

Digital Payments, Tax Compliance, and GST Revenue in India: Evidence from a NARDL Analysis of UPI, NEFT, and Digital Wallets



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Abstract

The present research explores the nonlinear impact of digitalization on Goods and Services Tax Revenue (GSTR) in India, using monthly data from 2018M07 to 2024M08. This study examines the impact of positive and negative changes in digital transactions proxied by the Unified Payment Interface (UPI), National Electronic Funds Transfer (NEFT), and Digital Wallets (DWs) on GST revenue, as well as the linear effect of tax compliance factors represented by E-way bills (EWBs) and Total Return Filed (TRF). The study employed the Nonlinear Autoregressive Distributed Lag (NARDL) model and found long-run cointegration among the variables. The study used the Bai-Perron test to identify a structural break in the model, found in 2021M10, and incorporated a dummy into the model. The BDS test is used in the study to determine the nonlinearity of the variables. The Wald test was used to investigate long- and short-run asymmetry, and the results revealed a significant non-linear relationship between the GSTR and digital payment factors. The findings show that a positive UPI is positively and significantly associated with GSTR, while a negative UPI shows no significant association; however, rising and declining NEFT are both highly significant and positively associated with GSTR. The decreasing DW is significantly and positively associated with GSTR, whereas the inclining DW is not. Furthermore, the tax compliance factors TRF is significantly and negatively associated with GSTR, whereas EWB is positively associated. These results provide new insights for the policymakers regarding the expansion of digitalization and strengthen tax compliance to enhance sustainable revenue mobilization.

Keywords: Digitalization, GST, NARDL, UPI, Fintech, JEL codes: H25, H26, O33, C22

Introduction

In India, there has been a significant increase in digital payments in recent years, particularly following demonetization and the covid-19 pandemic. The broad adoption of digital payment indicators such as UPI, DW, mobile banking, and others is driving the Indian economy towards a cashless economy (Dandona, 2023). Between July 2018 and August 2024, the value of UPI transactions surged by approximately 54 times. Similarly, the other payment indicators such as DW and NEFT also grew by 1.3 times and 2.1 times, respectively. This indicates that UPI is the dominant and fastest-growing digital payment channel during the period of the study in India. Currently, it is evident from the statistics that the Indian digital payment transactions have surpassed the combined four western nations' transactions, including the UK, the US, Germany, and France. The infrastructure of India's payment system heavily relies on the widespread use of QR codes, which enable real-time transactions and connect millions of people, make the economy cashless, and remove the need for the presence of people. For instance, using the UPI, Indians can purchase anything from low-value tea to high-value jewellery (Kant, 2023). Moreover, the technological advancement can influence organizational and

socioeconomic environments in several ways. For example, the use of online platforms and AI chatbots enables the expeditious resolution of taxpayer concerns. Digital records and data analytics effectively address tax authorities' concerns, resolving GST-related grievances through a smoother, more transparent process (Bharti et al., 2024).

On July 1, 2017, a historic shift was marked in India's indirect tax system with the implementation of the Goods and Services Tax (GST), which superseded the complex, multiple central and state tax structures. It has been developed through different policy improvements and advancements in digitalization over the last eight years, aiming at minimizing the effect of double taxation or the cascading effect ((Dhruve, 2025); (GST-Concept-and-Status.Pdf, 2018)). The development of technological innovations, or digitalization, has played a substantial role in India's economic landscape, particularly in the GST framework, by improving the efficiency of GST compliance and the total return filing (TRF) process (Bharti et al., 2024). The introduction of e-invoicing is an important breakthrough in this context. The implementation of technology-driven e-invoicing has substantially contributed to the regulation of GST

compliance and enforcement (Bharti et al., 2024). It can reduce the costs of tax compliance with the improvement of information and services provided to the taxpayers and mitigate the opportunity for corruption from face-to-face interactions of people and tax authorities. It can create transparency and also reduce black money transactions (Bird & Zolt, 2008). The financial institutions facilitate electronic transactions, thereby creating paper trails. Using these traces, the tax authorities can assess tax obligations and increase tax revenue (Rogoff, 2016). GST compliance, data observation, and revenue monitoring underwent substantial changes due to rapid advances in digital financial services. This shift to digital transactions, catalysed by government initiatives such as Digital India, demonetization in 2016, and the COVID-19 pandemic, has significant implications for taxation. Digital payments augment tax revenues by promoting financial inclusion, stimulating economic activity, and improving tax enforcement and compliance. ((Rogoff, 2016); (Carrillo et al., 2014); (Oz-Yalaman, 2019)). Moreover, the integration of real-time invoice matching, e-way bill generation, and data analytics under the Goods and Services Tax Network (GSTN) framework makes digital footprints very vital for tax authorities to monitor and to eliminate or stop tax leakage and evasion. Nationally, from 2018M04 to 2023M04, the number of active taxpayers handled by the GSTN surged from 105 lakhs to 140 lakhs. The main aim of the GSTN is to make it easier for taxpayers to comply and prioritize securing data and information (Dandona, 2023). Thus, we can undoubtedly argue that the digital transformation is more than just an economic enabler; it is also a tax compliance facilitator in the context of taxation, particularly the Goods and Services Tax. Furthermore, at the global level, the usage of currency has declined due to technological progress and fast developments in the financial technology (fintech) domain, facilitated by regulatory initiatives (Kumar, 2024). This has prompted a considerable surge in digital transactions. The rapid advancement of the Unified Payments Interface (UPI) in 2016–17 hastened the digital transformation of India's public financial sector. These systems enabled cashless transactions and fostered a digital tax environment by integrating compliance tools such as automatic interstate tax (IGST) settlement, e-way bills, and e-invoicing. Thus, it is vital to analyze whether digitization influences GST revenue in a nonlinear way to assess policy effectiveness and strategize future digital initiatives. The current study contributes to the existing literature by examining the influence of digital payments and tax compliance on GSTR in an asymmetric manner using the non-linear autoregressive distributive lag model developed by (Shin et al., 2014), as there is limited literature on this area. The research enhanced existing literature by analyzing the distinct influences of UPI, NEFT, and DW on GSTR, whereas previous studies focused on the

overall effect of digital payments on GSTR, overlooked the individual contributions of payment channels, and did not examine the asymmetric relationship (Ramalingam & Joseph, 2021). Moreover, this research advanced knowledge by investigating the impact of both transaction-oriented (EWB) and return submission-based (TRF) compliance on GSTR.

This section of the study pertains to the introductory part. The remaining part of the paper is structured as follows. Section 2 provides a brief overview of the theoretical framework of the study. Section 3 summarizes the reviewed literature. Section 4 delineates the data and technique used. Section 5 delineates the empirical results of the research. Section 6 provides the discussion of empirical findings. Section 7 concludes the study and provide some policy recommendations.

Theoretical Framework:

The deterrence, or the detection theory, developed by (Allingham & Sandmo, 1972), is represented as a pure cost-benefit model. According to the theory, taxpayers always make a calculated decision to benefit from underreporting income or to evade the tax while weighing against the risk of being caught. Consequently, compliance increases as taxpayers anticipate an increase in the likelihood of detection. With the advancement of technology and digital payment, financial institutions automatically record transactions made via UPI, DW, and NEFT and match them with GSTN issuance of e-invoicing and e-way bills, resulting in a transaction traceability record. As a result, this theory provides a mechanism and a theoretical foundation for anticipating increased revenue generation with widespread adoption of digital payment systems such as UPI, NEFT, and DW as well as transaction-based and filing-based compliance such as EWB. This theoretical framework is very effective in elucidating alterations and significant transformations in compliance capability, which signifies the tax authority's ability to expand the whole taxpayer base simultaneously, rather than only an individual's risk assessment being changed. Within this context, TRF may be clearly comprehended, since the rise in TRF signifies an expanded administrative scope, a structural occurrence, rather than an impact of individual detection likelihood, as characterized by Allingham-Sandmo (Allingham & Sandmo, 1972). The TAM (Technology Acceptance Model) (Davis, 1989) explains what motivates people to adopt technology, while the institutional theory examines how legal frameworks, norms, and organizational structures influence behaviour. However, the research question of this study is to understand the consequences of technology adoption rather than drivers of adoption itself. Furthermore, (Kirchler et al., 2008) introduced the slippery slope framework, which is unlike the pure cost-benefit model; it identifies two different dimensions that jointly shape tax compliance. The two dimensions are named "trust" and "power."

The term "trust" refers to taxpayers willingly complying because they find the government system and authorities are fair, while, contrary to this, "power" is defined as when taxpayers are forced to comply. Unlike "trust" when they feel the authority is in power and capable of imposing the penalties on tax evaders, they have the risk of being caught. So, it has been inferred that tax compliance can be driven either by trust or by power; however, in this study the focus is more on "power" as people are coerced to comply as they find system authorities capable of detecting the evaders because of the advancement of digital transactions managed through the GSTN mechanism, which is the automatic generation of e-way bills, e-invoicing, and real-time data matching. This system-wide shift in enforcement capacity, which is consistent with the structural break identified in this study at 2021M10, coincides with the expansion of mandatory e-invoicing thresholds. . Therefore, the study focused on the Allingham-Sandmo (Allingham & Sandmo, 1972) and Slippery Slope Framework (Kirchler et al., 2008), which are directly related to compliance and tax revenue. The Allingham-Sandmo (Allingham & Sandmo, 1972) and the Slippery Slope (Kirchler et al., 2008) discussed above jointly suggest that digital payment adoption and tax compliance influence GSTR through cost-benefit, detection probability, and administrative power. However, neither of these two frameworks influences each other in a symmetric way or the same way in both directions. Once digital transactions enhance traceability and the estimated probability of being caught, this impact may not just revert if the use of a particular medium subsequently declines, like if one payment platform declines, they can switch to a different channel because when a taxpayer is accustomed to digital transactions, they are unlikely to revert to cash. Hence, it has been expected theoretically that the increase and decrease in the NEFT, DW, and UPI can affect GSTR in an asymmetric way or nonlinearly, which cannot be captured through the linear ARDL framework and therefore motivates the adoption of the NARDL model, which allows the decomposition of each variable into positive and negative shocks to capture their different effect.

Review of Literature:

In theory, there are different pieces of evidence that can provide the idea to trace the nexus between digitalization, economic growth, tax compliance, and GST revenue, as they postulated that the advent of digitalization enhances the GST revenue by improving the financial inclusion of incorporating the weaker or marginalized section of society into the regulated economy ((Kumar, 2024); (Maherali, 2017)). Nevertheless, traceability does not completely eradicate evasion of taxes. (Carrillo et al., 2014) examined firms in Ecuador, analyzing their reporting practices subsequent to tax authorities obtaining third-party sales data. This indicates that enhanced traceability raises the expense of evasion and

marginally boosts compliance; however, it does not completely eradicate intentional underreporting, since taxpayers modify their actions in response to new scrutiny techniques. Collectively, these studies suggest that cash's anonymity facilitates evasion (Rogoff, 2016), while digital traceability generally enhances compliance and revenue, as shown in Greece (Hondroyannis & Papaoikonomou, 2017) and more broadly across Europe (Immordino & Russo, 2017). However, evidence of continued strategic adaptation by firms even under increased monitoring (Carrillo et al., 2014) suggests that this relationship may not be uniform or symmetric across contexts. Apart from its implications for VAT or GST compliance, digitalization has been related to a more extensive decrease in the shadow or informal sector; hence, (Maherali, 2017) posits that the proliferation of digital payments and financial inclusion integrates once informal, cash-centric economic activities into apparent, formal, and hence taxed systems. This arises because digital transactions demand a formal financial framework, such as bank accounts or sanctioned payment applications, which assimilates both individuals and businesses who were once unbanked or informally functioning into a traceable network. Therefore, the tax base itself expands instead of only increasing compliance among already registered taxpayers—this is a unique process compared to the traceability/detection feature, as it aims to broaden the scope of individuals included in the tax system rather than merely expanding the compliance among those already within it. Moreover, (Akram, 2016), in his study using the time-series data from Pakistan, reveals that a surge in the number of bank branches and market capitalization had a positive and significant effect on tax revenue both in the long and short runs. This emphasizes the comprehensive financial-inclusion framework stated earlier, indicating that the development of the financial sector contributes to in the enhancement of tax revenue, irrespective of a focused concentration on digital payments, with regional data extending this association beyond Europe. In addition, methods used for information reporting have demonstrated an enhancement in compliance among smaller economic participants. The growth rate of GST revenue has been increasing consistently and has surpassed the GDP growth rate since its implementation, driven by factors such as the broad acceptance of technological innovations, stronger economic activity, and more efficient tax compliance (Ramalingam & Joseph, 2021). Further, ((Balasoju et al., 2023); (Oz-Yalaman, 2019); (Raouf, 2022); and (Ren et al., 2025)) have also made similar observations that higher economic activity has a multiplier effect across several dimensions, such as increased consumption, savings, investment, wealth creation, and, consequently, enhanced tax revenue for the government. Restricting cash transactions and promoting digital transactions will mitigate tax evasion and avoidance (Madzharova, 2013). The traceability of these transactions reduces

the risk of tax evasion and supports discussions on price competitiveness and equitable benefits. Furthermore, (Rogoff, 2016) contends that physical cash, particularly high-denomination notes, facilitates the underground economy, which includes tax evasion, corruption, and organized crime, owing to the anonymity of cash transactions and the lack of traceability. Large denominations are more problematic because they are simple to store more money in physical form and leave no transactional record. As a result, in his study, (Rogoff, 2016) suggests that higher-denomination currency should be reduced in circulation, reducing the operating capacity of the underground economy. Conversely, this implies that cashless transactions are inherently traceable and reduce the possibility of tax evasion. This conceptual linkage between traceability and compliance is further reinforced by real evidence in the work of (Hondroyannis & Papaoikonomou, 2017), who investigated the impact of card payments on VAT revenue in Greece, particularly after the imposition of cash withdrawal restrictions in 2015. In their study using the time-varying coefficient methods on quarterly data, they found that with a one percent point increase in the share of card payments in private consumption, VAT revenue increased by approximately one percent, operating through better compliance. Moreover, they found that card transactions support the tax buoyancy, which implies that revenue grows faster than the underlying tax base. (Immordino & Russo, 2017) offers an additional elucidation of this mechanism, contending that cash facilitates "collaborative tax evasion," wherein buyers and sellers cooperate, with sellers providing a price reduction in return for untraceable cash payments that evade VAT.

According to (Slemrod, 2018) review of tax compliance literature, third-party information reporting, represented by electronic payments, significantly enhances the reported income of small-scale sole proprietorships, as transactions are independently verifiable instead of solely self-reported. Consequently, it has become clear that these studies broaden the traceability and financial-inclusion frameworks previously mentioned to particular institutional and business settings, strengthening the underlying assumption that digitization increases tax income via several interdisciplinary avenues. Nonetheless, the correlation between digitization and tax compliance is not always positive in each case. (Etim et al., 2020) utilized primary data and simple linear regression in Nigeria, revealing that the digitization of the economy negatively affected tax compliance. This finding contradicts the previously mentioned studies, indicating that the impact of digitalization on tax-related results may be contingent upon the broader institutional context, including the robustness of enforcement mechanisms, the advancement of digital payment integration, or the dependability of foundational data systems.

This discrepancy indicates that the impact of digitalization on tax-related outcomes varies by context, highlighting the necessity of empirical testing instead of presuming the nature and direction of this relationship, particularly regarding whether the influence of increasing and decreasing digital payment adoption affects GST revenue in a symmetrical manner. (Ramalingam & Joseph, 2021) conducted a study closely related to the current research, investigating the correlation between digital payments and GST revenue in India through an autoregressive distributed lag (ARDL) model, revealing a positive long-run relationship between digital payments and GST revenue, as well as positive impacts from economic growth, tax compliance, and imports, whereas inflation and exports exerted negative effects. Despite this, their assessment of digital payments amalgamated various channels, such as UPI and card transactions, into a single variable instead of analyzing the impact of each channel independently. Their compliance metric was restricted to a single proxy, specifically the proportion of GSTR-3B forms submitted by the deadline, reflecting just the timeliness aspect of compliance and overlooking other facets like the amount of the underlying taxable transactions. The sample timeframe is till March 2022, preceding UPI's next phase of swift expansion and supremacy as India's prime digital payment medium.

The literature reviewed above, altogether, consistently represents the positive relationship between digitalization and the tax revenue outcomes, whether through improved tax compliance, financial inclusion, or expansion of the formal tax base. However, this consistency itself reveals a gap. All the existing studies, particularly those closely related to the current study, generally posit the linear relationship between digitalization and tax revenue, without testing if the assumption holds. Moreover, none of the existing studies have examined the separate effect of UPI from other digital payments despite its high dominance in India's payment system, nor has any study jointly incorporated both transaction-based and filing-based measures of tax compliance. Hence, the current study addresses all the gaps by employing the NARDL model to investigate the asymmetric impact of UPI, DW, and NEFT alongside the linear effect of transaction-based (EWB) and filing-based (TRF) tax compliance measures using the secondary time-series data from July 2018 to August 2024.

Materials and Methodology:

The main objective of this study, based on secondary data, is to assess the asymmetric long-run impact of digitalization on GST revenue using monthly time-series data from 2018M07 to 2024M08, with GST revenue as the dependent variable and digitalization proxied by DWs, NEFT, and UPI. EWBs and TRFs are used as tax compliance factors. A more detailed description and sources of the variables' data have

been presented in Table 1. Unlike the other existing literature, in which most of the studies use the standard ARDL model, the present study employed the Nonlinear Autoregressive Distributed Lag (NARDL) framework suggested by (Shin et al., 2014). The model is used because the data are integrated at a combination of levels (I (0)) and first differences (I (1)), it is resilient, and it does not require integrating variables at the same order. Moreover, as theoretically motivated in Section 2, the effects of increases and decreases in digital payment adoption on GSTR may

differ due to the persistence of compliance behaviour and substitution across payment channels; the NARDL framework of (Shin et al., 2014) is therefore employed specifically to capture this asymmetry, which a standard linear ARDL specification would not detect. Hence, the following equation (1) delineates the Autoregressive Distributed Lag Error Correction Model (ARDL-ECM) of the study as follows, which provides us with the ability to capture the short-run dynamics and long-run cointegration among the variables by incorporating the lag values:

$$\Delta y_t = \alpha_0 + \sum_{i=1}^{p-1} \beta_i \Delta y_{t-i} + \sum_{i=0}^{q-1} \delta^i_1 \Delta x_{1,t-i} + \sum_{i=0}^{q-1} \delta^i_2 \Delta x_{2,t-i} + \sum_{i=0}^{q-1} \delta^i_3 \Delta x_{3,t-i} + \sum_{i=0}^{q-1} \delta^i_4 \Delta x_{4,t-i} + \sum_{i=0}^{q-1} \delta^i_5 \Delta x_{5,t-i} + \phi(y_{t-1} - \theta_1 x_{1,t-1} - \dots - \theta_5 x_{5,t-1}) + \varepsilon_t \quad (1)$$

Here, y_t = dependent variable.

x_1, x_2, x_3, x_4 , and x_5 = independent variables.

ϕ = error correction term.

Further, the BDS test proposed by (Brock et al., 1996) has been applied to the level series of the digitalization proxies, namely LNNEFT, LNDW, and LNUPI, to assess independence and nonlinearity, thereby justifying the use of an asymmetric framework over a standard linear model. Independently, following (Shin et al., 2014), each of these variables is decomposed into positive and negative shocks elucidated by (2), (3), (4), (5), (6), (7), (8), (9), and (10):

$$LNNEFT_t = LNNEFT_\theta + LNNEFT_t^+ + LNNEFT_t^- \quad (2)$$

Here,

$$LNNEFT_t^+ = \sum_{j=1}^t \max(\Delta NEFT_j, 0) \text{ (cumulative positive changes)} \quad (3)$$

$$LNNEFT_t^- = \sum_{j=1}^t \min(\Delta NEFT_j, 0) \text{ (cumulative negative changes)} \quad (4)$$

$$LNDW_t = LNDW_\theta + LNDW_t^+ + LNDW_t^- \quad (5)$$

Here,

$$LNDW_t^+ = \sum_{j=1}^t \max(\Delta DW_j, 0) \text{ (cumulative positive changes)} \quad (6)$$

$$LNDW_t^- = \sum_{j=1}^t \min(\Delta DW_j, 0) \text{ (cumulative negative changes)} \quad (7)$$

$$LNUPI_t = LNUPI_\theta + LNUPI_t^+ + LNUPI_t^- \quad (8)$$

$$LNUPI_t^+ = \sum_{j=1}^t \max(\Delta UPI_j, 0) \text{ (cumulative positive changes)} \quad (9)$$

$$LNUPI_t^- = \sum_{j=1}^t \min(\Delta UPI_j, 0) \text{ (cumulative negative changes)} \quad (10)$$

Because of the policy changes in the economy, there can be structural discontinuities in the data, and to examine

those, the Bai-Perron multiple breakpoint test has been employed, as suggested by ((Bai & Perron, 1998); (Bai & Perron, 2003)) which endogenously determines the unknown break date in the series. The test detects a break at 2021M10, coinciding with the phased rollout of mandatory e-invoicing to decrease GST turnover criteria. Therefore, a dummy variable is incorporated in the model as D1. As a result, the ARDL-ECM model illustrated in equation 1 is modified into a nonlinear error correction model (NARDL-ECM) developed by (Shin et al., 2014). The ECM model is estimated using the least-squares approach to assess the rate of adjustment that returns the system to long-run equilibrium. It signifies the velocity of adjustment to short-term fluctuations, as well as the extent and orientation of these associations. The ECM illustrates the dependent variable's response to deviations from the equilibrium path, shown below through Eqn 11:

$$\begin{aligned} \Delta GSTR_t = & \alpha_0 + \sum_{i=1}^{p-1} \beta_i \Delta GSTR_{t-i} + \sum_{i=0}^{q-1} \gamma_{1i}^+ \Delta LNNEFT_{t-i}^+ + \sum_{i=0}^{q-1} \gamma_{1i}^- \Delta LNNEFT_{t-i}^- + \sum_{i=0}^{q-1} \gamma_{2i}^+ \Delta LNDW_{t-i}^+ \\ & + \sum_{i=0}^{q-1} \gamma_{2i}^- \Delta LNDW_{t-i}^- + \sum_{i=0}^{q-1} \gamma_{3i}^+ \Delta LNUPI_{t-i}^+ + \sum_{i=0}^{q-1} \gamma_{3i}^- \Delta LNUPI_{t-i}^- + \sum_{i=0}^{q-1} \gamma_4 \Delta LNEWB_{t-i} \\ & + \sum_{i=0}^{q-1} \gamma_5 \Delta LNTRF_{t-i} + \phi \Delta GSTR_{t-1} - \theta_1^+ LNNEFT_{t-1}^+ - \theta_1^- LNNEFT_{t-1}^- - \theta_2^+ LNDW_{t-1}^+ \\ & - \theta_2^- LNDW_{t-1}^- - \theta_3^+ LNUPI_{t-1}^+ - \theta_3^- LNUPI_{t-1}^- - \theta_4 LNEWB_{t-1} - \theta_5 LNTRF_{t-1} - \theta_6 D1_{t-1} + \psi_1 \Delta D1_t \\ & + \varepsilon_t \end{aligned} \quad (11)$$

Here, Δ indicates short-run dynamics, ϕ , the adjustment coefficient, and θ_i signifies the long-run coefficients for all respective independent variables. D1t represent the dummy variable of structural break. ε_t depicts the constant and error term.

Table 1. Description of the Variables:

Variable code	Time Period	Description	Source
LNGSTR	2018M07-2024M08	Monthly GST revenue collection in India.	Statistical report on GST by Goods and Services Tax; gst.gov.in
LNEWB	2018M07-2024M08	Monthly data on e-way bills in India.	Statistical report on GST by Goods and Services Tax; gst.gov.in
LNTRF	2018M07-2024M08	Monthly total returns filed by those who have filed GST-3B in India	Statistical report on GST by Goods and Services Tax; gst.gov.in
LNDW	2018M07-2024M08	Monthly data on digital wallets	RBI's publications on payment system indicators.
LNNEFT	2018M07-2024M08	Monthly data on National Electronic Funds Transfer in India	RBI's publications on payment system indicators
LNUPI	2018M07-2024M08	Monthly data on Unified Payments Interface	National Payments Corporation of India (NPCI)

Note: All variables have been transformed into natural logarithmic values.

The long-run cointegration among the variables was tested using the F-bound test (Pesaran et al., 2001), which illustrated the long-term cointegration despite short-term fluctuations. The null hypothesis posits that the variables are not cointegrated. In the long-run bound test, an F-statistic above the upper bound critical value, denoted as I (1), rejects the null hypothesis of no cointegration among the variables; hence, it implies cointegration exists. If the F-statistic is below the I(0) limit, it fails to reject the null of no cointegration (Pesaran et al., 2001). Furthermore, the outcome would be indeterminate if the value falls between the upper and lower limits.

Moreover, the Wald test has been applied to check the existence of long-run, short-run, asymmetry between the dependent and decomposed variables. Further, several diagnostic tests have been performed to assess the model's robustness and stability.

Empirical Findings:

This segment has outlined the empirical findings of the research, categorized into various subsections as follows:

Summary of the data:

To eliminate dispersion, variance, and heteroskedasticity, all study variables were logarithmically transformed. The mean and median are practically equal, indicating similar distributions and consistency with Table 2. variable summary statistics. The Jarque-Bera value of some of the variables indicates that the data deviates from normality, and some variables exhibit high skewness and kurtosis. Although such deviations from normality occur frequently in macroeconomic time-series data, particularly as a result of economic policy changes over time, they do not preclude the use of the ARDL framework.

Nonlinearity Test:

The evaluation of the BDS test method helps in examining whether the time series are identically and independently distributed or depict linear dependence. Therefore, the BDS test has also been employed to assess the non-linearity in the data set. The null hypothesis of the test posits that the time series exhibits no dependence, while the alternative represents the non-linear dependence. When the value of the BDS test statistic is greater than the critical value, the null hypothesis is rejected; if the value of the BDS statistic is less than the critical value, we are unable to reject the null hypothesis, and thus ARDL is the best model for linear dependencies. Table 3 depicts the BDS test results, which show that all variables are significant at 1% and have nonlinear dependencies across all dimensions.

Table 2. Summary of the data:

	LNGSTR	LNUPI	LNNEFT	LNDW	LNEWB	LNTRF
Mean	11.72	8.013	14.69	8.32	18.26	15.98
Median	11.71	8.131	14.70	8.29	18.28	16.00
Maximum	12.25	9.61	15.27	8.69	18.76	16.33
Minimum	10.37	5.61	14.08	7.51	15.34	15.54
Std. Dev.	0.296	1.11	0.252	0.21	0.44	0.188
Skewness	-1.205	-0.27	0.073	-0.70	-3.82	-0.03
Kurtosis	6.99	1.88	2.25	4.35	25.51	2.45
Jarque-Bera	67.02	4.71	1.79	11.69	1743.6	0.92
Probability	0.000	0.09	0.40	0.002	0.000	0.63

Source(s): Author's calculation

Table 3. BDS Testing

BDS statistics Dimension	LNUPI	LNDW	LNNEFT
2	0.198***	0.118***	0.101***
3	0.336***	0.197***	0.169***
4	0.432***	0.249***	0.215***
5	0.498***	0.286***	0.233***
6	0.546***	0.301***	0.241***

Source(s): Author's calculation

Note: The asterisks ***, **, and * denote the significance level at 1%, 5%, and 10% respectively.

Unit Root Testing:

Before employing the NARDL model, there is a requisite of testing the stationarity of all the variables. Therefore, to assess time series data stationarity, the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests were used. The variables have I (1) and I (0) orders of integration, as shown in Tables 4 and 5. Thus, the NARDL model is justified since the variables integrate in mixed order.

Table 4. Unit Root (ADF-Test)

	ADF Test				
	Constant			Constant and Trend	
variables	level	First difference	Level	First difference	Decision
LnGSTR	-1.418	-	-4.894***	-	I(0)
LnUPI	-2.153	-5.439***	-0.894	-	I(1)
LnNEFT	1.058	-10.946***	-2.872	-	I(1)
LnDW	-2.507	-6.341***	-3.144	-	I(1)
LnTRF	-2.121	-6.935***	-2.092	-	I(1)
LnEWB	-4.136***	-	-	-	I(0)

Source(s): Author's calculation

Note: The asterisks ***, **, and * denote the significance level at 1%, 5%, and 10% respectively.

Table 5. Unit Root (PP-Test)

	PP Test				
	Constant			Constant and Trend	
variable s	level	First difference	Level	First difference	Decision
LnGSTR	-2.479	-	-4.906***	-	I(0)
LnUPI	-2.731	-	-3.562**	-	I(0)
LnNEFT	-2.222	-	-6.877***	-	I(0)
LnDW	-2.395	-10.814***	-3.188	-	I(1)
LnTRF	-10.08***	-	-	-	I(0)
LnEWB	-4.066***	-	-	-	I(0)

Source(s): Author's calculation

Note: The asterisks ***, **, and * denote the significance level at 1%, 5%, and 10% respectively.

Long-run Bound Test for Cointegration:

Table 6 shows the bound test, long-run, short-run, Wald test, and diagnostic test findings. Table 6, Subsection A, shows that the F-statistic value of 24.89 exceeds the lower and upper bound values, rejects the null hypothesis of no cointegration, and establishes a long-run equilibrium relationship at all significance levels (1%, 5%, and 10%). Figures 7 illustrate the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests, used by (Pesaran & Shin, 1999), have been used to assess the stability of the model. The coefficients show structural stability because the statistics are significant at the 5% significance level.

Table 6. Long-Run and Short-Run Findings of the NARDL Model:

Subsection A: Bounds test					
Test stat	value	significance level	I(0)	I(1)	Cointegration
F-statistic	24.89***	1%	2.500	3.680	Yes
		5%.	2.040	2.080	
		10%.	1.800	2.800	
No. of Regressors(k)	9				
Subsection B: Long-run NARDL findings					
Variables	coefficient	std. Error	t-statistic	prob.	
Ln UPI (+)	0.0995*	0.0506	1.964	0.0540	
Ln UPI (-)	-0.0336	0.2188	-0.1539	0.8782	
Ln NEFT (+)	0.3634 ***	0.0909	3.994	0.0002	

Ln NEFT (-)	0.2693***	0.0978	2.752	0.0078
Ln DW (+)	-0.1493	0.0898	-1.662	0.1015
Ln DW (-)	0.1331**	0.0644	2.066	0.0431
LN TRF	-0.2210***	0.0686	-3.219	0.0021
LN EWB	0.4256***	0.0569	7.472	0.0001
D1	0.1132***	0.0283	3.991	0.0002
Subsection C: Short-run estimation.		Coefficient.	Prob.	
ECM _{t-1}		-0.981***	0.0000	
Subsection D: Asymmetry estimates		Test Statistics	P-value	
Wald Test (LR Asymmetry)		6.349***	0.0002	
(SR Asymmetry)		5.58***	0.0001	
Subsection E: Residual Diagnostic Tests		F-statistics	p-value	
Heteroskedasticity test(B-P-Godfrey)		0.617	0.900	
Serial correlation test(Breusch-Godfrey)		0.907	0.411	
Ramsey RESET Test		1.0009	0.322	
CUSUM			Stable	
CUSUM SQUARE			Stable	

Source(s): Author's calculation

Note: The asterisks ***, **, and * denote the significance level at 1%, 5%, and 10%, respectively.

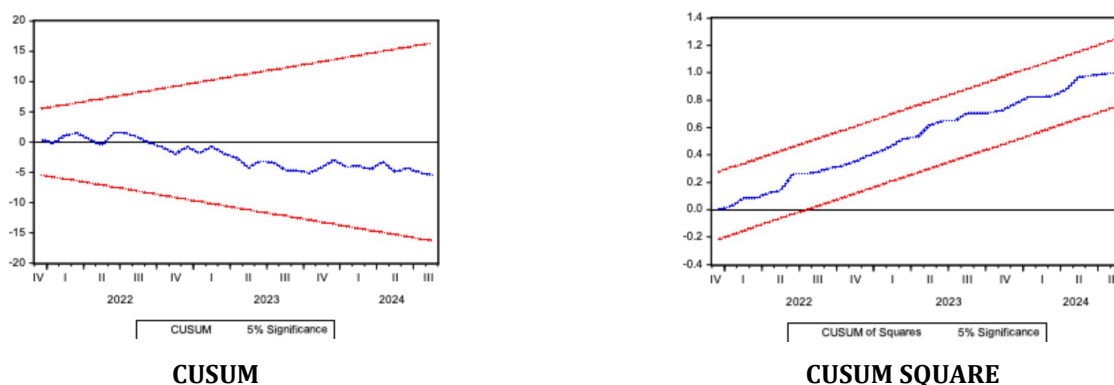


Figure 7. Stability test

Discussion of Empirical results:

The NARDL findings are illustrated in Table 6, the subsection A depicts the long-run nonlinear relationship between digitalization and GSTR. Subsection B represents the long-run coefficients of the non-linear ARDL model. The findings reveal that UPI shows an asymmetric pattern; the positive effects of UPI are marginally significant at the 10% level of significance, while the UPI⁻ is not significant. The results imply that a 1% change in UPI⁺ is associated with a 0.099% increase in the GSTR and suggest that the growth in adoption of UPI raises detection probability and, hence, the GSTR, which is consistent with the theory of (Allingham & Sandmo, 1972), but the decline in UPI does not have any effect. This nonlinear pattern is consistent with the theory developed above because the traceability and

compliance habits, once developed, tend to persist; a decrease in the usage of UPI payments more plausibly reflects a substitution towards the other digital payment channels, such as NEFT, RTGS, and DW, rather than a reverse to untraceable cash. Further, it reflects the UPI's changing role as well over the period of time. The UPI transaction value grew about 54-fold between 2018 and 2024, while the growth of DW was marginal. Users and traders likely migrated across different digital payment channels rather than going back to the formal traceable cash transactions. This finding contradicts the findings of ((Ramalingam & Joseph, 2021) and (Kumar, 2024)), whose focus was to examine the impact of aggregate digital measures on GSTR, not the single impact of UPI and other digital payment channels. This asymmetric finding also provides a potential agreement for the mixed

evidence in the expanded literature. Although most of the research, such as (Oz-Yalaman, 2019) and (Maherali, 2017)), indicates a direct positive relationship between digitalization and tax-related outcomes. However, (Etim et al., 2020) found that digitalization negatively affects tax compliance in Nigeria. Instead of considering these as contrasting results, the present result indicates that the impact of digitalization might, in fact, depend on the direction of the change in usage itself, a distinction that cannot be captured by linear, non-decomposed frameworks like that of Etim et al. Moreover, conversely to the UPI, the rising effects of DW are insignificant, but the negative effects of DW lead to the positive change in the GSTR. A 1% decline in the DW is associated with a 0.13% increase in GSTR. This result may be due to the same substitution effect, given the stagnant growth of DW over the same period of time compared to the growth of UPI; people are likely to switch towards UPI when there is a decline in DW rather than moving towards the formal cash transactions. While the insignificant positive effects of DW may reflect the tendency of DW to be used for smaller, often lower-value, or tax-exempt transactions, this is consistent with the findings of (Kumar, 2024) own speculation regarding weaker results for transaction volume versus value. Furthermore, the negative and positive shocks in the NEFT reveal a significant positive impact on the GSTR. A one percent negative change in NEFT is associated with a 0.26% rise in GSTR, and the one percent positive change in NEFT is associated with a 0.36% increase in GSTR. This result implies that unlike the UPI and DW, NEFT does not assert the asymmetric relationship with the GSTR, because both the positive and negative shocks in NEFT have a significant positive impact only on GSTR. This may be due to the fact that the primary use of NEFT is generally for large payments, business-to-business, or salary-based transfers related to the formal banking sector; hence, according to Allingham-Sandmo, the effect on the detection probability is stagnant, regardless of the change in direction of usage or substitution, unlike the UPI and DW in which people are more likely to substitute the payment channels. This finding is in line with the studies of ((Hondroyannis & Papaoikonomou, 2017); (Immordino & Russo, 2017)), as well as (Madzharova, 2013) findings that usage of cash is negatively related to the VAT revenue across the European countries, as they found that advancement in digital payments improves tax compliance and tax revenue, although they didn't work on the examination of asymmetry in the relationship. However, the results contradict the findings of ((Ramalingam & Joseph, 2021); (Kumar, 2024)), as their aggregate payment system did not find a distinct and separate impact of the digital payments system. The transaction-based tax compliance factor EWB is highly and positively significant at 1%, indicating that a one percent increase in EWB is associated with 0.42% rise in GSTR. This finding aligns with the broader literature on

third-party information reporting: (Slemrod, 2018) analysis of tax compliance literature highlights that independently verifiable transaction records elevate reported income compared to solely self-reported data, whereas (Bird & Zolt, 2008) contend that digital transaction trails diminish the chances for in-person collusion or negotiated underreporting between taxpayers and tax authorities, a process that aligns directly with how EWBs create a verifiable record of goods movement, which is also supported by the theory of (Allingham & Sandmo, 1972), which explained the detective mechanism and justified that the EWBs are generated for the movements of tangible goods above a threshold value and provide it as a real indicator of actual, verifiable economic transactions entering the official taxation system. While in contrast with (Ramalingam & Joseph, 2021) the filing-based tax compliance factor TRF has shown the significant effect on GSTR but in a negative manner, which implied that a one percent change in the TRF is associated with a 0.22% decline in GSTR. but aligned with the slippery slope framework's power dimension, as per which the inclination in TRF reflects a rising administrative network incorporating additional taxpayers into the system, a structural occurrence apart from the individual detection-probability rationale that drives EWB. Additionally, the structural break dummy, D1, is positive and highly significant at the 1% level, indicating that they accurately capture rapid policy changes and genuine shocks, in line with the incremental increase of required e-invoicing thresholds described in the Theoretical Framework. This finding is consistent with the findings of (Dwivedi & Sinha, 2016) regarding the structural change found in VAT collection in West Bengal after the implementation of e-governance and enforcement reforms, representing that advancement in the digitalization initiatives can provide measurable changes in the tax revenue collections apart from the gradual impacts from the different payment channels. In subsection C of Table 6, the coefficient of ECM as cointeq (-1) is negative and substantial, meaning that 98% of short-term divergence from equilibrium will be corrected in the following month. The negative sign of the ECM term suggests that the system self-corrects, reducing any deviation from equilibrium in one period and reverting to the long-run equilibrium in the next. Diagnostic tests, such as the Breusch-Godfrey serial correlation LM test, the Breusch-Pagan-Godfrey heteroskedasticity test, and the Ramsey Reset test, were used to assess the model's robustness. The statistics of the long-run and short-run Wald test are represented in subsection D of table 6, confirmed the asymmetry in both the short and long run as the significant p-value rejects the null hypothesis, which is below the 5% level of significance. Subsection E depicts that the value of heteroskedasticity and serial correlation shows that the study is free from correlation in residuals and the absence of heteroskedasticity in the model, as supported by

(Kumar, 2024) and the Ramsey RESET test, which show no misspecification in the model.

As shown in Figure 7 and subsection E of Table 6, the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests, used by (Pesaran & Shin, 1999), are stable.

Conclusion and Policy Recommendations:

This study employs the NARDL model to investigate the asymmetric relationship between digital transactions and GSTR in India from 2018M07 to 2024M08, breaking variables into positive and negative shocks. The empirical findings indicate that positive changes in UPI are positive and marginally significant, while negative changes are insignificant, and DW also exhibits asymmetry, with negative shocks in DW being significant and positively affecting GSTR, but positive changes are not significant. However, the NEFT did not depict the asymmetric relationship because both changes are significant and have a positive impact on GSTR. It demonstrates that economic variables do not always have a linear effect, whereas other studies ignore nonlinear effects. Moreover, the tax compliance factors EWB and TRF are significantly and respectively associated with a positive and negative change in GSTR. This research conceptually enhances the understanding by illustrating that the relationship between digitalization and tax revenue is not symmetric or linear based on the (Allingham & Sandmo, 1972) and slippery slope framework (Kirchler et al., 2008). Further, it indicates that tax compliance factors are not substitutable, since transaction-based (EWB) and filing-based (TRF) statistics reveal divergent, even contradictory, relationships with revenue. From a policy perspective, given UPI's preeminent and nonlinear role, policymakers ought to regard it as a separate policy objective instead of consolidating it with other digital payment methods. Moreover, the negative TRF depicts that the extent of filings alone is an inadequate compliance measure and that assessing the value, rather than merely the quantity, of filings may more accurately reflect authentic revenue increases. This research is constrained by its comparatively small sample size in relation to the number of variables and its emphasis on a single nation, potentially restricting generalizability. Furthermore, as with most cointegration-based time-series approaches, the results identify robust dynamic associations and asymmetries rather than strictly causal effects, given the potential for reverse causality and omitted-variable influences between digitalization and tax administration. Further investigations may broaden this paradigm that includes state-level GST data or go deeper into the TRF-revenue association, for example, by analyzing filings based on taxpayer size.

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