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DP21163

SELF-ENFORCING TAX DESIGN AND SUPPLY CHAIN FORMALIZATION: EVIDENCE FROM INDIA'S GST REFORM

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PUBLIC ECONOMICS

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Abstract

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JEL Classification: H25, H32, O17

Keywords: Tax compliance

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Self-Enforcing Tax Design and Supply Chain Formalization:
Evidence from India's GST Reform

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February 8, 2026

Abstract

I study India's 2017 Goods and Services Tax (GST) to examine how self-enforcing tax design generates formalization cascades through supply chains. GST created incentives for formal procurement by allowing input tax credits only for purchases from registered suppliers. Using firm-level data on 12,024 firms, I find that firms at the mean pre-reform exposure to non-creditable taxes increased documented input purchases by 6 percent while reducing tax payments by 8 percent. Effects double over five years, consistent with formalization propagating sequentially upstream—a dynamic pattern that provides the first empirical evidence on the dynamics of VAT-driven formalization cascades. At the aggregate level, large firms' share of national GST collections fell from 46 to 30 percent, implying smaller enterprises entering the formal tax net. The interquartile range of effective tax rates collapsed by 72 percent, reflecting the replacement of heterogeneous cascading taxes with uniform credits.

Keywords: Tax compliance, formalization, supply chains, India
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1   Introduction

Developing countries collect far less tax revenue than developed countries. Besley and Persson (2014) document that low-income countries collect roughly 10–14 percent of GDP in taxes compared to 30–40 percent in high-income countries. A key constraint is limited enforcement capacity: governments cannot easily observe economic activity or verify tax liabilities (Gordon and Li, 2009). Traditional enforcement through audits and penalties is costly and of limited effectiveness when the informal sector is large (La Porta and Shleifer, 2014).

Tax structure may substitute for direct enforcement. Kleven et al. (2011) show that third-party reporting virtually eliminates evasion for income subject to information trails. Value-added tax creates such trails: because firms can deduct input taxes only with documentation from registered suppliers, buyers have incentives to transact with compliant sellers (Pomeranz, 2015). de Paula and Scheinkman (2010) develop a model where VAT generates "formalization cascades" through supply chains. However, empirical evidence on how formalization propagates in emerging economies remains limited.

This paper studies India's Goods and Services Tax (GST) reform of July 2017 to examine how self-enforcing tax design generates formalization cascades at national scale. GST replaced a fragmented system of central excise duties, state-level value-added taxes, and the Central Sales Tax with a unified destination-based tax featuring comprehensive input tax credits. Under the pre-GST regime, indirect taxes cascaded through supply chains: the Central Sales Tax on interstate purchases was non-creditable, VAT credits were blocked across state lines, and excise duties compounded through production stages. Firms with high embedded tax burdens had the most to gain from GST's unified credit system.

I use firm-level data from the CMIE Prowess database, which covers India's formal corporate sector through audited annual financial statements. The sample comprises 12,024 firms over fiscal years 2013–2022, spanning four years before and five years after GST implementation. I exploit heterogeneity in firms' pre-GST exposure to cascading taxes in a difference-in-differences framework. Firms that paid more in non-creditable indirect taxes per rupee of inputs had stronger incentives to formalize supply chains under GST, since claiming input credits requires invoices from registered suppliers.

I find significant effects on both margins of interest: firms at the mean pre-reform exposure increased documented input purchases by 6 percent while reducing indirect tax payments by 8 percent—more inputs at lower tax cost, reflecting GST's simultaneous elimination of cascading and incentivization of formal procurement. Effects vary in ways that support the formalization interpretation: they are concentrated among private Indian firms and in

manufacturing, where informal procurement and multi-stage cascading were most prevalent. Public sector enterprises and foreign subsidiaries—already subject to stringent auditing—show no significant response.

The dynamic pattern of effects is central to the paper's contribution. Event-study estimates reveal that formalization effects grow over time rather than appearing as a level shift, approximately doubling between the first and fifth post-reform years. This trajectory distinguishes genuine supply chain restructuring from one-time accounting reclassifications and maps onto the sequential propagation predicted by de Paula and Scheinkman (2010): as downstream firms demand invoices, their suppliers face pressure to register, who in turn demand documentation from their own suppliers.

Beyond firm-level treatment effects, I document two aggregate patterns consistent with self-enforcement expanding the formal tax base. On the intensive margin, GST dramatically compressed effective tax rate dispersion among formal firms, consistent with uniform credits replacing heterogeneous cascading burdens. On the extensive margin, large formal firms' share of national GST collections declined steadily after implementation, implying that collections from smaller and previously less formal enterprises grew faster.

These findings advance our understanding of how tax structure can substitute for direct enforcement. The central contribution is empirical evidence that formalization cascades propagate at national scale and do so gradually — effects double over five years as formal procurement requirements ripple upstream through supply chains. This dynamic pattern provides a direct empirical test of the sequential formalization mechanism in de Paula and Scheinkman (2010), whose prediction that enforcement at one production stage increases formality both downstream and upstream has not previously been taken to data in a nation-wide reform setting. The evidence extends Pomeranz (2015) from a randomized experiment in Chile to a quasi-experimental analysis of a nation-wide reform, and contrasts with de Mel et al. (2013), who find that direct interventions to formalize informal firms have limited effects: the GST mechanism instead creates demand-side pressure from formal buyers who need invoices to claim credits, making formalization self-sustaining rather than government-administered. The results speak to a specific design choice: conditioning input credits on supplier reporting. Many VAT systems worldwide allow credits based on buyer self-reporting alone; the Indian design creates the cross-verification that generates self-enforcement. The evidence therefore supports not just VAT generally, but a particular architectural feature that other countries could adopt. Finally, the compression of effective tax rate dispersion speaks to the production efficiency literature. Best et al. (2015) highlight the tradeoff between production efficiency and revenue in developing countries; the findings here suggest that well-designed VAT can improve both by reducing the tax wedge heterogeneity that

distorts input allocation across firms.

The paper proceeds as follows. Section 2 provides institutional background on India's pre-GST indirect tax system and the GST reform. Section 3 describes the data. Section 4 presents the empirical strategy. Section 5 reports main results, including heterogeneity by firm characteristics and dynamic effects. Section 6 discusses allocative efficiency implications. Section 7 concludes.

2   Context

2.1   The Pre-GST Indirect Tax System

Prior to July 2017, India's indirect tax system was characterized by fragmentation across multiple levels of government and incomplete creditability of taxes paid on intermediate inputs. Ahmad and Stern (1984) document substantial scope for welfare improvement through indirect tax reform in India, a finding that motivated decades of reform efforts culminating in GST.

The pre-GST system comprised three principal layers of indirect taxation. At the central level, excise duties were levied on the manufacture of goods under the Central Excise Act. The central government also levied service tax on the provision of services, introduced in 1994 and gradually expanded to cover most service categories. At the state level, value-added taxes (VAT) were levied on the sale of goods within each state, with rates and exemptions varying across jurisdictions. Interstate transactions were subject to the Central Sales Tax (CST), an origin-based tax collected by the exporting state.

The credit mechanism under this system was fundamentally incomplete. Central excise permitted credits for excise duties paid on inputs used in manufacturing, but credits did not extend to services or to taxes levied by state governments. State VAT systems generally permitted credits for VAT paid on inputs purchased within the same state, but credits were unavailable for purchases from other states or for central excise duties. CST was not creditable against any other tax. This structure created cascading: taxes were embedded in input costs at each stage of production and distribution, with the cumulative burden passed forward to subsequent stages.

The cascading problem was quantitatively significant. When a manufacturer purchased inputs from another state, CST of 2–4 percent was levied without credit. When these inputs entered production, excise duty was levied on the full value including embedded CST. When the finished good was sold, state VAT was levied on the value including both embedded CST and excise. The cumulative effective rate could substantially exceed the sum of statutory

rates. Firms responded by restructuring supply chains to minimize interstate transactions, establishing redundant facilities in multiple states, and purchasing from unregistered suppliers to avoid documented tax burdens.

The lack of integrated information systems across central and state authorities further limited enforcement capacity. Each tax was administered by a separate authority with its own registration, filing, and audit procedures. The absence of cross-verification between buyer and seller returns enabled underreporting of transactions and facilitated evasion.

2.2 The GST Reform

The Goods and Services Tax was implemented on July 1, 2017, replacing the fragmented system of central and state indirect taxes with a unified destination-based value-added tax. The reform represented the culmination of a policy development process spanning more than a decade, beginning with the Kelkar (2004) Task Force which proposed a comprehensive goods and services tax based on VAT principles.

The Constitution (One Hundred and First Amendment) Act of 2016 created the legal framework for concurrent central and state taxation of goods and services, established the GST Council as a federal body to determine rates and rules, and provided for compensation to states for revenue losses during the transition period. The Central GST Act, Integrated GST Act, and State GST Acts were enacted in 2017, with implementation commencing on July 1.

The GST structure embodies several design features relevant to this study. First, GST permits registered firms to claim credits for taxes paid on all business inputs against their output tax liability. Credits are available regardless of whether inputs are goods or services, and regardless of whether they are sourced from within the state or from other states. This comprehensive creditability eliminates the cascading that arose from non-creditable CST and from the absence of cross-crediting between central and state taxes.

Second, the ability to claim input tax credit (ITC) is contingent on the supplier being registered and having reported the corresponding sale in their GST return. This creates a direct linkage between buyer and seller tax positions: buyers cannot claim credits unless sellers have reported the transaction and remitted tax. The mechanism gives downstream firms strong incentives to purchase from compliant suppliers (Gadenne et al., 2019).

Third, the GST Network (GSTN) provides a unified IT infrastructure for registration, return filing, and invoice matching across all states. The system enables automatic cross-verification of buyer and seller returns, creating information trails that were absent under the previous regime.

Fourth, GST was implemented simultaneously across all states by constitutional amendment, with rates and rules determined by the GST Council rather than by individual state legislatures. Firms could not avoid the reform through location choices, and the timing was determined by national legislation rather than firm decisions.

The combination of comprehensive creditability and supplier verification creates incentives for both supply chain formalization and the elimination of tax cascading.

3 Data

The analysis uses firm-level data from the Centre for Monitoring Indian Economy (CMIE) Prowess database. Prowess compiles audited annual financial statements from regulatory filings for all companies listed on Indian stock exchanges and a large number of economically significant unlisted companies. The database covers manufacturing, services, utilities, construction, and primary sector firms, providing comprehensive representation of the formal corporate sector in India. The sample period spans fiscal years 2013–2022, covering four years before and five years after the July 2017 GST implementation.[1]

To construct the sample, I start with all firm-years in Prowess with non-missing company code and fiscal year (2013–2022), excluding financial sector firms (NIC 64–66: financial services, insurance, and other financial activities). I require non-missing and positive raw material expenditures and indirect taxes in the pre-GST period (2014–2016) to compute exposure, which I winsorize at the 1st and 99th percentiles. Finally, I exclude observations with missing log raw materials in the outcome period. The final sample comprises 12,024 firms and 131,052 firm-year observations for the raw materials analysis.

Table 1 reports summary statistics for the analysis sample of 12,024 firms over 2013–2022. The median firm has raw material expenditures of Rs. 550 million and paid Rs. 7.4 million in indirect taxes on inputs.

The median firm has net sales of Rs. 1,026 million (approximately USD 12 million at 2017 exchange rates), total assets of Rs. 1,023 million, and total expenditure of Rs. 1,064 million. Employee costs are Rs. 66 million at the median, representing approximately 6.2 percent of total expenditure. Among firms reporting imports, median total imports are Rs. 113 million. The sample is concentrated in manufacturing (NIC 10–33), followed by services (NIC 45–99), utilities and construction (NIC 35–43), and agriculture and mining (NIC 01–09).

Appendix A provides detailed variable definitions.

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[1]Indian fiscal years run from April through March; fiscal year 2017 (April 2016–March 2017) is the last complete pre-GST year, and fiscal year 2018 (April 2017–March 2018) is the first complete post-GST year.

Table 1: Summary Statistics

Variable	Mean	SD	P25	Median	P75	Obs.
Raw Materials	4,548	49,040	135	550	1,930	133,724
Indirect Taxes	549	12,250	1	7.4	56	122,462
Net Sales	8,748	89,541	277	1,026	3,506	143,490
Total Assets	11,035	105,938	308	1,023	3,601	149,195
Total Expenditure	8,899	95,480	296	1,064	3,572	148,391
Employee Cost	581	7,692	17	66	240	142,670
Total Imports	2,320	37,696	20	113	530	54,645

Notes: Summary statistics computed over the analysis sample of 12,024 firms from the CMIE Prowess database over 2013–2022. All financial variables are measured in millions of Indian Rupees. Net Sales is total sales revenue net of excise duties. Raw Materials is raw material expenditures from the expenditure statement. Indirect Taxes is the sum of excise duties, sales tax, VAT, and other indirect taxes paid on inputs. Total Assets is total assets from the balance sheet. Total Expenditure is total operating expenditure. Employee Cost is compensation to employees. Total Imports is the sum of imported raw materials, stores and spares, finished goods, and capital goods. Obs. reports the number of firm-year observations with non-missing values.

4 Empirical Strategy

The empirical strategy exploits heterogeneity in firms' exposure to GST's self-enforcing mechanism in a difference-in-differences framework with continuous treatment intensity. Firms that faced higher embedded tax costs under the pre-GST regime, due to non-creditable taxes, blocked credits, and cascading, had stronger incentives to formalize input sourcing under GST. I measure this exposure using pre-reform indirect tax burdens relative to input purchases, then estimate whether high-exposure firms differentially increased documented input purchases after GST implementation. The key identifying assumption is that, absent the reform, firms with different exposure levels would have followed parallel trends in measured inputs.

4.1 Exposure Measure

I construct a firm-specific measure of exposure to GST's self-enforcing mechanism using pre-reform data. For each firm i, exposure is defined as:

$$\text{Exposure}_i = \frac{1}{3} \sum_{t=2014}^{2016} \frac{\text{Indirect Taxes}_{it}}{\text{Raw Materials}_{it}} \tag{1}$$

where the numerator is total indirect taxes paid and the denominator is raw material expenditures, averaged over the three fiscal years immediately preceding GST (2014–2016). I normalize by raw materials as the mechanism operates through input sourcing decisions, and so the ratio directly measures the tax wedge on the input margin.

For the variable construction, firms with zero or negative raw material expenditures in the pre-period are excluded, as exposure cannot be meaningfully computed. I winsorize the exposure measure at the 1st and 99th percentiles. The median exposure is 0.082, indicating that the median firm paid indirect taxes equal to 8.2 percent of raw material expenditures in the pre-GST period. There is substantial cross-sectional variation: the interquartile range spans 0.009 to 0.169, a nineteen-fold difference. This variation provides the identifying variation for the difference-in-differences analysis.

A higher value of the exposure measure indicates more embedded, non-creditable taxes per rupee of inputs. Under the pre-GST regime, CST on interstate purchases was non-creditable, VAT credits were blocked across state lines, and excise duties cascaded through supply chains. These firms had the most to gain from GST's unified credit system: a firm paying 16 percent of raw materials in indirect taxes benefits more from full creditability than a firm paying 1 percent. Crucially, to claim input tax credits under GST, firms need invoices from registered suppliers. High-exposure firms had higher credit value and therefore had stronger incentives to shift from informal to formal suppliers.

The exposure measure is predetermined with respect to post-GST outcomes since it is constructed entirely from pre-reform data. Firms could not anticipate the precise design of GST or adjust their pre-2017 tax positions in response to the reform. The constitutional amendment enabling GST was passed in 2016, but the final rate structure and implementation details were determined by the GST Council and remained uncertain until shortly before the July 2017 rollout.

A potential concern is that exposure correlates with other firm characteristics that independently affect post-GST outcomes. Table A2 in the Appendix reports pre-GST firm characteristics by ITC exposure tercile. High-exposure firms (tercile 3) are larger on all dimensions: average net sales of Rs. 7,822 million compared to Rs. 4,343 million for low-exposure firms; total assets of Rs. 9,467 million compared to Rs. 6,490 million.

4.2 Baseline Specification

The baseline specification is:

$$Y_{it} = \alpha_i + \lambda_t + \beta(\text{Post}_t \times \text{Exposure}_i) + \varepsilon_{it} \tag{2}$$

where Y_{it} is the outcome for firm i in fiscal year t, with t indexing the start year of the Indian fiscal year (April of year t to March of year $t+1$).[2] α_i are firm fixed effects, λ_t are

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[2]Thus $t = 2016$ corresponds to the fiscal year April 2016–March 2017 (FY2017 in ending-year convention), the last complete pre-GST year; $t = 2017$ corresponds to April 2017–March 2018 (FY2018), the first post-

year fixed effects, $\text{Post}_t = \mathbb{1}\{t \geq 2017\}$ indicates fiscal years beginning in April 2017 or later (i.e., post-GST implementation), and Exposure_i is the pre-determined exposure measure. I will estimate this specification for outcome variables of Log raw materials and Log indirect taxes.

The coefficient β captures the differential change in measured input purchases for firms with higher pre-GST exposure, relative to firms with lower exposure.

I include industry-year fixed effects to control for sector-wise trends and firm fixed effects to control for level differences in firm characteristics. Standard errors are clustered at the firm level.

4.3 Event-Study Specification

To examine dynamics and assess parallel trends, I estimate an event-study specification. The event study is important because it allows me to examine whether effects emerge immediately or grow over time. If formalization cascades through supply chains, we expect effects to grow as upstream suppliers progressively formalize in response to downstream demand for documentation. The specification is:

$$Y_{it} = \alpha_i + \lambda_t + \sum_{k \neq -1} \beta_k (\mathbb{1}\{t - 2017 = k\} \times \text{Exposure}_i) + \varepsilon_{it} \tag{3}$$

where k indexes event time relative to GST implementation: $k = -1$ corresponds to $t = 2016$ (April 2016–March 2017, the last pre-GST fiscal year), $k = 0$ to $t = 2017$ (April 2017–March 2018, the first post-GST fiscal year), and so on. The omitted category is $k = -1$.

Pre-reform coefficients ($k < -1$) test for differential pre-trends: if parallel trends hold, these coefficients should be statistically indistinguishable from zero. The exposure measure is computed from $t = 2014$–2016 (April 2014–March 2017), which is strictly pre-reform and does not overlap with any post-GST fiscal year.

5 Results

Table 2 reports difference-in-differences estimates. All specifications include firm and industry $\times$ year fixed effects. Columns (1)–(2) present baseline results; Columns (3)–(8) examine heterogeneity by size, sector, and ownership.

Column (1) reports the effect on raw material expenditures. The coefficient on Post $\times$ Exposure is 0.297 (p $<$ 0.01). Since the implied effect for firm i is $\beta \times \text{Exposure}_i$, evaluating

GST year.

Table 2: Effect of GST Exposure on Firm Outcomes

	Baseline		Size (ref: Large)		Sector		Ownership	
	Raw Mat. (1)	Ind. Tax (2)	Raw Mat. (3)	Ind. Tax (4)	Raw Mat. (5)	Ind. Tax (6)	Raw Mat. (7)	Ind. Tax (8)
Post × Exposure	0.297***	-0.407***	0.172	-0.272***				
	(0.090)	(0.060)	(0.114)	(0.071)				
× Small			0.711***	-0.053				
			(0.234)	(0.139)				
× Medium			0.193	-0.504***				
			(0.191)	(0.155)				
Agric./Mining					-0.129	-0.352*		
					(0.268)	(0.197)		
Manufacturing					0.276***	-0.576***		
					(0.094)	(0.123)		
Utilities/Constr.					0.647***	-0.361***		
					(0.209)	(0.106)		
Services					0.193	-0.174		
					(0.204)	(0.119)		
Private Indian							0.275***	-0.678***
							(0.093)	(0.114)
Public/Foreign							0.126	-0.021
							(0.139)	(0.083)
Observations	131,052	131,052	131,052	131,052				
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE					Yes	Yes	Yes	Yes

Notes: Difference-in-differences estimates of GST's effect on firm outcomes. Columns (1)–(2) report baseline estimates. Columns (3)–(4) interact with firm size (Large is reference). Columns (5)–(6) report total effects from separate regressions by sector. Columns (7)–(8) report total effects from separate regressions by ownership. Exposure is pre-GST (2014–2016) indirect taxes / raw materials, winsorized at 1st and 99th percentiles. Standard errors clustered at firm level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

at the mean exposure (0.186) yields $0.297 \times 0.186 \approx 5.5$ percent. Column (2) reports the effect on indirect taxes. The coefficient is -0.407 (p < 0.01), implying a $0.407 \times 0.186 \approx 7.6$ percent decline in indirect tax payments at mean exposure. Columns (1) and (2) together reflect GST's dual impact of eliminating cascading while incentivizing formal procurement.

Columns (3)–(4) interact the treatment with firm size, using large firms as the reference category. Small firms show a significantly larger effect on raw materials than large firms: the interaction coefficient is significant at 0.711. This is consistent with small firms having more scope for informal purchasing arrangements prior to GST. Large firms, already subject to intensive auditing and with established formal supply chains, had less room for further formalization. For indirect taxes, medium firms show a significant additional decline (-0.504), suggesting they had the most embedded tax cascading to eliminate.

Columns (5)–(6) report total effects from separate regressions by sector. The formalization and tax cascading effects are concentrated in sectors with multi-stage production and physical input requirements. Manufacturing shows the clearest pattern: a significant increase in raw materials (coefficient 0.276) alongside the largest decline in indirect taxes (coefficient -0.576), consistent with cascading being most severe where inputs pass through multiple production stages. Utilities/Construction displays the strongest formalization response (coefficient 0.647), likely reflecting a shift away from informal contracting arrangements that characterized this sector prior to GST. Agriculture/Mining and Services show insignificant effects on raw materials, suggesting limited scope for formalization in sectors where inputs are either primary commodities or intangible services.

Columns (7)–(8) report total effects from separate regressions by ownership type. Private Indian firms show significant effects on both outcomes: coefficients of 0.275 ($p < 0.01$) on raw materials and -0.678 ($p < 0.01$) on indirect taxes, implying effects at mean exposure of approximately 5 percent and -13 percent, respectively. In contrast, public and foreign firms show no significant effects on either outcome. This pattern strongly supports the formalization interpretation. Private Indian firms—which include unlisted family businesses and closely-held companies—had greater scope for informal purchasing arrangements prior to GST. Public sector enterprises, foreign subsidiaries, and listed business group affiliates were already subject to more stringent auditing and compliance requirements, leaving less room for the reform to induce behavioral change.

Figure 1 presents event-study estimates that test for parallel pre-trends and trace the dynamic path of GST's effects. For indirect taxes, pre-reform coefficients are close to zero in the years immediately preceding the reform ($t = -2$ and $t = -3$), consistent with the identifying assumption that exposure does not predict differential pre-trends. For raw materials, pre-reform coefficients are noisier but show no clear trend in the years closest to

Figure 1: Event Study: Effect of GST Exposure on Indirect Taxes and Raw Materials
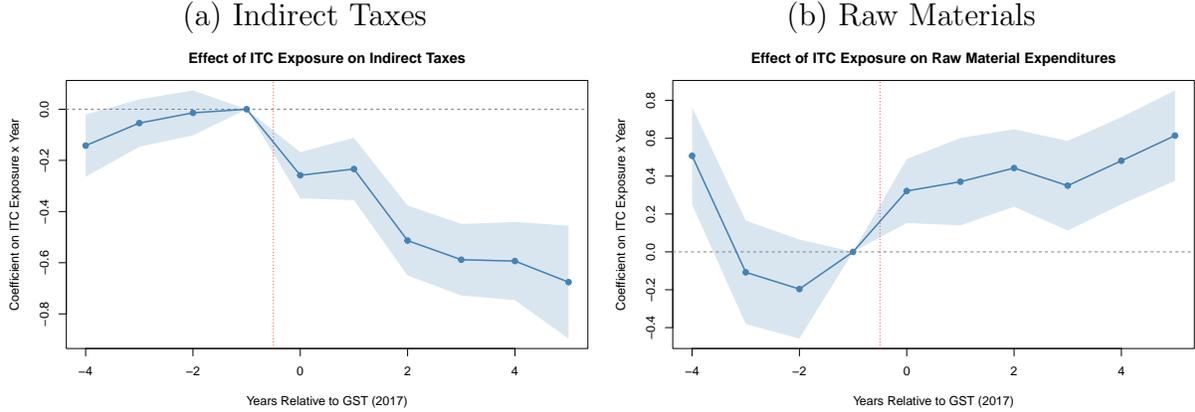
(a) Indirect Taxes

(b) Raw Materials

Notes: Figures plot coefficients from event-study regressions on interactions between exposure and year indicators. All specifications include firm fixed effects and industry $\times$ year fixed effects. The reference period is $k = -1$, corresponding to the fiscal year April 2016–March 2017 (the last pre-GST year); $k = 0$ is April 2017–March 2018 (the first post-GST year). Shaded areas show 95% confidence intervals based on firm-clustered standard errors.

Table 3: Dynamic Effects: Event-Study Coefficients by Year

| | Years Since GST Implementation | | | | | |
Outcome	$t = 0$	$t = 1$	$t = 2$	$t = 3$	$t = 4$	$t = 5$
Raw Materials	0.321***	0.370***	0.443***	0.350***	0.481***	0.614***
	(0.086)	(0.118)	(0.104)	(0.121)	(0.117)	(0.122)
Indirect Taxes	−0.258***	−0.234***	−0.513***	−0.588***	−0.593***	−0.676***
	(0.046)	(0.062)	(0.070)	(0.071)	(0.078)	(0.113)

Notes: Coefficients from event-study regressions with firm and industry $\times$ year fixed effects. Reference period is $t = -1$ (2016). Standard errors clustered by firm in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

implementation. Post-reform coefficients show immediate effects that grow over time.

Table 3 summarizes the trajectory of effects on raw materials and indirect taxes. The event-study estimates reveal that GST's effects grew over time rather than appearing immediately and stabilizing.

For raw materials, the implied effect at mean exposure grows from 6 percent in the first year ($t = 0$) to 9 percent by year four ($t = 4$), and reaches 11 percent by year five—approximately doubling over the post-reform period.

The growing trajectory is inconsistent with one-time accounting adjustments or reclassification, which would produce a level shift followed by stability.

For indirect taxes, implied effects at mean exposure follow a similar trajectory: the decline deepens from −5 percent at $t = 0$ to −13 percent by $t = 5$, reflecting the progressive

Table 4: Prowess Sample Coverage of National GST Collections

Fiscal Year	Prowess Firms	Firms Reporting	Prowess Total (Cr)	Prowess Share
2018-19	37,130	20,957	538,335	45.7%
2019-20	37,666	19,941	493,543	40.4%
2020-21	37,394	20,051	508,438	44.8%
2021-22	36,815	19,266	647,779	43.9%
2022-23	35,633	19,051	695,737	38.4%
2023-24	30,651	18,057	667,601	33.1%
2024-25	23,671	15,051	655,165	29.7%

Notes: Prowess Total is the sum of indirect taxes and GST paid by firms in the Prowess database. National GST collections from government sources. Prowess Share is the ratio of Prowess Total to national gross GST collections. Prowess covers primarily large and medium formal sector firms.

realization of input tax credits as the share of creditable purchases increases with supplier formalization.

Event-study estimates by sector (Figure A1, Table A3) confirm that the growing trajectory is not driven by any single sector. Manufacturing shows the largest and most persistent effects on indirect taxes, with implied effects at mean exposure growing from -6% at $t = 0$ to -13% by $t = 5$. For raw materials, all sectors show positive effects by $t = 5$, with Utilities/Construction (12%) and Services (12%) displaying the largest implied magnitudes at mean exposure—consistent with significant formalization in sectors where informal contracting was prevalent.

6 Discussion

GST should compress the distribution of effective tax rates across firms. Pre-GST, firms faced heterogeneous (effective) tax rates due to differences in supply chain structure, input mix, and access to formal suppliers. By making input tax credits uniform, GST affects efficiency through two channels: expanding the tax base through formalization (extensive margin) and compressing tax wedge dispersion among formal firms (intensive margin).

On the extensive margin, Table 4 reports the share of national GST collections accounted for by Prowess firms. Despite covering India's largest formal-sector firms, this share declined from 46 percent in FY2018 to 30 percent in FY2024. This suggests that collections from smaller, previously less formal enterprises grew faster than collections from large formal firms. The self-enforcement mechanism explains this: to claim input credits, buyers demanded invoices from suppliers, creating market pressure for formalization throughout the supply chain.

Table 5: Effective Input Tax Rate Dispersion Before and After GST

Period	Mean	Variance	IQR	N
Pre-GST (2013–2016)	0.167	0.146	0.156	54,009
Post-GST (2018–2022)	0.101	0.130	0.043	76,377
Change	-0.067	-0.016	-0.113	
Percent change	-40%	-11%	-72%	

Notes: Effective input tax rate τ_M = indirect taxes / raw materials. This is the treatment variable from the main analysis, measuring cascading tax exposure. Winsorized at 1st and 99th percentiles. IQR = interquartile range (P75 − P25).

On the intensive margin, Table 5 shows that GST compressed effective input tax rate heterogeneity among formal firms. The effective input tax rate τ_M (indirect taxes divided by raw materials) measures the cascading burden that GST eliminated. The mean fell from 16.7 to 10.1 percent. More importantly, the variance fell by 11 percent (from 0.146 to 0.130) and the interquartile range collapsed by 72 percent (from 0.156 to 0.043).

The compression of effective tax rates has direct implications for allocative efficiency. The Diamond and Mirrlees (1971) production efficiency theorem establishes that the optimal tax system avoids distorting intermediate input choices. Pre-GST, the heterogeneous cascading burden functioned as a de facto differential tax on inputs: two otherwise identical firms purchasing the same input could face effective tax rates differing by a factor of nineteen (the ratio of the 75th to 25th percentile in the pre-period). Such dispersion distorts relative input prices across firms and generates misallocation of the kind documented by Hsieh and Klenow (2009) for India and China. The 72 percent reduction in the interquartile range implies that GST moved India's indirect tax system substantially closer to production efficiency— not by eliminating taxes on inputs, but by making the residual burden uniform through comprehensive crediting. This represents a channel distinct from the formalization effects documented above: even holding the set of formal firms fixed, the equalization of effective tax rates should improve aggregate productivity by reallocating inputs toward firms with the highest marginal products rather than toward firms that happened to face lower cascading burdens. Quantifying the TFP gains from this reallocation channel, potentially using the sufficient-statistics framework of Baqaee and Farhi (2020), is a natural direction for future work.

The magnitudes documented here are economically meaningful relative to existing evidence on formalization interventions. de Mel et al. (2013) find that direct subsidies to encourage formalization among Sri Lankan informal firms had limited take-up and modest effects on firm outcomes. In contrast, the 6 percent increase in documented input purchases at mean exposure documented here arises without any direct government intervention at the

firm level—it is generated endogenously through the credit mechanism. The initial effect is comparable to the 8 percent increase in reported purchases that Pomeranz (2015) found in response to randomized audit threats in Chile, but unlike audit effects, the GST mechanism continues to grow over time—reaching 11 percent by year five as formalization propagates upstream. This suggests that permanent structural incentives embedded in the tax architecture can match episodic enforcement actions in the short run and substantially exceed them in the medium run, consistent with the theoretical distinction between incentive-compatible mechanism design and costly monitoring.

These estimates represent a conservative lower bound on total gains from the GST, for three reasons. First, the Prowess sample captures only the intensive margin among already-formal firms; extensive margin gains from newly formalized enterprises are excluded by construction. Second, Prowess firms—among the largest and most audited in the economy—had better pre-GST credit access than typical firms. Tax rate dispersion in the broader economy, including the universe of smaller firms and proprietorships, was almost certainly larger, implying greater scope for compression. Third, the decline in Prowess's share of national GST collections from 46 to 30 percent implies that the majority of tax base expansion occurred among firms outside this sample. With India's informal sector accounting for approximately 80 percent of employment, the efficiency gains from formalizing previously untaxed transactions likely exceed substantially the effects documented among already-formal firms.

Together, tax wedge compression among formal firms and tax base expansion through formalization represent the dual benefit of self-enforcing tax design. The results also underscore a specific architectural feature: GST's requirement that input credits are conditional on supplier reporting creates the cross-verification that drives self-enforcement. Many VAT systems worldwide permit credit claims based solely on the buyer's records, without requiring that the corresponding sale appear in the supplier's return. The Indian experience suggests that this design choice—matching buyer and seller returns through a unified IT infrastructure—is central to realizing the formalization benefits of VAT.

7 Conclusion

India's 2017 GST reform created self-enforcing incentives that generated measurable formalization cascades through supply chains. At the mean pre-reform exposure, firms increased documented input purchases by 6 percent while reducing indirect tax payments by 8 percent, with effects concentrated among private Indian firms and in manufacturing. The dynamic pattern—effects approximately doubling over five years—provides empirical evidence for the sequential propagation mechanism modeled by de Paula and Scheinkman (2010).

Two aggregate patterns reinforce the firm-level findings. The interquartile range of effective input tax rates collapsed by 72 percent, indicating that GST substantially reduced the tax wedge heterogeneity that distorts input allocation across firms. And the Prowess sample's share of national GST collections fell from 46 to 30 percent, suggesting that self-enforcement expanded the tax base to smaller and previously less formal enterprises. Because these estimates are based on the most audited segment of the economy, they represent a lower bound on the reform's total efficiency gains.

The results carry implications for tax policy design beyond India. The key architectural feature driving formalization is not the VAT per se, but the requirement that input credits are contingent on supplier reporting through a unified IT infrastructure. Countries seeking to harness self-enforcement should invest in the digital backbone—centralized invoice matching and cross-verification—that makes the credit mechanism operational. The Indian experience suggests that such systems can achieve formalization outcomes that direct enforcement interventions have struggled to deliver, and that the benefits compound over time as formal procurement requirements propagate upstream through supply chains.

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Appendix A: Additional Tables

Table A1: Variable Definitions

Variable	Definition
Indirect Taxes	Sum of excise duties, sales tax, VAT, and other indirect taxes from the expenditure statement. Captures non-creditable tax burden on inputs under the pre-GST regime.
Raw Materials	Raw material expenditures from the Prowess expenditure statement. Captures documented purchases of intermediate inputs.
Net Sales	Total sales revenue net of excise duties.
Total Assets	Total assets from the balance sheet.
Exposure	Ratio of indirect taxes to raw materials, averaged over the pre-GST period (2014–2016) and winsorized at the 1st and 99th percentiles.
Firm Size	Terciles (Small, Medium, Large) based on total assets averaged over 2014–2016.
Industry	Two-digit NIC code: Manufacturing (10–33), Services (45–99), Utilities & Construction (35–43), Agriculture & Mining (01–09).

Table A2: Pre-GST Firm Characteristics by ITC Exposure Tercile

	Low (Tercile 1)	Medium (Tercile 2)	High (Tercile 3)
Number of Firms	4,008	4,008	4,008
Net Sales	4,343	5,501	7,822
Raw Materials	2,560	3,036	3,162
Total Assets	6,490	7,582	9,467
Employee Cost	212	367	566
EBITDA	513	686	1,023
Indirect Taxes	14	257	865
ITC Exposure	0.006	0.083	0.268

Notes: Pre-GST characteristics (averaged 2014–2016) by ITC exposure tercile. ITC Exposure is indirect taxes divided by raw materials. All monetary values in Rs. million. Differences in levels motivate fixed-effects estimation; differences in trends are examined using event studies.
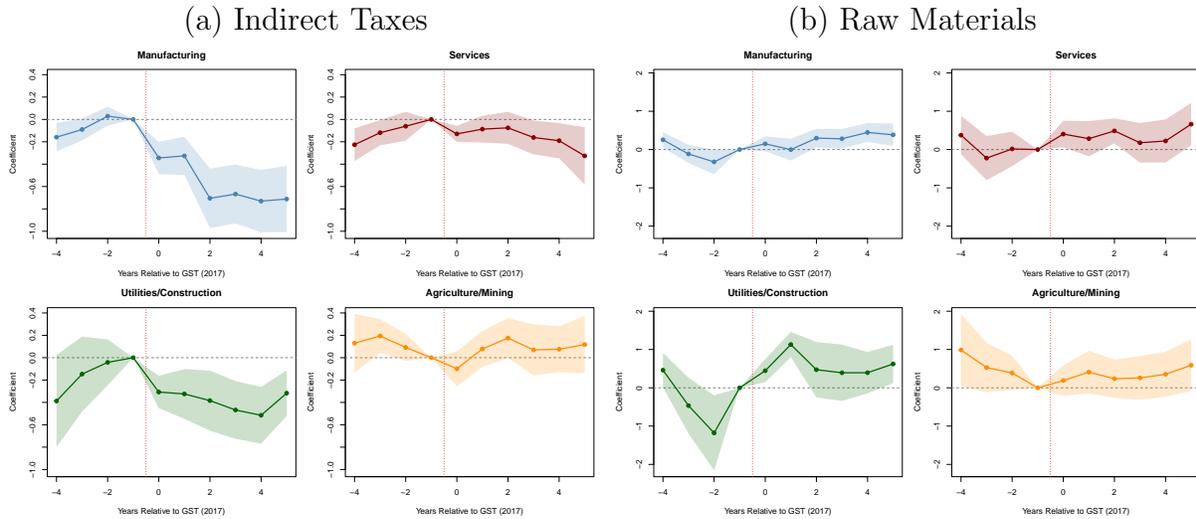
Table A3: Event Study Coefficients by Sector

	Manufacturing	Services	Utilities/Constr.	Agric./Mining
Panel A: Indirect Taxes				
$t = 0$	-0.344***	-0.129***	-0.307***	-0.099
$t = 1$	-0.326***	-0.087	-0.324***	0.078
$t = 2$	-0.705***	-0.075	-0.384***	0.176*
$t = 3$	-0.667***	-0.161**	-0.468***	0.070
$t = 4$	-0.730***	-0.190**	-0.515***	0.076
$t = 5$	-0.712***	-0.326**	-0.317***	0.117
Panel B: Raw Materials				
$t = 0$	0.149	0.405**	0.446***	0.188
$t = 1$	-0.002	0.284	1.129***	0.410
$t = 2$	0.297**	0.487***	0.473	0.238
$t = 3$	0.282**	0.177	0.392	0.258
$t = 4$	0.447***	0.224	0.394	0.354
$t = 5$	0.384***	0.662**	0.622**	0.590*

Notes: Coefficients from event-study regressions on ITC Exposure × Year interactions. Reference period is $t = -1$ (2016). All specifications include firm and year fixed effects. Standard errors clustered at firm level. *** p<0.01, ** p<0.05, * p<0.10.

Appendix B: Additional Figures

Figure A1: Event Study: Effect of GST Exposure by Sector

(a) Indirect Taxes   (b) Raw Materials

Notes: Figures plot coefficients from event-study regressions on interactions between exposure and year indicators, estimated separately by sector. All specifications include firm and year fixed effects. The reference period is $k = -1$, corresponding to the fiscal year April 2016–March 2017 (the last pre-GST year); $k = 0$ is April 2017–March 2018 (the first post-GST year). Shaded areas show 95% confidence intervals based on firm-clustered standard errors.