rapid pace, although peer-reviewed researches relating to Indian context are less compared to policy analysis [2][3][6]. An IEEE conference paper published in 2026 presented a hybrid model of deep learning that integrates LSTM, GRU, and Transformer encoders for GST revenue forecasting. The paper highlights that such models incorporate non-linearities and policy shocks, which are overlooked by traditional econometric modeling. An AI application in the field of tax has been studied in a Zenodo publication (2026). According to the author, smart filing, automatic

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reconciliation, and fraud detection in the context of Indian tax system have led to improved compliance and revenue collection but raised issues of data protection and ethical considerations. Sources from the government have validated the usage of AI and ML for compliance, as per the statement made in Parliament by the Ministry of Finance on the basis of which it can be said that GST refund applications receive a rating on the basis of risk analysis, and the registration, scrutiny, and audit process is done for high-risk taxpayers [2][6].

Scholarship on critical governance has started considering the implications of algorithmic enforcement from the perspective of procedure and the constitution. An article in *Fortune India* in 2026 highlighted how such risk flagging through algorithms might not be in line with natural justice, given the fact that show cause notices that refer to “system identified high risk” without mentioning any parameters do not comply with the rule of proper officer using his judicial mind [7]. The AI Act (2024) of the European Union regarding the categorization of use of AI in tax administration as highly risky, along with transparency and human intervention, can be taken as a comparative example against India’s current model, which is underdeveloped in this regard.

One common thread in the existing literature has been the challenge posed by the interplay between capabilities of technologies and institutions. The existing scholarly understanding in this field, where one may be said to exist, is that digital technologies have indeed enhanced the quality of information in the GST administration process, but the conversion of such information into enforcement processes requires governance decisions which technologies cannot alone resolve [2][4][7]. This paper adds to that literature by bringing together technical, empirical and governance perspectives.

III. Proposed Methodology

For this particular research, a research design that employs the approach of mixed methods synthesis is used to examine the documents produced by governmental organizations, peer reviewed articles and conference papers published from 2021 to

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2026 and also comparison of the technologies. Four different phases make up the research methodology and they include:

- Identification and classification of emerging technologies applied in GST operations in India
- Identification of institutional actors and information flow in the GST digital ecosystem
- Assessment of operation and impacts
- Comparison of technological options based on functional capacity, governance and equity considerations

Phase 1: Technology Identification & Classification

In Phase 1, the systematic identification of technologies mentioned in official government communications (Parliamentary Answers, Press Information Bureau communiqués, National Informatics Centre projects) and academic literature was undertaken. The technologies identified were classified into four types based on their functionality, which were:

- Technologies related to data capture and reporting (e-invoicing, e-way bills, API integration)
- Technologies related to analytics and prediction (machine learning based risk scoring, network analysis, revenue prediction)
- Distributed ledgers technology (blockchain for invoice verification and ITC reconciliation)
- Technologies related to payments (GST tokenised payments, e-rupee)

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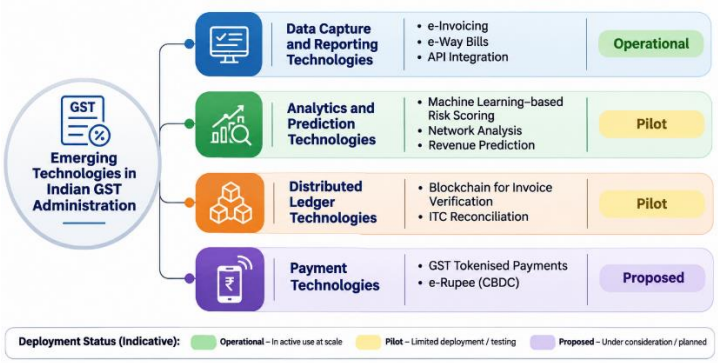


Figure 1: Technology Classification and Deployment Status Framework

Phase 2: Mapping of Institutions and Data Flows

In this phase, a process map of the GST digital ecosystem was created. It included the major institutional actors in this system (GSTN, CBIC, state tax administrations, NIC, and banks), the flows of data generated or consumed by them (GSTR-1, GSTR-3B, JSON invoice, e-way bill data, income tax returns, customs declarations, bank reports), and the interfaces through which intelligence is generated (GST Prime, BIFA, and risk scoring systems).

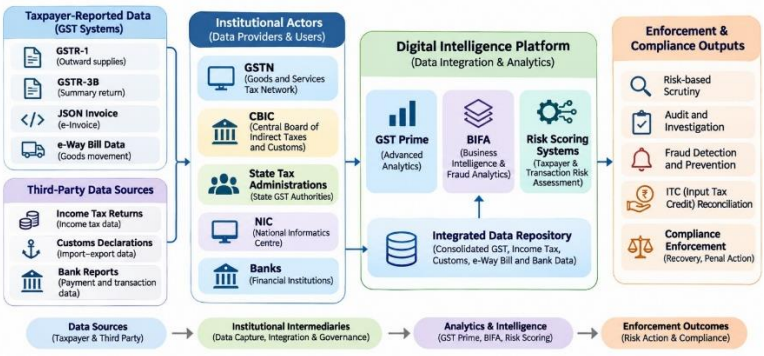


Figure 2: Institutional Architecture and Data Flow in GST Digital Intelligence

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The map was based on government technical documentation and cross-referenced with descriptions from peer-reviewed literature.

Phase 3: Operation Mechanism Analysis

In the third phase, the operation mechanism of the identified technologies was qualitatively analyzed. In the case of AI and machine learning solutions, this analysis looked into the inputs that were mentioned (return data, invoice data, third-party data), the approaches used to analyze those inputs (supervised learning algorithms to identify risks, unsupervised learning algorithms to detect anomalies, network analysis to map relationships), and the decision-making process (scrutiny selection, refund risk rating, trigger events to verify registration). In the case of blockchain proposals, the analysis considered consensus mechanism, smart contracts, and performance in experimental studies. The phase was based on the concept of triangulation.

Phase 4: Comparative Evaluation

The last phase involved a comparison of technological alternatives based on three criteria: functionality (capabilities of technologies to assist with compliance and enforcement), governance (levels of transparency, accountability, and redress that are ensured for the use of specific technologies), and equity implications (differences in distribution between various size categories of taxpayers). The framework of comparative analysis was created in an inductive manner based on the existing literature and applied to the main types of technologies that were identified in Phase 1. The findings of comparative analysis are provided in the Analysis section in the form of a comparative table along with discussions of tradeoffs and implementation issues.

The methodology has some natural limitations due to its design. First of all, it is impossible to gain much operational insight because of the usage of documentary sources, not direct fieldwork. In particular, it concerns the algorithms, the parameters of which are unknown to the public. Secondly, there are no systematic data about outcomes that would be disaggregated by taxpayers' size categories and sectors.

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IV. Analysis

Empirical Trajectory of Digital Compliance

The quantitative data on GST collection and compliance since 2017 form the empirical context within which technological solutions should be evaluated. GST collection increased from ₹7.19 lakh crore in 2017-18 to ₹20.18 lakh crore in 2023-24, registering an annual average growth rate of approximately 18.7% despite considerable month-to-month volatility. As of April 2026, total payments made via the GSTN portal crossed ₹107.64 lakh crore. While such numbers provide information about revenue generation, they do not break down the role of particular technologies in the process. Still, one can notice a correlation between the period of rapid growth and the introduction of mandatory electronic invoicing and analytics-based enforcement.

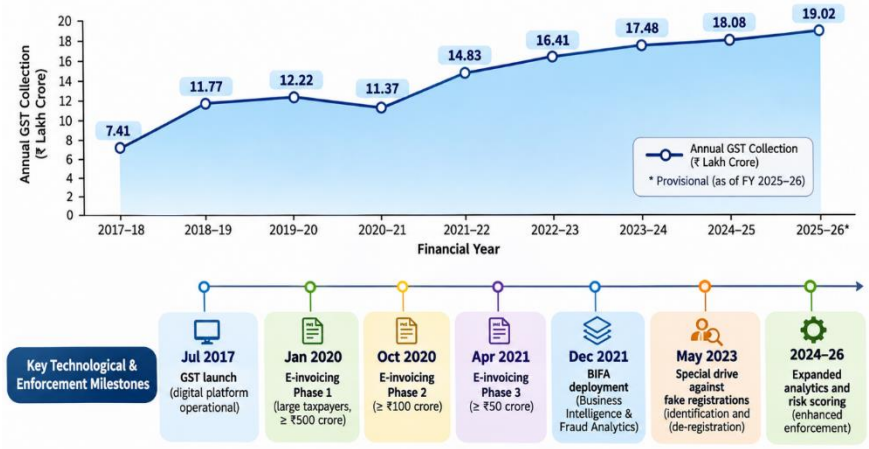


Figure 3: GST Revenue Trajectory and Enforcement Milestones (2017–2026)

A more micro-level view is available through outcomes from enforcement operations. In the crackdown on false registrations (May 2023 to 2024), more than 29,000 cases of false GST registrations with fraudulent claims of input tax credits worth

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about ₹25,000 crore have been uncovered by applying AI models for analyzing anomalies in network structures. From parliamentary revelations, it can be observed that during FY21 and January FY25, there have been 42,673 cases of fraud involving input tax credits, valued at ₹1,66,241 crore. Though these figures might seem alarming in absolute terms, they must be viewed relative to the size of the tax base and the counterfactual: had there not been algorithmic detection, the number would definitely have been lower.

Algorithmic Risk Assessment: Mechanisms and Implications

The engine behind India's digital tax intelligence is the algorithmic risk scoring which is operated through the GSTN and CBIC. The engine uses several data sources: GSTR-1 and GSTR-3B returns, e-invoicing data (mandatory for firms exceeding turnover limits since 2020, with the limits being progressively reduced), e-way bill data, income tax returns, customs data, and data on bank accounts. The machine learning models use these data sources to assign risk scores which will decide how intensive the scrutiny will be – the lower the score, the lower the intensity of the scrutiny (registration verification, return scrutiny, audit selection, or refund verification).

More than 80 reports are available for field-level officers on the GST Prime platform of the NIC, covering such types of analyses as collection predictive analysis, taxpayers ABC analysis, scrutiny identification using risk-based criteria, 360-degree taxpayer profiles, and circular transactions detection through supply chain mapping. This is a major breakaway from the previous approach when the selection of the scrutiny was random or intuitive.

The implications of such a transfer for governance cannot be overstated. As critical scholarship has noted, where a risk alert leads to adverse action – suspension of registration under Rule 21A, blocking of input tax credit under Rule 86A, or action under Sections 67 and 74 – it becomes difficult for taxpayers to mount an effective defence since the grounds for the risk alert remain obscure. Where a show-cause notice simply says “you have been identified by the system as being high risk,” the requirement of natural justice of giving the affected party knowledge of what is alleged against him is not fulfilled. It should also be remembered that “reason to believe” as

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required in the statute implies the exercise of human mind, and not simply an action based on an alert generated by the system.

According to the European Union's AI Act (2024), AI systems in tax administration are considered "high risk" and require "transparency, human involvement and impact assessment." In India, there are no regulatory instruments specifically designed to regulate algorithmic tax enforcement. The 2024 OECD's recommendations are also calling for transparency of algorithms and for the assessment of their biases. The difference between the international standards and Indian practices represents a serious governance deficit.

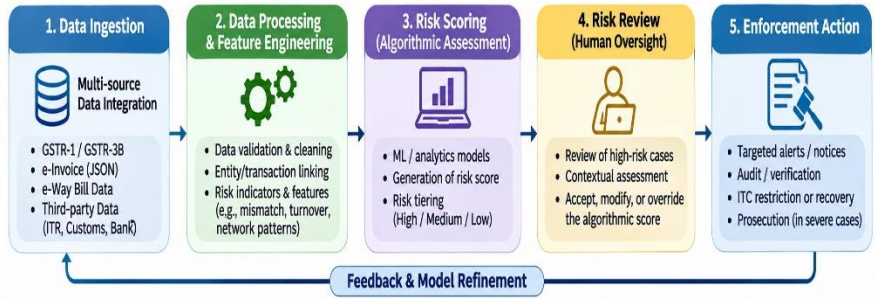


Figure 4: Algorithmic Risk Assessment Workflow and Decision Points

Blockchain and Distributed Ledger Alternatives

Although the centralised structure of GSTN works fine, it has received criticisms with regard to system down time, point of failure and opacity. The blockchain alternative to this problem would have a completely different structure where the ledger is distributed between taxpayers' nodes, tax authority nodes, and financial institution nodes and consensus would ensure that there is no unilateral changes made to the ledger. The smart contract would help in automatically validating the invoice, determining input tax credit, and in determining the tax liability.

When experimenting on DPBLE blockchain GST system compared to centralised and Raft-based systems, some results were found. In this experiment, the centralised

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system performed the best in terms of throughput (latency ranging from 12 milliseconds at 200 transactions per second to 201 milliseconds at 2,000 TPS). However, it took longer time to recover as it had the problem of external failover management. The DPBLE blockchain was better in throughput by 22 percent than the Raft-based alternative. Its mean time to recovery was 1,332 milliseconds under six node failure because of its preference for reliability nodes in the leader election.

However, the even greater possibility of blockchain technology is its ability to solve the input tax credit fraud issue that has been persisting despite any algorithmic solutions. The suggested solution from the Economic Times article was to use the blockchain for GST payments in the form of e-rupee tokens in which all the details of the sales transaction are included (from who to whom, at what time and what for) and as a result, makes ITC fraud impossible since the token cannot be forged. While such a solution is dependent upon the policies chosen to implement it beyond the realm of GST, it shows that technological possibilities go beyond improving detection.

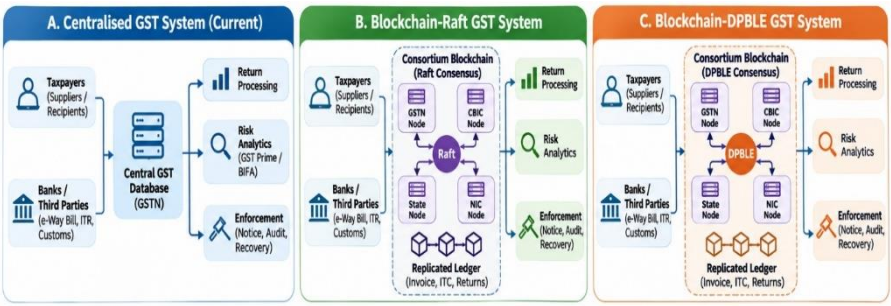


Figure 5: Comparative Architecture of Centralised, Blockchain-Raft, and Blockchain-DPBLE GST Systems

Comparative Analysis of Technology Families

The comparison analysis of the four technological families that have been mentioned in the methodology has been done through Table 1 below.

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Table 1: Comparative Analysis of Emerging Technologies in GST Administration

Technology Family	Functional Capability	Governance Readiness	Equity Implications	Maturity
AI/ML Risk Analytics	High: pattern detection, network analysis, predictive scoring across multiple data streams	Low: opaque parameters, limited disclosure, no statutory framework for algorithmic accountability	Mixed: targets high-risk taxpayers efficiently but may impose disproportionate burdens on digitally less sophisticated entities	Operational (widely deployed)
Blockchain/DLT	Moderate: tamper-evidence, auditability, smart contract automati	Moderate: transparency inherent to ledger design, but implementation	Potentially favourable for small firms via disintermediation, but high technical barriers	Pilot/Experimental

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Technology Family	Functional Capability	Governance Readiness	Equity Implications	Maturity
	on; performance below centralised systems	governance unresolved	may disadvantage them	
API Integration	High: real-time data exchange, automated compliance for large taxpayers	Moderate: access controls and data protection require specification	Favourable for large taxpayers with IT capacity; may widen gap with smaller firms lacking resources	Early operational
Tokenised Payments (e-rupee)	High (proposed): structural	Low: policy framework undevelop	Uncertain: depends on design; could reduce	Proposed

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Technology Family	Functional Capability	Governance Readiness	Equity Implications	Maturity
	elimination of ITC fraud through payment-invoice linkage	ed; privacy and monetary implications unresolved	compliance burden if seamlessly integrated	

This comparison indicates an interesting pattern whereby the technologies that currently have the highest impact on functionality—AI/ML analytics and API integration—are the same that lack the most developed governance structures and have the most unequal equity outcomes. In contrast, despite being promising in terms of providing solutions for structural problems, the ideas regarding blockchain and tokenised payment are still underdeveloped and their practical implementation poses many questions. This shows that the problem of regulation is not about developing more advanced technology but about developing proportional governance.

The equity dimension deserves special consideration. The finding of Shacheendran (2024) that 42% of businesses in their sample had no knowledge of e-invoicing mandates and 38% faced severe problems with e-way bills suggests that the compliance costs associated with digitisation are not evenly shared. In an increasingly algorithmic process of regulation enforcement, the divide between well-equipped large businesses with a specialist technology team and less equipped small businesses without such resources is bound to become even wider. The “digital by default, optional by preference” approach, proposed in recent literature, gives us a guiding principle, but needs to be translated into practice through differential compliance routes.

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V. Conclusion

In this paper, an examination of the journey of the digital tax intelligence has been made with respect to the GST regime in India. The journey from rule-based digitization to algorithmic intervention and its implications on compliance, governance, and equity have been discussed. This research leads us to some principal findings.

Firstly, the use of artificial intelligence and machine learning in the implementation of GST has shifted from being experimental to being implemented. The GSTN and CBIC currently utilize algorithmic risk scoring, network analysis, and predictive analytics for assigning enforcement resources and identifying any pattern of fraud. The detection of over 29,000 instances of fraudulent registration and the discovery of ITC fraud worth lakhs of crores indicate the capacity of such systems to detect fraud, while the detection rate in the absence of the system is unknown. The revenue trajectory – which has been ₹7.19 lakh crore in 2017-18 to over ₹20 lakh crore in 2023-24 – demonstrates the aggregate effect that the digital infrastructure has not hampered the revenue generation, although the exact effect of individual technologies cannot be isolated from other factors.

The second problem area relates to the governance model of algorithmic enforcement. At present, there exist no mechanisms for the taxpayers who have been made an unfavorable determination by the algorithms to make sense of it or challenge its grounds. It is very hard to meet the natural justice principle of making a person aware of the case against him/her where the "case" is the output of a model with parameters that are proprietary or hidden from view. A comparative study of the EU AI Act and the OECD's recommendations shows that India has not yet implemented the standards of transparency and impact assessments which are being increasingly required in other jurisdictions.

Third, blockchain and distributed ledger technology provides a fundamentally different model of functioning whose full potential still lies untapped. According to experimental findings, blockchain systems can deliver better fault tolerance and auditability in comparison with their centralized counterparts, although at the expense

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of performance efficiency. The radically more promising option to tokenize GST payments to make any ITC frauds structurally impossible will move the industry towards a future where payment and verification are combined rather than separate processes. The implementation of such system depends not only on the GST regime but also on policy choices related to the architecture of the e-rupee and mandatory payment mechanisms.

Fourth, the equity issues of digital tax intelligence need to be addressed through appropriate policy measures. The facts are clear that compliance costs and digital capacity are not equally shared among the group of taxpayers, with smaller companies bearing more burdens due to their struggle to adjust themselves to electronic invoicing, e-way bill and filing using portals. Algorithmic enforcement, by focusing on the "high-risk" categories, which could be associated with inadequate digital capacity and not necessarily any evasion, would only add more hurdles. Differentiated treatment approach, where more help and tolerance is provided for small taxpayers, is not contradictory to the algorithmic efficiency and it should be explicitly designed in the policies.

The trajectory of digitalisation in India's GST reveals that the next stage of development will be influenced by three interconnected problems. Firstly, the governance framework has to catch up with technological ability to ensure transparency, accountability, and redress mechanisms to match the algorithmic power. Secondly, there is the problem of bridging the digital divide to prevent the compliance regime from becoming an obstacle which may exclude or punish people due to their inability to use technological tools. Thirdly, there is the problem of evaluating structural options such as the blockchain and tokenised payment systems as a means of fixing the vulnerability of the existing system rather than an alternative to it.

The digitalisation of the GST compliance regime using emerging technologies is neither inherently empowering nor inherently coercive. It is a matter of choice of governance, made through the creation of systems, safeguards, and adaptation costs. The evidence accumulated in this paper demonstrates that India has shown quite impressive technological innovativeness in tax administration. However, the other task

– building institutions to make this technology legitimate, accountable, and equitable – remains far from being completed.

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