

Supply Chain De-Bottlenecking and Inventory Turnover: Evidence from The Indian Automobile and Pharmaceutical Sectors

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Abstract—This paper investigates whether the elimination of inter-state check-posts and the absorption of the Central Sales Tax (CST) under India's Goods and Services Tax (GST) framework yielded a statistically significant, structural improvement in inventory turnover and logistics efficiency. Using Automobile and Pharmaceutical manufacturing sectors as comparative cases, the study analyses standalone financial data from 20 listed companies (10 per sector) across a seven-year timeline (FY2015–FY2021). The study critically analyses three key variables namely, the Inventory Turnover Ratio (ITR), Days of Inventory Held (DIH) and Logistics and Freight Expenses as a percentage of Total Costs, across three different operational horizons namely, pre-GST (3 years), transition (1 year) and post-GST (3 years). Using repeated-measures ANOVA and paired-sample tests (Wilcoxon Signed-Rank and Paired t-tests), the findings indicate a sector-specific, divergent impact with no uniform structural de-bottlenecking. In the immediate transition period, the Automobile sector showed a very significant increase in operational efficiency in inventory days, which was later masked by pandemic-adjacent disruptions and macroeconomic demand shocks. Theoretically, the consolidation within the pharmaceutical sector was expected to enhance inventory efficiency; however, this anticipated benefit was significantly undermined by unique supply chain vulnerabilities, reliance on Active Pharmaceutical Ingredients (APIs), and the strategic decision to maintain buffer stockpiles during the same timeframe. Therefore, the complexities associated with these factors led to a reduction in operational effectiveness, highlighting the multifaceted challenges confronting the industry during this period. Our findings indicate that the logistics de-bottlenecking effect of GST is real but susceptible to sectoral dynamics and macroeconomic confounds.

Index Terms—Central Sales Tax; Days of Inventory Held; Goods and Services Tax; Inventory Turnover

Ratio; Logistics and Freight Expenses; Supply Chain De-bottlenecking. JEL Classification H25, M11, L62, L65.

I. INTRODUCTION

The architecture of India's pre-GST indirect tax system structurally penalised the seamless movement of goods across domestic borders, dictating corporate supply chain configurations. Prior to the implementation of the Goods and Services Tax (GST) on 1 July 2017, the taxation framework was highly fragmented, comprising Central Excise Duty, State Value Added Tax (VAT), Entry Tax, Octroi, and the Central Sales Tax (CST). The CST, levied on inter-state commercial transactions, functioned as an origin-based tax that was not creditable against state VAT liabilities in the destination state, creating a cascading tax burden on goods moving across state lines.

To enforce this regime, state governments maintained physical border check-posts. Commercial freight carriers queued for manual verification of tax compliance, waybills, and statutory declaration forms (such as C-Forms and F-Forms). A pre-GST study by the Ministry of Road Transport and Highways estimated that long-haul trucks spent roughly twenty per cent of their transit time idling at inter-state check-posts [1]. This systemic inefficiency forced manufacturing firms to adopt sub-optimal supply chains. Rather than paying CST and enduring transit delays on inter-state sales, corporations responded by multiplying their warehousing footprint. Firms systematically established carrying and forwarding (C&F) depots in nearly every operational state, a pattern linked directly to the avoidance of cascading CST costs [2]. They avoided CST altogether by

treating the movement as an intra-state branch transfer by transferring goods to their own state-level warehouses and serving local markets directly.

The implementation of GST subsumed the CST and most localised taxes into a unified, destination-based structure. The logistical promise of this reform was the creation of a unified national market, allowing corporations to dismantle fragmented, state-wise warehouse networks in favour of strategically located regional hubs. However, the technological mechanism required to practically replace physical check-post verification the electronic waybill (e-way bill) system was implemented on a mandatory scale on 1 April 2018 [3]. Consequently, the fiscal year containing this gap (FY2018) represents a distinct operational transition phase rather than a clean structural break.

To evaluate the true supply chain impact of this reform, the Automobile and Pharmaceutical manufacturing sectors serve as optimal comparative subjects. Automobile production requires just-in-time (JIT) inventory management and is highly vulnerable to delays in inter-state transit. In theory, the reforms in the GST era enabled automobile manufacturers to restructure distribution networks, consolidate warehouse space and speed up the transit of finished vehicles. Conversely, Pharmaceutical firms possessed the most compelling structural imperative to consolidate post-GST, given their history of extreme CST-driven warehouse fragmentation across state lines. Because medicines are low-volume, high-value goods, pharma companies historically maintained highly decentralised inventory networks solely for tax arbitrage.

A. Objectives of the Study

- To examine whether the Inventory Turnover Ratio (ITR) and Days of Inventory Held (DIH) changed significantly across the Pre-GST, Transition, and Post-GST periods in the Automobile and Pharmaceutical sectors.
- To test whether Logistics and Freight Expenses as a percentage of Total Costs shifted significantly across the same time horizons.
- To comparatively evaluate the magnitude and direction of operational efficiency changes between a JIT-dependent sector (Automobiles) and a historically fragmented sector (Pharmaceuticals) over an extended seven-year timeline.

II. LITERATURE REVIEW

The existing literature in evaluation of GST and supply chain logistics is mostly bifurcated. Immediate post-implementation consultancy assessments primarily measured transit time, while academic commentary often described supply chain consolidation theoretically, lacking longitudinal empirical validation.

A. Indirect Taxation and Supply Chain Configuration

Historically, tax policy determines supply chain network design in developing economies. Research preceding the GST implementation consistently highlighted how India's complex tax web distorted supply chain decisions. Contemporaneous industry reports noted that while the unified tax launched in mid-2017, localised transit friction remained active until the national e-way bill enforcement in 2018 [4], [5]. Transporters reported that Regional Transport Office check-posts and local entry tax collections continued informally for months after July 2017. This critical context justifies the methodological decision in this paper to utilise a phased, three-period analytical design, isolating FY2018 as a transition year.

B. Working Capital and Inventory Management Dynamics

Academic precedent on firm-level financial ratios provides a robust foundation for empirical testing. Working capital management theory dictates that inventory conversion periods maintain a statistically rigorous relationship with overarching financial performance. A panel-data study of Indian manufacturing companies confirmed a significant interaction between firm size, working capital efficiency, and GST implementation in explaining post-reform profit margins [6]. Likewise, the inventory conversion period has been proved to be a major driver of corporate profitability in listed sectoral indices [7].

In the Indian corporate reporting, the adoption of Indian Accounting Standards (Ind AS), especially Ind AS 2 (Valuation of Inventories) has brought uniformity in reporting carrying costs, finished goods and work-in-progress by the manufacturing entities. The standardisation ensures that the longitudinal data extracted from Schedule III of the Companies Act, 2013 is a highly reliable metric to evaluate policy

shifts. However, existing literature frequently relies on consolidated financial statements, which include overseas subsidiaries operating outside the Indian tax jurisdiction, thereby polluting the data with irrelevant international inventory metrics.

C. Differences by Sector: Automobile versus Pharmaceutical

There is an evident lack of cross-sectoral comparative studies. The review of impacts of GST on automobile sector concluded that the unified tax helped manufacturers to rationalise distribution and reduce warehouse duplication [8]. However, that study primarily tested revenue growth and asset turnover, rather than isolating inventory velocity and pure logistics costs. In the pharmaceutical context, expert commentary heavily links pre-GST CST avoidance to state-wise distribution fragmentation. A study of the healthcare and pharma sector highlighted that distribution was entirely dictated by tax arbitrage [9]. Yet, peer-reviewed empirical testing of this anticipated post-GST consolidation remains sparse. The assumption that pharmaceutical firms would seamlessly abandon state-level depots ignores the realities of cold-chain logistics, regional regulatory compliance, and drug safety buffer requirements. This paper actively addresses these empirical gaps. By strictly isolating standalone Ind AS financial metrics across a balanced seven-year horizon, this study strips away international operational noise to test the direct, localised inventory and logistics outcomes of check-post removal on two fundamentally different manufacturing supply chains.

III. RESEARCH METHODOLOGY

A. Research Design and Sampling

This is a quantitative, comparative, ex-post-facto research study utilising secondary panel data.

The research provides a balanced and structurally rigorous comparison through testing the selected efficiency variables over a continuous 7-year timeline divided into 3 defined periods:

- Pre-GST Period: 3 years (FY2014-15, FY2015-16, FY2016-17)
- Transition Period: 1 year (FY2017-18)
- Post-GST Period: 3 years (FY2018-19, FY2019-20, FY2020-21)

The population represents the manufacturing firms which are listed on the stock exchange in India. The final sample consisted of 20 companies with high market capitalisation (10 from the Automobile sector and 10 from the pharmaceutical sector). Sample selection was purposive, based strictly on the availability of continuous, fully audited standalone financial data for the entire seven-year observation window, ensuring consistent longitudinal tracking across the sample.

B. Data Collection and Variable Construction

The data was extracted directly from the audited annual reports and standalone financial statements of the companies – in particular the Profit and Loss Account, the Balance Sheet and the Notes to Accounts. These documents are prepared in strict accordance with the prevailing Indian Accounting Standards (Ind AS) and the disclosure requirements of Schedule III (Division II) of the Companies Act, 2013. A critical methodological parameter of this study is the exclusive reliance on standalone financial statements. Consolidated statements were deliberately rejected, as they aggregate the financial positions of global subsidiaries. Because international operations are completely unaffected by the Indian GST framework and domestic check-post removals, including them would mathematically dilute and distort the impact of the domestic tax reform.

A further methodological safeguard concerns year-on-year comparability. For each fiscal year, the figures used are those reported as the prior-year comparative in the subsequent year's annual report, rather than the figures as originally published in that year's own report. This convention absorbs the effect of line-item regrouping and reclassification that companies periodically undertake, ensuring the panel reflects a consistent basis of presentation across the observation window. Because prior-year comparatives are restated on this basis whenever a company changes its reporting framework, the dataset is not meaningfully exposed to the transition from Indian GAAP to Ind AS; the shift in accounting standards during the study period does not have a material bearing on the findings reported here.

Because companies disclose expense breakups inconsistently in their Notes to Accounts, 'Logistics and Freight Expenses' was constructed as a standardised composite of comparable line items

encompassing freight outward, carriage inward, distribution expenses, and direct selling costs to preserve parity across the corporate sample rather than relying blindly on any single firm's unique nomenclature.

C. Analytical Techniques and Variables

The study operationalises the independent variable as the GST-driven tax transition and physical check-post reform across the three defined periods.

The dependent variables for measuring operational efficiency are:

- Inventory Turnover Ratio (ITR): Calculated as Cost of Goods Sold (COGS) divided by Average Inventory. A higher ratio indicates faster, more efficient inventory movement.
- Days of Inventory Held (DIH): Calculated as $(\text{Average Inventory} / \text{COGS}) \times 365$. This metric measures the absolute number of days capital is tied up in physical stock.
- Logistics Percentage: Calculated as $(\text{Logistics and Freight Expenses} / \text{Total Costs}) \times 100$. This tracks

whether transit efficiencies translated into direct monetary savings.

Aggregated company-year metrics were used to compute firm-level period averages. Statistical significance was assessed by two methods. First, paired sample tests were used to compare absolute means of Pre-GST and Post-GST. Given the different distributional characteristics of the underlying data (verified using the Shapiro-Wilk normality testing), the non-parametric Wilcoxon Signed-Rank test was used for the pharmaceutical dataset, while the parametric Paired t-test was used for the automotive dataset. Second, a one-way repeated-measures Analysis of Variance (ANOVA) was executed to capture and evaluate the intra-firm longitudinal variations across all three distinct time periods.

IV. RESULTS AND DISCUSSION

The empirical analysis yields compelling evidence that the logistical impact of GST is highly nuanced, challenging the mainstream narrative of uniform, economy-wide supply chain optimisation.

TABLE I: SECTOR-PERIOD MEANS AND SIGNIFICANCE TESTS (n = 10 FIRMS PER SECTOR). * SIGNIFICANT AT $p < 0.05$.

Sector	Variable	Pre-GST	Transition	Post-GST	Paired p	ANOVA p
Automobile	ITR	11.99	13.61	11.24	0.410	0.017*
Automobile	DIH	40.54	34.69	43.50	0.212	0.004*
Automobile	Logistics %	2.41%	2.76%	2.53%	0.697	0.424
Pharmaceutical	ITR	1.81	1.51	1.61	0.105	0.044*
Pharmaceutical	DIH	215.01	251.28	244.24	0.064	0.023*
Pharmaceutical	Logistics %	6.26%	6.30%	6.17%	0.846	0.943

The simple Pre-versus-Post paired statistical tests inherently mask critical, mid-cycle operational shifts that the three-period Repeated-Measures ANOVA successfully isolates.

With the analytical timeline extended to include FY2021, the data underscore that the two sectors diverged significantly, in diametrically opposed directions, with ANOVA significance increasing substantially over the larger window of observation.

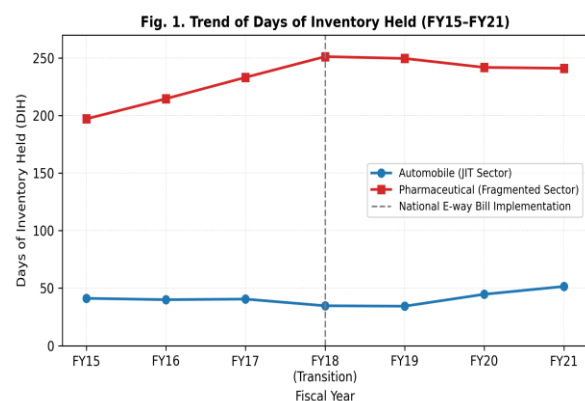


Fig. 1. Trend of Days of Inventory Held (FY15–FY21).

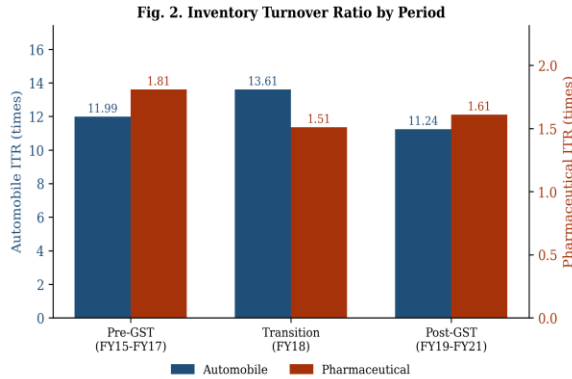


Fig. 2. Inventory Turnover Ratio by period, Automobile vs. Pharmaceutical.

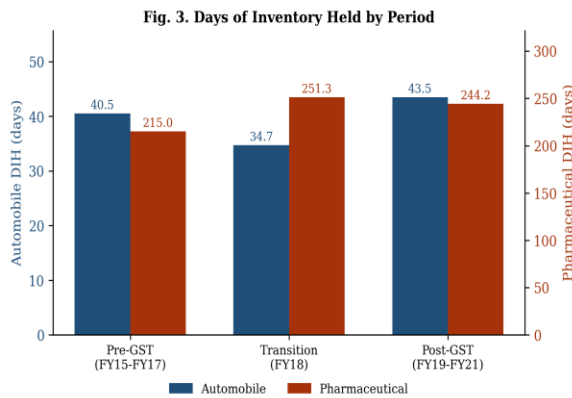


Fig. 3. Days of Inventory Held by period, Automobile vs. Pharmaceutical (dual-axis view).

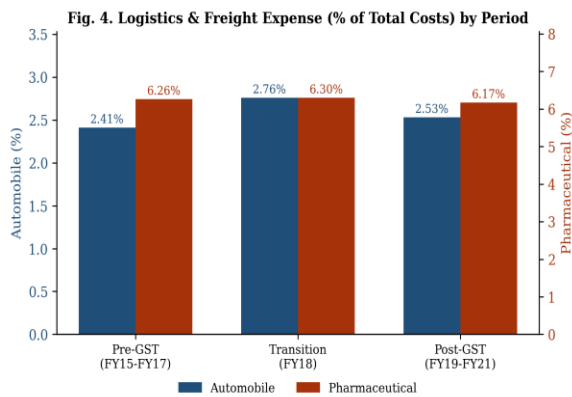


Fig. 4. Logistics and Freight Expense (% of Total Costs) by period, Automobile vs. Pharmaceutical.

A. The Automobile Sector: Temporary Gains and Macroeconomic Confounds

In the Automobile sector, the data reveals a highly significant statistical variance (ANOVA $p = 0.004$; Table. 1) in Days of Inventory Held (DIH).

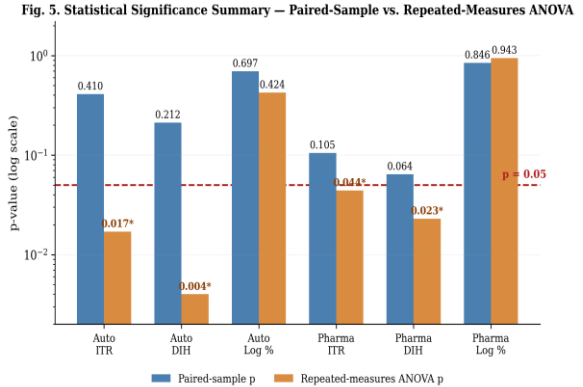


Fig. 5. Statistical significance summary paired-sample and repeated-measures ANOVA p-values across all six sector-variable combinations.

As shown in Fig. 1 and Fig. 3, DIH dropped significantly and instantly in the Transition period, reaching an average of 34.69 days from a Pre-GST baseline of 40.54 days. The most obvious indication of efficiency in the study is the significant drop in FY2018.

This is in close proximity to the statutory implementation of the national e-way bill and physical dismantling of state border check-posts. For a sector heavily reliant on Just-In-Time (JIT) inbound logistics, the removal of transit friction allowed original equipment manufacturers (OEMs) to immediately run leaner operations and accelerate inventory velocity.

However, this efficiency proved highly transient, as DIH subsequently rebounded to 43.50 days in the three-year post-GST period (FY19–FY21). The severe fall in inventory efficiency does not negate the GST de-bottlenecking effect, but instead demonstrates the sensitivity of inventory metrics to the macroeconomic shocks. The long post-GST window threw up two unprecedented domestic crises.

Firstly, the collapse of IL&FS in late 2018 led to a severe liquidity squeeze for the Non-Banking Financial Companies (NBFCs). Because the Indian automotive market is heavily reliant on NBFC credit for retail vehicle financing, this liquidity freezes decimated consumer demand throughout FY2019 and FY2020, mechanically inflating unsold finished-goods inventory at manufacturing plants and dealer yards independently of supply chain transit speeds.

Second, the COVID-19 pandemic induced severe nationwide lockdowns in late FY2020 and throughout FY2021. Automotive plants faced complete production halts and zero-sales months, severely distorting the Inventory Turnover Ratio (ITR), which also demonstrated significant ANOVA variance ($p = 0.017$; Table. 1). The data is consistent with a tax reform that successfully de-bottlenecked transit, with those logistical gains subsequently overwhelmed by a collapse in end-consumer demand.

B. The Pharmaceutical Sector: Defensive Stockpiling and Supply Chain Vulnerability

Conversely, the pharmaceutical sector yields result that run directly counter to pre-implementation theoretical expectations. Because pharmaceutical distribution was historically fragmented purely to avoid Central Sales Tax, it was widely anticipated that GST would trigger massive warehouse consolidation and drastically reduce inventory holding periods.

The empirical evidence runs counter to this hypothesis. As illustrated in Fig. 2, Fig. 3 and Fig. 5, both ITR (ANOVA $p = 0.044$; Table. 1) and DIH (ANOVA $p = 0.023$; Table. 1) demonstrate statistically significant movement, but strictly in the direction of deteriorating operational efficiency. Average inventory holding periods actually expanded from a Pre-GST mean of 215.01 days to a staggering 244.24 days in the post-GST era.

Because this data was strictly extracted from standalone Ind AS financial statements excluding international operational noise it is consistent with domestic pharmaceutical inventory behaviour during this specific window being driven substantially by factors outside domestic tax reform. The pharmaceutical supply chain operates inherently on a 'Just-In-Case' model rather than 'Just-In-Time'. Driven by stringent regulatory requirements, drug shortage penalties, and an overwhelming reliance on imported Active Pharmaceutical Ingredients (APIs) from China, pharmaceutical manufacturers actively chose to increase their raw material stockpiling. At the beginning of 2020, the COVID-19 pandemic led to export bans, global shipping delays and massive hoarding of APIs across India's pharma industry. This strategic, defensive buffer stocking overwhelmingly neutralised and reversed any marginal warehouse consolidation benefits delivered by the GST transition.

C. The Rigidity of Logistics Costs

Notably, neither sector exhibited a statistically significant shift in the Logistics and Freight Expense ratio (ANOVA $p = 0.424$ for Auto; $p = 0.943$ for Pharma; Fig. 4 and Fig. 5). Despite faster transit times resulting from check-post removals, pure carriage and freight costs as a percentage of total operational costs remained stubbornly static. Part of the explanation is definitional: to maintain parity across inconsistent corporate disclosures, the variable had to include broader distribution and selling costs which move independently of tax reform. However, from an economic standpoint, it highly suggests that the monetary savings generated by faster truck turnaround times were not passed down to the manufacturers. Instead, transport operators likely absorbed these operational savings to offset concurrently rising baseline diesel costs, increased highway toll levies (FASTag), and higher insurance premiums during the observation period.

V. CONCLUSION

This research evaluated whether the transition to India's Goods and Services Tax (GST) framework and the subsequent retirement of physical check-posts translated into measurable, sustainable corporate inventory and logistics efficiencies across a seven-year timeline. The empirical evidence confirms that the logistical impact of this landmark tax reform is profoundly sector-specific and highly vulnerable to external macroeconomic disruption.

The quantitative analysis demonstrates that Automobile manufacturers realised a statistically significant improvement in inventory holding efficiency precisely aligned with the roll-out of the e-way bill infrastructure. This supports the tax reform's core logistical rationale: removing transit friction appears to benefit JIT-dependent manufacturing. However, this operational gain proved fragile, as consecutive external shocks a severe demand-side credit deceleration and the unprecedented pandemic lockdowns subsequently masked these logistical improvements. In this respect, the extension of the observation window to include FY2021 incidentally functions as a stress test of the reform's structural logistics gains: it shows that black-swan macroeconomic events can readily overpower and

obscure tax-driven efficiencies, at least within the horizon this data can observe.

In stark contrast, the pharmaceutical sector experienced a statistically significant degradation in inventory efficiency across the exact same timeline. This suggests that the theoretical benefits of post-CST warehouse consolidation can be superseded by sector-specific risk management strategies. Here, it was the defensive regulatory pressures and global supply-chain vulnerabilities that drove the pharmaceutical firms to hoard inventory, not the structural benefits of a unified domestic market. Furthermore, the stabilisation of freight costs across both sectors indicates that time-savings on the highway do not automatically translate into balance-sheet cost reductions for manufacturers.

A. Strategic Implications and Scope for Future Research

For corporate strategy, the data highlights that tax-driven supply chain redesign yields the highest net financial benefits only in sectors highly dependent on continuous inventory velocity. Structurally defensive sectors cannot rely on domestic logistics de-bottlenecking to offset broader working capital expansion. For policymakers, the results are a welcome reminder that structural tax efficiencies are a necessary operational baseline, but can be quickly obscured by normal cyclical demand shocks or systemic supply chain breakdowns.

The study admits the limitations of the sample size, which was confined to large, high-capitalisation listed corporate entities to ensure strict Ind AS data conformity and parity of disclosures. Major players often have the capital reserves to absorb inefficiencies that would cripple smaller operations. Future research should actively expand the dataset to include unlisted, mid-tier manufacturing companies, as smaller entities face far tighter working capital constraints and may exhibit a significantly more pronounced operational elasticity in response to logistics de-bottlenecking.

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