# India's Paperless Border Paradox: Evidence from Empirical Estimations

Sovini Mondal[1] and Sanjib Pohit[2]

National Council of Applied Economic Research (NCAER)

## ABSTRACT

A nation's efficient participation in global supply chains and accelerated economic growth are driven by trade facilitation. Paperless trade has been a significant reform under the WTO's Trade Facilitation Agreement. Quantifying its potential efficiency in global trade dynamics is essential for informed policy. Therefore, this study undertakes an empirical estimation from India's perspective to understand how the paperless and cross-border paperless reforms have enhanced its efficiency in countries' export–import movements over its other major trading partners. Central to the paper's argument, the study reveals a paradox in paperless-border realities. While this paper captures the positive implications of the reforms, it also highlights the key challenges that hinder the seamless movement of cargo across borders. This study also identifies bottlenecks and highlights an asymmetric pattern of efficiency gains for India, depending on the size of its partner countries' economies. Therefore, strengthening cross-border interoperability and digital and physical infrastructure is essential to ensure that India's paperless trade reforms translate into faster, cheaper, and more reliable trade flows with key partners.

***Keywords***: trade facilitation, paperless trade, cross-border digitalisation, logistics performance, export competitiveness, digital infrastructure, globalisation, economy, World Trade Organisation (WTO) Trade Facilitation Agreement

***JEL Classification***: F13, F14, F15, O24, O53, C23, L86

## 1. Introduction

The historic negotiation of the India-European Union Free Trade Agreement (FTA) marks a turning point in India's integration into global trade. Though tariff reduction is the central key to the agreements, the success of these agreements will depend on India's capacity to efficiently and effectively facilitate the seamless movement of merchandise goods across international borders. In today's world of deeply integrated supply chains, power play, and rising compliance costs, trade competitiveness is determined not just by market access but also by the quality of border infrastructure and the strength of digital trade facilitation infrastructure (Jin & Pan, 2025).

In the context of India's ambition to emerge as one of the world's leading manufacturing hubs and a major, stable trade partner, reducing trade costs through procedural simplification and digitalisation has become a strategic necessity (Kumar, 2024; Banerjee, Mukherjee, & Srishti, 2024). Digitalisation will

[1] smondal@ncaer.org, [2] spohit@ncaer.org

enhance the seamless movement of containers across borders, reducing paperwork and shortening clearance times. Therefore, it depends on the functions of speed, predictability, and data interoperability, which require high-quality paperless trade infrastructure and fully digitalised border infrastructure. Henceforth, next-generation trade facilitation, predominantly paperless and cross-border, has emerged as a significant factor, meeting global trade facilitation (TF) standards and further enabling greater participation in international trade integration (Banga, 2019).

However, India has made significant progress in this area since ratifying the World Trade Organisation's Trade Facilitation Agreement (TFA) in 2016 (WTO, 2016). Reforms such as the Single Window Interface for Facilitating Trade (SWIFT), e-SANCHIT, electronic risk management systems, Direct Port Delivery, and the Authorised Economic Operator program have extensively modernised customs administration (Reddy, 2019).

These initiatives have been further supported by the formation of the National Committee on Trade Facilitation and the implementation of the National Trade Facilitation Action Plan (2024-2027) (UNCTAD, 2024), indicating continued institutional commitment to digital trade reform. Together, these measures provide a coherent framework that aligns domestic reforms with global best practices. They also signal to international partners that India is serious about reducing transaction costs and enhancing transparency in cross-border trade. Such initiatives have led to improved performance on the Logistics Performance Index (LPI) over time (see Figure 1).

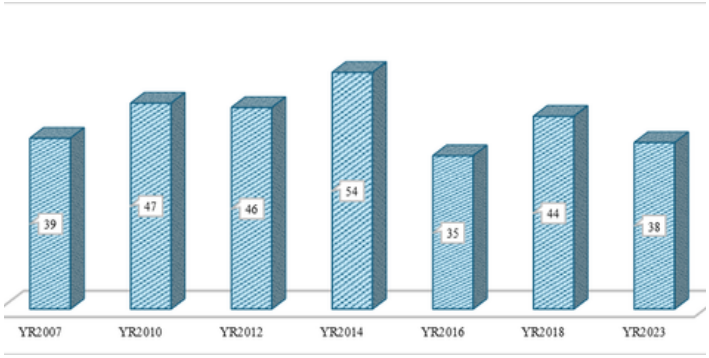


Figure 1: Logistics performance index:
Overall rank for India over the years measured from 2007-2023.

*Source: World Development Indicators (WDI), Author's own research*

Beneath this hopeful narrative of a seamless, paperless trade environment, however, lies a persistent and frequently disregarded factor that continues to hinder Indian trade: the quality of border infrastructure. At India's border points, paperless trade systems are anything but universal, even though they work well along the main trade routes and gateway ports. Lack of reliable internet access, sufficient digital infrastructure, and agency-level standardisation remain commonplace in many locations (Banga, 2019). When shipments leave the main customs terminals, traders are frequently forced to resort to manual systems because electronic documentation is ineffective beyond the port gates (De & Saji K, 2025).

To investigate these aspects, this paper conducted a thorough literature review to examine India's paperless trade efficiency and the responses of its major partner countries to smooth cargo movements. Therefore, the immediate question the current paper aims to address is: "Has India's EXIM movement gained from the digitalisation and paperless services, or are there gaps persisting, leading to a challenge in its efficiency?" By

utilising panel data that includes India and its most important trading partners, which cover up to 90% of India's overall import and export activities, the overall relationship that exists between trade facilitation performance, logistics connectivity, trade values, and exchange rates is explored when focusing on the value that India does or does not gain from digital trade.

In doing so, it also enriches the literature on trade facilitation and digital trade, while bringing valuable policy insights on how India's trade diplomacy, including its unprecedented partnerships with the EU, can be benchmarked against its border preparedness.

The rest of the paper is organised into five sections. This section introduces the research context and significance. Section 2 reviews the existing literature and identifies key gaps, highlighting the conceptual aspects of paperless trade and its empirical evidence. Section 3 outlines the data sources and methodology used to assess the efficiency in paperless trade for India and its major trading partners. Section 4 presents the empirical results and their implications. Section 5 concludes with key insights and policy recommendations to enhance the implementation of paperless trade, along with a forward-looking policy implication.

## 2. Review of Literature

### 2.1 Institutional Foundations of Paperless Trade and Digital Trade Facilitation

The digitalisation of trade and paperless trade are two essential components of TF, referring to the replacement of manual documentation procedures with electronic data exchange systems via an electronic single window, automated customs processes, and interoperable data platforms across different agencies linked to the process (Duval & Mengjing, 2017; Civelek et al., 2017). This streamlines border compliance costs, customs clearance, and logistics coordination across the jurisdiction (Duval, Utoktham, & Kravchenko, 2018).

However, these reforms reduce compliance costs, information asymmetries, procedural uncertainty, and market-entry costs, thereby enhancing firms' participation in the international market. The WTO Trade Facilitation Agreement formalised these principles by making transparency, e-documentation, and risk-based border management the significant components of this reform (WTO, 2013).

Many studies highlight the disproportionate gains from such reforms; nations characterised by high trade costs and substantial 'red tape' benefit most, leading to better integration into regional and international supply chains (Ajewumi, Afolabi, & Joe-Akunne, 2024). Whilst the efficiency benefits rich countries, developing countries, least developed countries (LDCs), and landlocked developing countries (LLDCs) experience the most significant relative impact (Ali & Shakoor, 2020). Time-sensitive goods, global value chain (GVC) trade, and small firms are particularly responsive to such institutional improvements (De, 2023).

Both domestic governance capabilities and international regulatory standardisation influence the institutions driving the development of paperless trade. The provisions on electronic documents in instruments such as the Revised Kyoto Convention, the ASEAN Single Window, and the UNCITRAL Model Law on EDI demonstrate how legal recognition of electronic

documents enables cross-border interoperability (ALsheyab, 2025).

These steps reframe paperless trade not merely as a technical innovation, but as an institutionally driven process through which reform can create new structural opportunities to enhance trade competitiveness and participation in global markets (Khan, 2024). Whilst such initiatives highlight the positive implications of the reforms, significant challenges remain in translating these reforms into reality.

## 2.2 Review of India's Paperless Trade Opportunity vs Hurdles

The positive implications of electronic document submission include reduced risk-based inspections and digital payments, which, in turn, reduce border delays and enhance export competitiveness, particularly in time-sensitive, GVC-oriented trade (De, 2023). Capturing this perspective, India's digital customs modernisation represents a structural opportunity to deepen integration with the EU while strengthening domestic logistics efficiency.

Although the process appears seamless, a set of persistent constraints lies beneath the surface. Paperless trade can only be fully successful if implemented with strong infrastructural support (Senyo, Effah, & Osabutey, 2021; Bassa, Kwateng, & Kamewor, 2021). Such infrastructure is absent in practice. Whilst digital platforms operate effectively at major maritime gateways, TF outcomes exhibit an asymmetrical balance across Container Freight Stations (CFS), Inland Container Depots (ICDs), Integrated Check Posts (ICPs), and land borders, owing to weak infrastructure leading to congestion, constrained road and rail connectivity, limited laboratory infrastructure, and capacity shortages, resulting in continued delays in cargo release (De & Saji K, 2025). Inadequate physical infrastructure, therefore, undervalues the potential of digital reforms (Manny et al., 2021), which in turn necessitates a manual documentation process.

The underutilisation of information and communication technologies (ICTs) presents a parallel challenge. Even though electronic filing and clearing have been institutionalised in ICEGATE and the DGFT systems, hybrid methods are still utilised in many of India's ports and land borders, which reduces their efficiency advantage (Banga, 2019). The inability of ICT systems to communicate, comprehend, and leverage trade-related data, referred to as Technical Interoperability, however, assumes legal force (Banerjee & Sanganeria, 2023). These highly fragmented software architectures across Customs, Port Authorities, and Participating Government Agencies affect the readiness levels for cross-border data exchange and domestic integration (LPAI, 2022).

These problems compound, especially in cross-border paperless trade, because of the lack of coordination across different national legal and regulatory frameworks and technology platforms (Chang, Iakovou, & Shi, 2019). Moreover, it has been observed, based on international experience, that the advantages accrued through digital 'Certificate of Origin' systems, SPS e-certificates, electronic Bills of Lading, and electronic Customs Declarations would be achieved through harmonised data standards, platforms, and mutual legal recognition, as has been pointed out in. Even with improvements achieved through the SWIFT and DGFT systems, exporters from various FTA/PTA regions in India remain at a disadvantage, as they must

still comply with physical documentation due to regulatory and acceptance issues encountered with these systems (De & Saji K, 2025).

Therefore, the literature converges on a critical insight: while India's paperless trade reforms are part of a broader institutional transformation, they are constrained by significant economic consequences. Digitalisation will not deliver seamless trade unless it is embedded within a harmonised physical, legal, and institutional ecosystem. This underlines significant gaps in policy interventions and the hidden structural frictions. In view of the above, this paper empirically re-evaluates whether paperless trade and cross-border digital facilitation reforms at the frontier actually translate into measurable gains in export and import performance for India by applying a gravity-inspired model across India's major trading partners.

## 3. Empirical Strategy and Summary Statistics

This study employs a gravity-inspired framework with high-dimensional fixed effects within a Poisson Pseudo-Maximum Likelihood estimator. Fixed effects are used to control for unobserved time-invariant differences across countries. The time-varying country differences allow us to identify the relationship between trade facilitation and trade performance. Although we concentrate on exports and imports to the global market at the country level rather than the bilateral flow, the PPML intuition remains true: the overall volume of trade represents the combined impact of economic size, trade costs, logistical friction, and institutional efficiency in forming a nation's trading network (Baltagi, Egger, & Erhardt, 2024). Therefore, to capture how paperless and digital trade facilitation affected the overall trade performance of India and its most significant trading partners, we grounded a dataset based on an extensive literature review to align with the paper's core arguments. Likewise, the variables are selected to capture both policy-level reforms and intrinsic trad drivers, while remaining consistent with the theoretical structure. The following subsection explores the selection of a particular variable and how that contributes to illuminating trade facilitation dynamics.

### 3.1 Empirical Models

The dependent variables, ‘y ’, such as exports and imports, are expressed as functions of logistics performance, macroeconomic fundamentals, and indicators of institutional and digital trade facilitation.

$$y_{i,t} = f(LPI_{i,t}, RGDP_{i,t}, ER_{i,t}, PL_{i,t}, CBPL_{i,t}, SCI_{i,t}, EoDB_{i,t}, Expected\_time_{i,t}) \quad \ldots. (1)$$

$$y_{i,t} = \alpha + \beta(\text{Macro Economic Terms})_{i,t} + \vartheta(\text{Logistics Parameters})_{i,t} + \theta(\text{India} * X)_{j,t} + \delta_t + \tau_t + \varepsilon_{i,t} \quad \ldots. (2)$$

where *i* denotes partner countries, and t denotes time. India × Xj,t, where “j” represents the India specific India’s paperless, cross-border trade, LPI and EoDB responsiveness differs from the global baseline effects captured by θ, ensuring that country-level differences are captured within a unified framework while preserving the efficiency and consistency of the full-sample estimation. α is the fixed coefficient. β are the coefficients for RGDP and exchange rate, and ϑ are the coefficients for the rest of the logistics parameters. The model incorporates time-fixed effects $\delta_t$, country-specific annual time trends $\tau_t$, and an error term $\varepsilon_{it}$.

The log form is used in this model, except for the score variables, and the data has undergone stationarity checks. All variables are described in Table 1.

Table 1. Variable Description and Sources

| Variable | Description | Category | Source |
|---|---|---|---|
| Export | Global export to the world. The paper considers the log form of export | Dependent Variable | WITS, UNCTAD |
| Import | Global import to the world. The paper considers the log form of import | Dependent Variable | WITS, UNCTAD |
| LPI | The Logistics Performance Index (LPI) score evaluates how effectively countries manage trade logistics by assessing areas such as customs efficiency, infrastructure quality, shipment arrangement, logistics services, tracking systems, and delivery timeliness. | Independent Variable | WDI |
| RGDP | Real Gross Domestic Product. The paper considers the log form of RGDP | Independent Variable | World Bank |
| ER | Real Effective Exchange Rate. The paper considers the log form of the exchange rate | Independent Variable | WDI |
| PL | Paperless trade in % | Independent Variable | Global Trade Facilitation Survey, UNESCAP. |
| CBPL | Cross-border Paperless trade in % | Independent Variable | Global Trade Facilitation Survey, UNESCAP. |
| SCI | Linear Shipping Connectivity Index | Independent Variable | UNCTAD |
| EoDB | Ease of arranging competitively priced international shipments, score (1=low to 5=high) | Independent Variable | WDI |
| Expected _time | Frequency with which shipments reach the consignee within the scheduled or expected time, score (1=low to 5=high) | Independent Variable | WDI |

*Source: Authors' compilation*

By including country fixed effects, the approach effectively adjusts for quirks that might not change much over time in India or its trading partners. The intention is that the results now depend only on changes over time in each country, not on how the countries compare with each other. Adding year fixed effects helps address global shocks, business cycle fluctuations, and changes in the pattern of international trade, thereby reducing the significance of omitted variables. Most importantly, the fixed-effects approach helps address endogeneity, particularly reverse causality from trade flows to policy changes in areas such as logistics or digital facilitation, by using the time dimension within each country rather than the cross-country dimension. The fixed-effect version of the PPLE approach therefore provides a robust framework for estimating model results.

Therefore, this enables us to examine the effects of paperless trade facilitation, digital border processes, and logistics performance on India's exports and imports, while controlling for broad macroeconomic fundamentals and structural trade frictions. Doing so, we estimate whether improvements in trade facilitation generate differential export and import gains for India relative to other countries. At the same time, export and import parameters are the most appropriate variables for achieving the research objectives, as they represent the most direct and policy-relevant measures of a country's integration into the global market and the outcomes of TF reforms.

For our purposes, the Logistics Performance Index (LPI) serves as an essential driver, reflecting the efficiencies achieved with customs, timely shipment, tracking/tracing, and the quality of services provided. However, LPI fails to provide direct measures

regarding the efficiencies sought to be achieved through the implementation of paperless or digital trade; hence, specific measures for paperless trade and its cross-border processes are sought to be included.

Time-related trade costs are also incorporated in the model. Including the Liner Shipping Connectivity Index will enable us to assess the world's integration into global shipping connectivity. At the same time, the ease of doing business score reflects the broader operating environment. We also control major macroeconomic indicators, such as real GDP, to measure the size of the economy and the exchange rate to measure relative price competitiveness.

Additionally, India-specific interaction terms are incorporated into the model specification, and these coefficients are estimated from the global baseline effects, ensuring that country-level differences are captured within a unified framework while preserving the efficiency and consistency of the full-sample estimation. The India dummy is absorbed by country fixed effects and therefore omitted; however, interaction terms remain identified and capture India-specific marginal effects. Incorporating interaction terms, it allows a systematic comparison between India's trade responses and the panel average.

### 3.2. Variables and Summary Statistics.

In line with the objectives of our research, we proceed with Poisson pseudo-maximum likelihood (PPML) regression with high-dimensional fixed effects to account for heteroscedasticity and autocorrelation, yielding consistent and robust estimates of trade flows.

From a methodological perspective, our analysis employs a balanced panel data set, where the number of partner countries in the export equation and the import equation are 48 and 31, respectively, which represents 90% of total merchandise flows from and to India based on the FY 2024 in six time periods, namely 2010, 2012, 2014, 2016, 2018, and 2023. However, the selection of time periods was mainly guided by the availability of data on LPI indicators. The dataset has been collected from various reliable sources worldwide, including the World Bank, UNCTAD, WITS, UNESCAP's Global Trade Facilitation Survey, and the World Development Indicators database (WDI). Given that Table 2 summarises the statistics for both models.

Table 2. Summary Statistics

| *Variables* | *Mean (Export)* | *St. Dev (Export)* | *Mean (Import)* | *St. Dev (Import)* |
|---|---|---|---|---|
| Export | 18.58 | 1.82 | | |
| Import | | | 19.15 | 1.3 |
| LPI | 3.29 | 0.57 | 3.34 | 0.53 |
| RGDP | 26.72 | 1.67 | 27.39 | 1.37 |
| ER | 4.59 | 0.17 | 4.58 | 0.15 |
| PL | 0.52 | 0.5 | 0.55 | 0.49 |
| CBPL | 0.45 | 0.12 | 0.51 | 0.23 |
| SCI | 47.63 | 29.65 | 50.21 | 30.66 |
| EoDB | 3.19 | 0.48 | 3.23 | 0.43 |
| Expected time | 3.65 | 0.53 | 3.72 | 0.47 |

*Source: Authors' own calculation.*

*Note: export is based on 336 observations, and import is based on 217 observations for each parameter*

## 4. Results and Discussions

#### 4.1.1. Results from the Diagnostics Test – Export Model

The diagnostic tests for the export model provide clear guidance for model specification (see Table 3). The VIF (2.77) results confirm the absence of multicollinearity, while the Breusch–Pagan LM test (12.73, p = 0.0004) indicates heterogeneity. However, the Wooldridge (0.31, p = 0.000) and Pesaran CD tests (1.56, p = 0.002) reveal the presence of serial correlation and cross-sectional dependence, suggesting strong temporal persistence and spatial linkages across units.

The Hausman test ($\chi^2$ = 15.83, p = 0.000) decisively favours the fixed-effects specification, underscoring the importance of accounting for unobserved heterogeneity correlated with the regressors.

Table 3: Diagnostic Checks for Export Model

| ***Tests*** | ***Objective to Check*** | ***Statistic*** | ***P-value*** | ***Decision*** |
|---|---|---|---|---|
| VIF | Multicollinearity | 2.77 | | No Multicollinearity |
| Breusch Pagan | Heteroskedasticity | 12.73 | 0.0004 | Heteroscedastic |
| Wooldridge test | Autocorrelation | 0.31 | 0 | Serial Correlation |
| Pesaran CD Test | Cross-sectional dependence | 1.56 | 0.002 | Cross-Sectional Dependence |
| Hausman Test | Determining Fixed or Random Effects | 15.83 | 0 | Fixed Effect |

*Source: Author's own work*

### 4.1.2. PPML Model Estimation with India Export-specific Implications

Table 4 presents the empirical estimates from the panel model, revealing that countries' export performance is powerfully shaped by logistics efficiency, paperless trade, and macroeconomic size. In comparison, these estimates were captured by three models, which reconfirm its robustness as an estimator. Across, the OLS, two-way fixed-effect model, and preferred PPML specification ensure that real GDP reflects the economic size, which has a strong, positive, and significant effect on exports. Thereby confirming the core prediction of the gravity theory that larger economies lead to more trade.

Table 4. Export Model Results

| | ***OLS*** | ***Two-Way Fixed Effect*** | ***PPML*** |
|---|---|---|---|
| | *ln_export* | *ln_export* | *ln_export* |
| *eodb* | *0.867*** | *0.257*** | *0.0159** |
| | *(-0.346)* | *(-0.13)* | *(-0.00925)* |
| *expected_t~e* | *1.083**** | *0.232* | *0.0128* |
| | *(-0.361)* | *(-0.14)* | *(-0.00983)* |
| *pl* | *0.161*** | *0.098*** | *0.023** |
| | *(-0.067)* | *(-0.042)* | *(-0.033)* |
| *cbpl* | *0.112* | *0.014* | *0.009* |
| | *(-0.03)* | *(-0.023)* | *(-0.01)* |
| *lpi* | *1.178*** | *0.184*** | *0.00891**** |
| | *(-0.491)* | *(-0.296)* | *(-0.0201)* |
| *sci* | *0.00854**** | *0.00232 **** | *0.000183**** |
| | *(-0.00269)* | *(-0.004)* | *(-0.00031)* |
| *ln_rgdp* | *0.663**** | *0.985**** | *0.0589**** |
| | *(-0.0429)* | *(-0.177)* | *(-0.0229)* |
| *ln_er* | *0.178* | *0.0813* | *-0.0128* |
| | *(-0.436)* | *(-0.177)* | *(-0.0182)* |
| *india_pl* | | | *0.0261* |
| | | | *(-0.044)* |

| | | | |
|---|---|---|---|
| *india_cbpl* | | | *0.007* |
| | | | *(-0.011)* |
| *india_lpi* | | | *0.0404** |
| | | | *(-0.0562)* |
| *india_eodb* | | | *0.0192*** |
| | | | *(-0.0187)* |
| *_cons* | *-3.254* | *-9.190*** | *1.334*** |
| | *(-2.347)* | *(-4.613)* | *(-0.584)* |
| *r2_w* | | | *0.368* |
| *r2_b* | | | *0.759* |
| *r2_o* | | | *0.753* |
| *chi2* | | | *168* |

*Source: Author's estimation*

*Note: Standard errors in parentheses* p<0.10, ** p<0.05, *** p<0.01*

Beyond this, the ease of doing business, LPI, shipping index, and paperless trade have the potential to impact, suggesting that any improvement in regulation, digitalisation, and administration directly translates into tangible export gains. On the flip side, the estimated effect of the expected border processing time loses significance in the PPML model, indicating that cross-border processing delays, which are precisely the real-world challenge that multiple developing nations are struggling with. This picture is even more accurate for India, where, across multiple ICEGATEs, asymmetric infrastructure leads to substantial delays and inefficient reductions in dwell times at major ports and customs points, leaving exporters to face continued bottlenecks (Banerjee & Sanganeria, 2023). This friction limits trade efficiency and isolates its gains, suggesting the need for uniform, systemic reforms across all borders.

In India, ease of doing business and the LPI index score have a positive and significant impact on overall exports (see Table 5). Still, there is limited evidence of the significant positive implications of India's paperless, cross-border trade. This again reconfirms that, though digital platforms and other reforms like e-SANCHIT, faceless assessment, SWIFT, and digital bills of entry have a positive impact on the country's LPI structure, they do not significantly translate into the country's (India's) export story. Therefore, for India, where trade deals are important, this also has equal importance in uplifting its infrastructure, which does not just restrict to major ports but also its administrations, customs clearance points, a harmonised legal framework, and e-documentation with more transparent data interpolation to capture infrastructural gaps more prominently.

Table 5: Interpretation of Import Scenarios by Elasticity.

| ***Interpretation expressed as a unit improvement in these parameters' performance translates the increase/decrease in Export by:*** | | | |
|---|---|---|---|
| ***Variable*** | ***All-Countries Effect*** | ***India-Specific Effect*** | ***Explanations*** |
| *Ease of Doing Business* | *↑ 1.6%* | *↑ 1.9%* | *Regulatory efficiency consistently boosts export performance.* |
| *Expected Clearance Time* | *↑ 1.3%* | *-* | *Faster border processing improves export competitiveness.* |
| *Paperless Trade* | ***↑ 2.3%*** | *↑ 2.6%* | *Digital procedures significantly enhance export efficiency. But for India, it loses its significance* |
| *Cross-Border Paperless Trade* | *↑ 0.9%* | *↑ 0.7%* | *Interoperability modestly strengthens export flows, but it doesn't represent its significant contribution here.* |

| | | | |
|---|---|---|---|
| *Logistics Performance Index* | ↑ ***0.9%*** | ↑ ***4.04%*** | *Logistics improvements strongly promote India's and Global exports.* |
| *Linear Shipping Index* | ↑ ***0.02%*** | - | *Better maritime connectivity marginally raises exports.* |
| *GDP* | ↑ ***5.8%*** | - | *Economic growth expands export supply capacity.* |
| *Exchange Rate (₹/$)* | ↓ ***1.2%*** | - | *Currency depreciation may reduce exports if production relies on imported inputs.* |

*Source: Based on the authors' own calculation.*

*Note: The bold figures show the significance based on the PPML model estimation*

Henceforth, the results indicate that although there is a mean level of digitalisation at Indian ports, it often reverts to manual or paper verification, both domestically and in partner countries, particularly in landlocked countries. This fragmentation is particularly costly compared to advanced economies, where regulatory requirements are stringent and digital authentication is strictly enforced. Therefore, to meet the regulatory standards of the EU, UK, Russia and USA, which are the major export markets for India, requires deepening institutional readiness for truly seamless, digitally enabled cross-border commerce is essential.

### 4.2.1. Results from the Diagnostics test – Import Model

The diagnostic tests for the import model are given in Table 6. The results confirm the absence of multicollinearity, indicating heteroscedasticity and autocorrelation and suggesting a fixed effect model.

Table 6: Diagnostic Checks for Import Model

| ***Tests*** | ***Objective to Check*** | ***Statistic*** | ***P-value*** | ***Decision*** |
|---|---|---|---|---|
| VIF | Multicollinearity | 3.37 | | No Multicollinearity |
| Breusch Pagan | Hetero-skedasticity | 4.79 | 0.02 | Heteroscedastic |
| Wooldridge test | Autocorrelation | 0.56 | 0 | Serial Correlation |
| Pesaran CD Test | Cross-sectional dependence | 2.69 | 0 | Cross-Sectional Dependence |
| Hausman Test | Determining Fixed or Random Effects | 18.16 | 0.0059 | Fixed Effect |

*Source: Author's own work*

### 4.2.2. PPML Model Estimation with India Import-specific Implications

Table 7 presents the import model estimates, along with OLS and two-way fixed-effect estimates. The results show that macroeconomic factors remain the dominant drivers of India's inward trade flows. The partnering countries' GDP had a positive, highly significant effect in this specification. This therefore aligns with the gravity model prediction and highlights that India's import demand continues to be shaped by the market size and production complementarities with trading partners, particularly the advanced partner economies.

The import model shows that the exchange rate has a positive and significant impact, strongly indicating that currency movements, along with structural trade costs and institutional quality, play a role in determining India's sourcing patterns, unlike in the export model (see Table 5).

Table 7: Import Model Results

| | ***OLS*** | ***Two-Way Fixed Effect*** | ***PPML*** |
|---|---|---|---|
| | *ln_import* | *ln_import* | *ln_import* |
| *eodb* | *0.249* | *0.115* | *0.00523* |
| | *(-0.285)* | *(-0.151)* | *(-0.00558)* |
| *expected_t~e* | *0.384* | *-0.0311* | *-0.0144** |
| | *(-0.348)* | *(-0.189)* | *(-0.00842)* |
| *pl* | *0.032* | *0.021* | *0.0009* |
| | *(-0.721)* | *(-0.349)* | *(-0.013)* |
| *cbpl* | *0.112* | *0.067* | *0.053* |
| | *(-0.03)* | *(-0.016)* | *(-0.009)* |
| *lpi* | *0.0567* | *0.0757* | *0.0226** |
| | *(-0.418)* | *(-0.342)* | *(-0.0125)* |
| *sci* | *0.00989**** | *0.00446* | *0.00057* |
| | *(-0.00165)* | *(-0.00519)* | *(-0.000493)* |
| *ln_rgdp* | *0.568**** | *0.743**** | *0.0501**** |
| | *(-0.0371)* | *(-0.237)* | *(-0.0147)* |
| *ln_er* | *0.249* | *0.352** | *0.00656** |
| | *(-0.274)* | *(-0.182)* | *(-0.00931)* |
| *india_pl* | | | *0.0456* |
| | | | *(-0.0128)* |
| *india_cbpl* | | | *0.0227* |
| | | | *(-0.0159)* |
| *india_lpi* | | | *-0.0699**** |
| | | | *(-0.0176)* |
| *india_eodb* | | | *0.0430**** |
| | | | *(-0.00887)* |
| *_cons* | *-0.502* | *-2.445* | *1.543**** |
| | *(-1.727)* | *(-6.17)* | *(-0.385)* |
| *r2_w* | | | *0.258* |
| *r2_b* | | | *0.599* |
| *r2_o* | | | *0.59* |
| *chi^2* | | | *120.94* |

*Source: Author's estimation*

*Note: Standard errors in parentheses * p<0.10, ** p<0.05, *** p<0.0*

Trade facilitation variables indicate significant time costs at borders and dampen India's imports. While the expected clearance time shows a negative, significant impact, suggesting that procedural and customs clearance delays act as a barrier to efficient border movements. This highlights India's persistent challenges with port dwell time and congestion at major gateways, such as Nhava Sheva and Chennai ports. Coordination gaps among customs, port authorities, and logistics providers further compound this. This manual execution of border processes still imposes a significant time cost on importers and results in overall delays in consignment movements.

Table 8: Interpretation of Import Scenarios by Elasticity

| **Interpretation expressed as a unit improvement in these parameters' performance translates the increase/decrease** | | | |
|---|---|---|---|
| ***Variable*** | **All-Countrie** | **India-Specific** | **Explanations** |
| *Ease of Doing* | ↓ 0.5% | ↑ **4.3%** | In India, it significantly |
| *Expected Clearance* | ↓ **1.4%** | - | Improving customs speed is equivalent to |
| *Paperless Trade* | ↑ 0.09% | ↑ 4.5% | Digitalisation intends to simplify import |

| | | | |
|---|---|---|---|
| *Cross-Border Paperless Trade* | ↑ 5.3% | ↑ 2.2% | Interoperability strongly stimulates import flows, which also requires infrastructural support to make a significant contribution. |
| *Logistics Performance Index* | ↑ **2.2%** | ↓ **6.9%** | Improved logistics raise global imports, but for India, it means that logistics improvements can substitute imports by making domestic supply chains more efficient and competitive. |
| *Linear Shipping Index* | ↑ 0.06% | - | Maritime connectivity slightly increases imports. |
| *GDP* | ↑ **5.01%** | - | Economic expansion raises demand for imported goods. |
| *Exchange Rate (₹/$)* | ↑ 0.6% | - | Depreciation increases import value due to inelastic demand for essential goods. |

*Source: Based on the authors' own calculation.*
*Note: The bold figures show the significance based on the PPML model estimation.*

Focusing on the India-specific interaction effects provides a critical insight (see Table 8). The positive coefficient on the India-paperless interaction indicates that digitalisation of customs and clearance procedures can materially improve India's import performance, but does not significantly translate into improved import efficiency. In contrast, the negative interaction between India and logistics performance underscores that physical infrastructure constraints continue to offset some of the gains from digital reforms and again hinder India's import efficiency. This divergence highlights a structural imbalance in India's trade facilitation trajectory. While institutional and procedural reforms are progressing rapidly, upgrades in ports, strengthening the internet across all borders, complete adoption of TIR for the container's movements, and functional animal and plant quarantine at all borders will improve the time cost, and this will be directly translated to the positive gains in India's overall trade dynamics.

## 5. Conclusion and Policy Recommendations

This study highlights that paperless trade and digitalisation have positive implications, but that efficiency is hindered in practice. India's trade competitiveness is not yet fully reflected in its growth story. Therefore, from a policy perspective, alongside digitalisation and other reforms, India should invest in physical infrastructure that can serve as the backbone of trade facilitation.

Furthermore, India needs to bridge the gaps between agencies to enable the seamless movement of consignments. System-wide interoperability across port authorities, participating government agencies (PGAs), logistics service providers (LSPs), firms, and, most importantly, customs administration should be accelerated, with a focus on standardised, data-driven integration that reduces risk, manual documentation, and associated costs.

Additionally, India should strengthen its cross-border legal and technical systems through more intensified engagement with the UNESCAP Framework

Agreement on Cross-Border Paperless Trade. This initiative should be more focused on landlocked countries, which account for a significant share of India's total trade.

Finally, India should engage more actively in bilateral and FTA-based trade deals, as well as in the mutual recognition of electronic certificates of origin, SPS certifications, and electronic Bills of Lading. Collectively, these measures will contribute to India's trajectory towards a more efficient and sustainable supply chain.

*Disclaimer: The views expressed herein are based on the authors' estimations and do not reflect the views of NCAER.*

# Appendix

## Appendix A: India's Major Exporting Partners Constitute 90% of Its Total Exports to the World based on WITS data 2024

| India's Major Exporting Partners Constitute 90% of Its Total Exports to the World. | | |
|---|---|---|
| Australia | Iraq | Qatar |
| Austria | Israel | Russia |
| Bangladesh | Italy | Saudi Arabia |
| Belgium | Japan | Singapore |
| Brazil | Kenya | South Africa |
| Canada | Korea | Spain |
| China | Kuwait | Sri Lanka |
| Colombia | Malaysia | Switzerland |
| Czech Republic | Mexico | Tanzania |
| Egypt, Arab Rep. | Mozambique | Thailand |
| France | Nepal | Togo |
| Germany | Netherlands | Turkey |
| Ghana | Nigeria | UAE |
| India | Oman | UK |
| Indonesia | Philippines | USA |
| Iran, Islamic Rep. | Poland | Vietnam |

*Source: Author's Compilation*

**Appendix B: India's Major Importing Partners Constitute 90% of Its Total Imports from the World based on WITS data 2024**

| India's Major Importing Partners Constitute 90% of Its Total Imports from the World. | | |
|---|---|---|
| Angola | Italy | Saudi Arabia |
| Argentina | Japan | Singapore |
| Australia | Korea | South Africa |
| Brazil | Kuwait | Switzerland |
| Canada | Malaysia | Thailand |
| China | Mexico | UAE |
| France | Nigeria | United Kingdom |
| Germany | Oman | United States |
| India | Peru | Vietnam |
| Indonesia | Qatar | |
| Iraq | Russia | |

*Source: Authors' Compilation*

## References


- Ajewumi, O. E., Afolabi, J. A., & Joe-Akunne, I. (2024). Regional trade agreements and economic integration in Africa: assessing the impact of the African Continental Free Trade Area (AFCFTA). World Journal of Advanced Research and Reviews.

- Ali, W., & Shakoor, N. (2020). The Impact of Trade Facilitation on Trade Flow in Asian Countries. Journal of Business & Financial Affairs.

- ALsheyab, M. S. (2025). Legal analysis of the merits of electronic transferable records: toward cross-border trade digitalization. International Journal of Law and Management, 67 (1): 145–163.

- Baltagi, B. H., Egger, P. H., & Erhardt , K. (2024). The Econometrics of Gravity Models in International Trade. The Econometrics of Multi-dimensional Panels, pp 381–412.

- Banerjee , P., & Sanganeria, A. (2023). Strengthening Regional Integration in South Asia: Towards Highly Facilitated Trade Corridors. Journal of Land Ports and Border Economy.

- Banerjee , P., Mukherjee, A., & Srishti , A. (2024). E-commerce in trade agreements: India's strategies and options. ASIA-PACIFIC RESEARCH AND TRAINING NETWORK ON TRADE - Working Paper.

- Banga, R. (2019). Is India Digitally Prepared for International Trade? Economic & Political Weekly.

- Bassa, L., Kwateng, K. O., & Kamewor, F. T. (2021). Paperless custom clearance and business supply chains. Marine Economics and Management .

- Chang, Y., Iakovou, E., & Shi, W. (2019). Blockchain in global supply chains and cross border trade: a critical synthesis of the state-of-the-art, challenges and opportunities. International Journal of Production Research .

- Civelek, M. E., Çemberci, M., Uca, N., Çelebi, Ü., & Özalp, A. (2017). Challenges of Paperless Trade Redesign of the Foreign Trade Processes and Bundling Functions of Traditional Documents. International Business Research.

- De, P. (2023). Unlocking the GVC Potentials in India: Role of Trade Facilitation. In Risks and Resilience of Emerging Economies. Retrieved from http://link.springer.com/chapter/10.1007/978-981-99-4063-9_5

- De, P., & Saji K, A. (2025). Paperless Trade Facilitation in India: Achievements, Challenges and Opportunities. RIS Discussion Paper Series.

- Duval, Y., & Mengjing, K. (2017). Digital trade facilitation: Paperless trade in regional trade agreements. ADBI Working Paper, No. 747, Asian Development Bank Institute (ADBI), Tokyo.

- Duval, Y., Utoktham, C., & Kravchenko, A. (2018). Impact of implementation of digital trade facilitation on trade costs. ARTNeT Working Paper Series, No. 174, Asia-Pacific Research and Training Network on Trade (ARTNeT), Bangkok.

- Jin, P., & Pan, Q. (2025). The Impact of Digital Trade Barriers on Global Value Chains: A Perspective from Developing Countries. Global Academic Frontiers. doi:https://doi.org/10.5281/zenodo.15581881

- Khan, A. (2024). The Emergence of the Fourth Industrial Revolution and its Impact on International Trade. ASR: CMU Journal of Social Sciences and Humanities .

- Kumar, N. (2024). Manufacturing-led transformation for realizing India's 2047 Vision in the context of a fractured trading system: challenges, opportunities, and strategic interventions. Indian Economic Review.Kumar, N. (2024). Manufacturing-led transformation for realizing India's 2047 Vision in the context of a fractured trading system: challenges, opportunities, and strategic interventions. Indian Economic Review.

- LPAI. (2022). Strengthening Border Connectivity at India-Myanmar Border. Land Ports Authority of India (LPAI), New Delhi.

- Manny, L., Duygan, M., Fischer, M., & Rieckermann , J. (2021). Barriers to the digital transformation of infrastructure sectors. Policy Science.

- Reddy, S. (2019). India. In M. Abdou, R. Butiong, U. Kumar, & B. Shepherd, Borders Without Barriers Facilitating Trade in SASEC Countries. Asian Developmental Bank (ADB).

- Senyo, P., Effah, J., & Osabutey, E. L. (2021). Digital platformisation as public sector transformation strategy: A case of Ghana's paperless port. Technological Forecasting & Social Change.

- UNCTAD. (2024). Status and Outlook for National Trade Facilitation Committees . United Nations Conference on Trade and Development.

- WTO. (2013). Trade facilitation. Digital technologies and trade.

- WTO. (2016, April 22). India ratifies Trade Facilitation Agreement.