Internal Trade Barriers in India*

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Abstract

We study barriers to intranational trade in India, which has extensive roads but an inefficient transportation and logistics sector. The Goods and Services Tax introduced in 2017 imposed nationwide tax rates and eliminated the need for tax-collection checkposts at state borders. We quantify the impact of this checkpost reform using high-frequency Global Positioning System records, trucking logs, and a survey of truck drivers. The reform sped up border crossings substantially: average duration declined more than one-third. Eastern states, which had slower checkposts before the reform, improved the most. Household expenditures rose in districts where the reform improved market access, suggesting substantial returns to reducing interstate trucking costs.

Keywords: border costs, Goods and Services Tax, India, intranational trade, trucking

JEL codes: F14, H71, O17, R13, R4

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1 Introduction

Barriers to internal trade are an impediment to economic growth in developing economies. While highly visible physical frictions—such as poor infrastructure—and less visible obstacles—such as information frictions—hinder domestic transactions, government policies also often impede internal integration. We study policy-induced barriers to domestic trade in the context of India.

Prior to the introduction of the Goods and Services Tax (GST) system on July 1, 2017, India had a multi-layered central and state tax structure that included interstate customs duties, interstate entry taxes, and state-level value-added taxes that were assessed when goods crossed the borders between Indian states. These state-specific taxes necessitated checkposts at state borders at which government officials processed paperwork, inspected trucks, and collected taxes. In practice, trucks were often held up for long periods at these checkposts by government officials who sometimes solicited bribes. These delays, the accompanying congestion, and the bribes paid to checkpost officers were long criticized. By unifying final tax rates on goods and services across the country, GST replaced a multitude of varied taxes and obviated the need for tax collection at state borders.

The GST reform, described in Section 2, offered the promise of substantially improving India's inefficient transport and logistics sector. India has as many highways per square kilometer of land as the United States, triple that of Brazil and China (World Bank, 2011). Yet, its Ministry of Road Transport and Highways (MORTH) estimates that logistics costs are 14 percent of the value of goods, markedly higher than the 8–10 percent found in advanced economies. In a pamphlet promoting GST, the Ministry of Road Transport and Highways (2019) assessed that "stoppages at these check-posts have been one of the key reasons behind the inefficiency of [the] Indian logistics sector," and Debroy and Kaushik (2002) judged that "vehicle detention [was] the greatest malaise for the trucking industry." Das-Gupta (2006) estimates that "waiting costs would have been around 0.98 per cent of GDP in 2002." This paper assesses whether the GST's liberalization of policy-induced barriers to internal trade improved Indian trucking.

Ex ante, there were a number of reasons why eliminating the need for tax collection at state borders might not actually speed up interstate trucking in India. The Indian tax environment features many distinct participants with heterogeneous, competing interests in a reform that centralized the nation's tax system. In its advocacy of the reform, MORTH dubbed GST "the good and simple tax" that would substantially speed up border crossings. However, on the ground, the complicated vagaries of the Indian tax system mean that a single reform might not necessarily transform the trucking experience. Summarizing law and order in Indian trucking, Debroy and Kaushik (2002) judge that "the RTO [Regional Transport Office] checkposts en-route mainly function as revenue collection centres for individual benefits rather than for State exchequers." They estimate that more than three-quarters of checkpost fees are unofficial payments to officials, who would presumably not welcome reform. Moreover, there were risks that local governments would not faithfully implement the GST and that non-governmental actors could complement or offset changes in government barriers.[1] These sources of complications likely vary across states. Altogether, these features made

[1] See, for example, Christin Mathew Philip, "5 years after GST, RTO checkposts still thrive in Karnataka," *Times*

the effects of eliminating tax collections at border checkposts less than straightforward: whether this national reform effectively reduced stoppages at borders and integrated Indian states into one market is an empirical question.

To quantify the changes in transport efficiency at state borders, we use three complementary data sources that we describe in Section 3: high-frequency Global Positioning System (GPS) trucking data, trucking event logs, and a survey of truck drivers. Our main analysis is based on data from a GPS tracking firm that describes the movements of about 29,000 trucks during 2015 to 2018. In addition, we use event logs reporting the reasons for stoppages from a relay-trucking firm with thousands of trucks to precisely measure stoppage times at border checkposts. Finally, we surveyed about 1,500 truck drivers in order to provide a retrospective assessment of the changes in driving times and border stoppages associated with the GST reform and characterize the prevalence of GPS usage in Indian trucking. Each of these data sources suggests that the average duration of a border crossing fell by one-third to one-half after GST went into effect in July 2017.

In Section 4, we exploit the temporal and geographic precision of the readings from the on-board GPS devices to estimate location-specific effects of the GST reform on border-crossing times. Specifically, we compare the duration of border crossings before and after the reform for about 100 border-crossing areas. The "treated" segments of these border-crossing journeys are the locations near the state border and locations near checkposts cataloged by users of Google Maps. Truck speeds on these segments increase substantially after the reform. Speeds on the "control" segments of the same border-crossing truck journeys are largely unchanged, so the place-specific difference-in-differences estimates are quite close to the before-after comparisons for the treated segments. The greatest reductions in border-crossing times caused by the GST reform were in the eastern and northeastern regions of India. For example, at places like the Assam-West Bengal and Andra Pradesh-Odisha borders in eastern India, border-crossing times fell by more than three hours.

To evaluate the economic consequences of these faster border crossings, Section 5 examines how household expenditures changed in districts that experienced different declines in border-crossing times. We capture each district's exposure to the reform with a measure of "market access," as in Donaldson and Hornbeck (2016). Using India's road network and observed border-crossing times, we compute how the reform changed the time required to travel between each pair of districts in India and the consequent change in each district's access to potential customers in every other district.[2] By considering the fastest route between each pair of districts, our exposure measure captures the fact that the same delay in crossing a border imposes different trade costs at, for example, an isolated bottleneck and a central hub. By summarizing both the direct and indirect impacts of border-crossing times, market access captures the fact that a delay at the border between two states affects economic outcomes in other states.

Our estimates show that household expenditure rose in districts where GST improved market

of India, 7 July 2022 and "Illicit Toll Plaza Scam in Gujarat: Fraudsters Extract Millions in Taxes from Commuters Over 18 Months", *Herald*, 9 Dec 2023.

[2]One merit of this exposure measure is that it requires only changes in trade costs, which we can infer from observed truck movements. Our GPS data do not reveal the freight carried by trucks.

access. Our regression analysis uses within-state variation in market-access improvements to estimate the consequences for household expenditure. We include state-time fixed effects to absorb the consequences of GST-driven changes in state-level tax rates and changes in other state-level policies unrelated to GST. We estimate a market-access elasticity of household expenditure around four. Given the range of observed market-access improvements, this estimate implies that faster border crossings raised household expenditure by 0.16% to 0.64% across the range of districts. As such, there appear to be substantial returns to removing barriers to interstate trucking. Our paper contributes to research quantifying internal trade barriers and the economic gains from domestic integration. Our findings of large trade barriers within India and substantial economic gains from their liberalization are consistent with those from prior studies, such as Atkin and Donaldson (2016), who estimate internal trade barriers in Nigeria and Ethiopia to be four to five times higher than in the United States, and Van Leemput (2021), who finds that internal trade barriers in India are about five times larger than in the United States and estimates sizable welfare gains from lowering them.

Much of the literature on domestic market integration focuses on transportation infrastructure as a shifter of trade costs (Donaldson, 2015).[3] India's roads and highways are as dense as those of the United States; a number of studies have examined infrastructure investments in India ranging from new interstate highways to the paving rural roads.[4] Studies of internal integration in other economies have also overwhelmingly focused on improvements in transportation infrastructure.[5] In contrast, this paper studies the consequences of removing policy-induced barriers to intranational trade in India. It is closest to other studies of checkpost officials impeding trade in developing economies, such as bribes and delays on highways in Indonesia (Olken and Barron, 2009) and West Africa (Foltz and Li, 2023).

2 The Good and Services Tax reform

On July 1, 2017, the Indian government put into effect the Goods and Services Tax: a uniform nationwide consumption-based value-added tax regime. This major tax reform took several years to be negotiated between the central and state governments and was eventually approved in August 2016.[6] GST replaced a complex and multi-layered central, state, and local tax structure. It subsumed a multitude of different taxes on goods and services across the country, unifying final taxes into four nationwide slabs with rates of 5, 12, 18, and 28 percent with some essential commodities

[3] Redding and Turner (2015) survey the large and growing literature on transportation costs and the spatial distribution of economic activity.

[4] See, for example, Adukia, Asher, and Novosad (2020), Aggarwal (2018), Alder, Roberts, and Tewari (2018), Asher and Novosad (2020), Asturias, García-Santana, and Ramos (2018), Donaldson (2018), and Shamdasani (2020). Relatedly, Akbar, Couture, Duranton, and Storeygard (2023) study cross-city variation in travel speeds on Indian roads. Firth (2019) examines an Indian policy that prioritizes passenger trains over freight trains, dramatically slowing rail shipments.

[5] Donaldson (2015) highlights Young (2000), who studies Chinese local governments' imposition of interregional barriers to trade in the 1980s and 1990s, as a notable exception.

[6] Upon approval in 2016, the planned implementation date was July 2017. This gave firms and transport companies ample time to prepare for the policy change.

exempt. In addition to unifying tax rates across states, the Indian government's GST council prepared an online portal, the GST Network, to streamline the process for taxpayers including online registration, filing of returns, and making payments. While GST was intended to simplify the tax structure and eliminate cascading taxes, the government also aimed to improve the ease of doing business domestically, thereby promoting internal economic integration and making India's exports more competitive in global markets.[7]

Prior to GST, India's tax structure was predominantly origin-based, which meant that taxes were collected from a point where goods were produced. Moreover, there were additional taxes on cross-border trade, including interstate customs duties and interstate entry taxes. These taxes on interstate trade needed to be assessed and collected when goods crossed Indian state borders. These all necessitated checkposts near state-border crossings at which government officials inspected goods-carrying trucks and collected a variety of different taxes, which caused delays at border crossings. ed the hope of alleviating these delays, the accompanying congestion, and the bribes paid.

The reform eased cross-state freight shipping in two important ways. First, GST replaced various taxes that had been collected at state borders, narrowing the set of legitimate reasons for which officials might stop trucks. Second, GST is a destination-based value-added tax. As such, tax revenues are collected at the point of consumption. Therefore, GST abolished the tax-collection and document-verification purposes of cross-border checkposts, which led many states to abolish checkposts when GST was implemented.[8] However, many checkposts continue to operate, albeit with a narrower scope given that GST obviated the need for tax collection. Specifically, government officials still inspect trucks and verify information including the GST invoice number, consignment notes, and registration of the logistics firm. Tax enforcement authorities also continued spot checking inter-state goods movements using "flying squads" (Hindu Business Line, 2018).

One year after the GST reform, the government deployed a new transportation permit (waybill) system for truck shipments. The previous system involved state-specific rules and often-burdensome paperwork. To harmonize and streamline this process, the GST council created the electronic waybill (e-Way Bill) system, which was introduced in April 2018 and made mandatory in June 2018 (see Appendix A.2).

The policy focus on reducing delays at state borders parallels the 1985 Schengen Agreement and subsequent convention implemented as part of European integration. Previously, border controls were required because VAT rates varied across countries, delaying flows of goods. The 1993 launch of the European Union's single market—establishing the free movement of people, goods, services and money—removed these border controls. This liberalization of border controls was bundled

[7]The government also intended for GST to enhance tax compliance by increasing transparency, leveraging a VAT's self-enforcing features, and bringing more businesses into the formal economy (Goods and Services Tax Council, 2017).

[8]The government webpage on the reform says that "For quick and easy movement of goods across India without any hindrance, all the check posts across the country are abolished" (`https://docs.ewaybillgst.gov.in/apidocs/introduction.html`, accessed January 30, 2024). 19 states and 2 union territories officially abolished checkposts when GST went into effect on July 1, 2017. See Appendix A for details. The reform did not eliminate vehicle inspections for non-tax purposes (e.g., Road Transport Office checks for truck registration and driver license).

with many other important changes. Chen and Novy (2011) suggest that "the abolition of border controls among the participating countries has helped to foster trade integration, most probably through the elimination of time delays and administrative burdens that were previously experienced at borders."

3 Data

Our analysis exploits three types of trucking movement data. First, we observe the movements of about 29,000 trucks during 2015 to 2018 in high-frequency data provided by a GPS tracking firm. Second, we acquired trucking logs from a relay-trucking firm, which record detailed data on trucks' stoppages including at border checkposts. Third, we surveyed about 1,500 truck drivers at transport hubs about driving circumstances in early 2020 and four years prior. We describe all three sources of trucking movement data in detail below. Finally, we describe how we located tax-related checkposts using user-submitted Google Maps data.

3.1 GPS tracking firm data

We use data on the movements of thousands of trucks from an Indian trucking fleet management service provider that sells GPS tracking services to clients.[9] In order to monitor goods-carrying trucks in real time, trucking firms hire service providers who supply both on-board hardware (i.e., the GPS tracking devices) and an online platform that reports the trucks' locations. The raw GPS data for each truck report its latitude-longitude coordinates at a regular interval whenever the truck is running. The modal truck pings once per minute, and about three-quarters of trucks ping at least once per minute. We track truck movements (driving speeds and distances to borders) using the timestamps of pings from installed GPS devices.

We process these data to describe the routes, stops, and delays of 29,000 trucks appearing in the data between 2015 and 2018. Table B.1 reports the number of trucks by the number of years in which they appear in the data. About one-fifth of trucks are present in all four years.

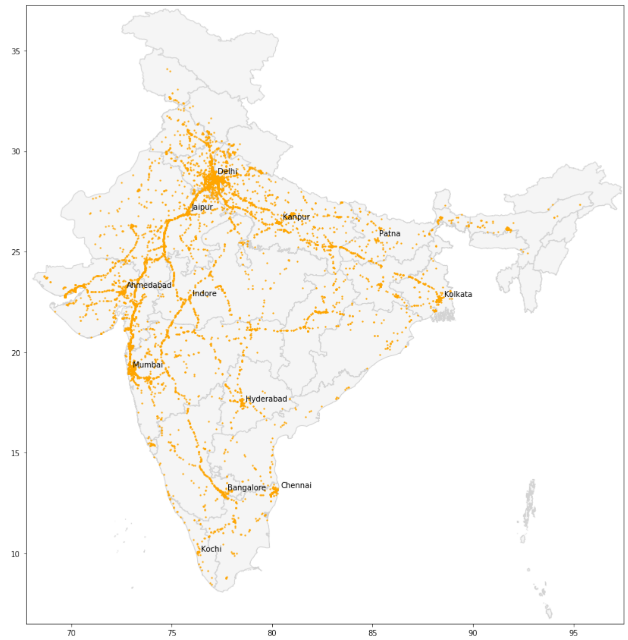
The movements of trucks we observe in the data span the whole country, but the customer composition of the GPS tracking firm means that truck movements in northern India are overrepresented. To illustrate, Figure 1 depicts the first ping of each truck observed on a single (arbitrary) day, 26 October 2016. The more than 10,000 trucks observed on that day span nearly every state in the country. The pings are disproportionately in northern India. Relative to the number of "goods vehicles" registered with the government in each state in 2016, the number of trucks pinging on this date are highest in the north and west of India and lowest in the northeast and south.

3.2 Relay-trucking firm data

We also use data from a relay-trucking firm, which has a distinctive business model in which drivers change over after every few hundred kilometres of driving through a network of change-over stops

[9] Our data-use agreement requires that we not name the service provider.

Figure 1: Trucks in the GPS tracking firm data on 26 October 2016



NOTES: This map shows the latitude-longitude coordinate of each truck's first ping on a single day, 26 October 2016.

called "relay pitstops" and then get scheduled back to their home each day.[10] These trucks deliver their loads to company warehouses, typically located outside of cities, rather than to the final recipient. Similar to other logistics companies, this relay-trucking firm records truck movements based on GPS tracking devices.

The relay-trucking firm data summarize the movements of almost 3,000 trucks traveling between March 2017 and October 2018. We have access to a data set compiled by a navigation services company, not the underlying raw GPS data. In these data, nearly 5 million trucking "events" are classified into categories listed in Table B.2, such as "driving", "(un)loading", and "border crossing." Relative to the GPS data that report only position, time, and speed, these data have the advantage that this classification allows us to distinguish between drivers taking a pitstop and waiting at a border checkpost. We use these data to measure the length of stoppages at border checkposts, which constitute 6% of the nearly 5 million trucking events. Since this company's driving practices differ from those of most Indian trucking companies, we use these data to corroborate the results from the high-frequency GPS trucking data that cover a more representative set of trucks.

3.3 Survey data

We complement the trucking data with survey data to analyze selection into GPS usage by truckers. The surveys also independently quantify changes in border-crossing times after GST. Starting in

[10]The motivating idea of relay trucking is to make truck driving a more attractive occupation by making trips be one-day jobs that allow drivers to sleep in their own homes each night.

February 2020, we surveyed 1,528 truck drivers in 12 major cities: Delhi, Hyderabad, Indore, Jaipur, Kanpur, Kolkata, Patna, Ahmedabad, Bangalore, Chennai, Bhubaneshwar, and Mumbai. Our fieldwork was interrupted by the COVID-19 pandemic in mid-March 2020 and resumed in April 2021. About half of respondents were surveyed before the pandemic, and the rest were surveyed during 2021 to 2022.

To recruit respondents, the field team first identified key transport hubs in each city and divided it into zones after a walk-around tour. Enumerators started walking from a central point in the assigned zone and approached every second truck driver, asking for their consent to be surveyed. About two-thirds of drivers approached by enumerators agreed to take part in the survey.[11] In face-to-face local-language interviews that typically lasted 45 minutes, enumerators first asked drivers questions about their driving practices and experiences at the time of the interview, followed by retrospective versions of the same questions that asked about circumstances in 2016.[12] About 90% of respondents reported that they started driving before July 2017.

41% of truck drivers report using GPS devices, and trucks with an on-board GPS device belong to larger firms and have more educated drivers. While only 37% of drivers employed by firms with fewer than 5 trucks report using GPS devices, 55% of drivers driving for firms with more than 100 trucks use GPS devices (Table B.3). Drivers driving their own trucks (likely as independent contractors) are less likely to use GPS device. Without controlling for other characteristics, GPS usage appears slightly higher among younger and more educated truck drivers. Table 1 reports regressions predicting GPS usage. The dependent variable is an indicator equal to one if the respondent has a GPS tracking device on their truck. Driver age and firm type are not statistically significant predictors. GPS usage is greater among more educated drivers and companies with larger fleets (column 5). While these patterns show that trucks with GPS devices are not representative of all Indian trucking, Section 4.5 shows that reported changes in border-crossing times do not vary with GPS usage.

3.4 Border-crossing journeys and checkpost locations

We analyze the duration of border crossings in areas where we observe a sufficient number of truck journeys. As described in detail in Appendix B.2, we denote a border-crossing area as the center of a cluster of GPS pings in which trucks' consecutive pings were in different states. This yields the border-crossing areas depicted in Figure 2a.

We collected checkposts locations using information submitted by users of Google Maps, as we are not aware of a prior comprehensive list of border checkposts. We searched Google Maps Places for 20 keywords related to excise tax checkposts, RTO checkposts, and customs offices within 50 kilometers of each border-crossing area.[13] We narrowed the large set of results to relevant locations

[11]Driver respondents were monetarily compensated for their time.

[12]While GST took effect in July 2017, we chose early 2016 as the reference period because circumstances in early 2017 could have reflected effects of the major demonetization shock of November 2016 (Chodorow-Reich, Gopinath, Mishra, and Narayanan, 2020).

[13]The 20 keywords are booth, excise, toll, plaza, post, rta, rto, state, tax, taxes, border, checkpost, integrated,

Table 1: GPS device usage in truck-driver survey data

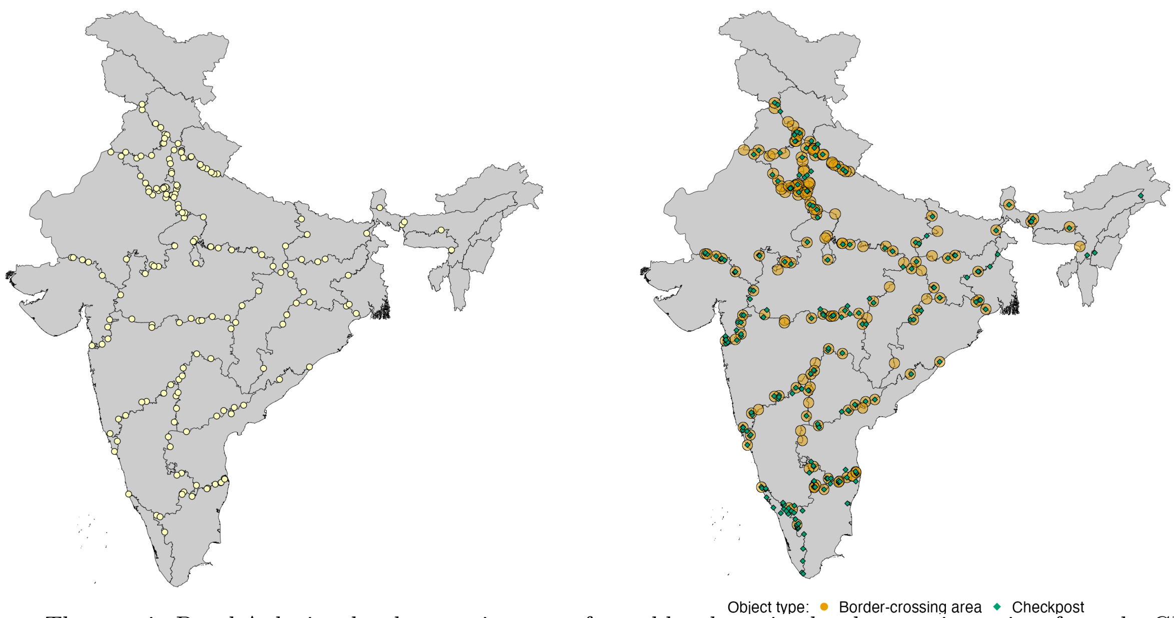
	(1)	(2)	(3)	(4)	(5)
Driver age	-0.00199				-0.000652
	(0.00128)				(0.00159)
Driver education					
Up to 5th standard		-0.00944			0.0279
		(0.0397)			(0.0506)
Up to 10th standard		0.120			0.109
		(0.0367)			(0.0473)
12th standard or diploma		0.124			0.150
		(0.0498)			(0.0637)
Graduate and above		0.0192			-0.132
		(0.0801)			(0.106)
Firm Type					
Broker/Agent			-0.0742		-0.105
			(0.0462)		(0.0580)
Aggregator			-0.0180		-0.0177
			(0.0715)		(0.0785)
Private Company			-0.0338		-0.0663
			(0.0416)		(0.0472)
Self employed			-0.153		-0.122
			(0.0677)		(0.0753)
Government			0.574		0.321
			(0.490)		(0.489)
Other			-0.426		-0.440
			(0.164)		(0.187)
Firm size					
log(fleet size)				0.0546	0.0469
				(0.00998)	(0.0102)
Constant	0.482	0.344	0.426	0.335	0.332
	(0.0485)	(0.0315)	(0.0146)	(0.0267)	(0.0759)
Observations	1,528	1,528	1,528	1,007	1,007
R-squared	0.002	0.016	0.010	0.029	0.053

NOTES: This table reports coefficients estimated by regressing GPS usage on truck driver and trucking firm characteristics. The dependent variable is an indicator equal to one if the respondent has a GPS tracking device on their truck. The sample includes data from all drivers in the truck-driver survey. Columns 4 and 5 have smaller samples primarily due to respondents not reporting their firm's fleet size. Standard errors are in parentheses.

Figure 2: Border-crossing areas and checkpost locations

(a) Border-crossing areas

(b) Location of checkposts



Notes: The map in Panel A depicts border-crossing areas formed by clustering border-crossing points from the GPS data. Border-crossing points are the average latitude-longitude coordinates of the two consecutive pings that are located in different states. To identify the border-crossing areas, we apply the density-based spatial clustering of applications with noise (DBSCAN) algorithm using parameters $\epsilon = 1$km and MinPts = 300. The map in Panel B depicts checkposts within 50 kilometers of these border-crossing areas. Of the 174 border-crossing areas, 153 have a checkpost within 50 kilometers.

by selecting places that (1) matched precise phrases (e.g., "border checkpost"); (2) coincided with places where trucks systematically stop in our GPS data; or (3) had a name like "tax office" and were within 100 meters of a road in a sparsely populated subdistrict. We manually reviewed the 850 places satisfying these stricter criteria, using the text of reviews, user-submitted photos, and satellite imagery to designate nearly 300 places as checkposts. Figure 2b depicts these checkpost locations.

4 Effect of border-tax reform on border-crossing times

This section shows that the removal of border-tax checkposts substantially reduced border-crossing times, with considerable heterogeneity across regions of India. We make location-specific comparisons of border-crossing durations before and after the reform for about 100 areas. Section 4.1 starts by describing changes in driving duration during border-crossing truck journeys after the GST reform. Section 4.2 introduces our estimating equations and describes how we define the treated segments of border-crossing journeys based on proximity to state borders and checkposts. Section 4.3 shows that trucks passed through these locations substantially faster after the GST reform, especially in the eastern states of India. Sections 4.4 and 4.5 corroborate these findings using the trucking logs and restrospective survey data.

4.1 Border-crossing truck journeys

We first depict how driving duration changed after July 1, 2017 during border-crossing journeys as a function of distance to the border. Specifically, for each border-crossing journey, we take pings within 30 kilometers of the border and partition these pings into 30 rings of 2km width using the cumulative elapsed distance between the pings. For each ring r, we calculate the elapsed time between the last ping in ring $r-1$ and the last ping in ring r. We compare the total time spent in each ring before and after the reform by estimating the following equation:

$$y_{ri} = \sum_{r'=-15}^{15} \beta_{r'} \times \mathbf{1}(r = r', \text{post}(i) = 1) + \lambda_{m(i)} + \alpha_{rc} + \epsilon_{ri}, \quad (1)$$

where r denotes a ring, $m(i)$ denotes the month of journey i, and c denotes a directed border-crossing area.[14] The dummy post(i) is one if border-crossing journey i happens after the reform. The estimated sequence $\{\beta_r\}_{r=-15}^{15}$ captures changes in driving duration throughout the 60-kilometer border-crossing journey. We describe the sample of border-crossing journeys in Appendix B.3.

Figure 3a shows that border-crossing journeys are faster after the reform. The decrease in duration is concentrated in rings less than 4 kilometers from the border. The two rings immediately adjacent to the state border experience duration declines of about five minutes each. These rings

checkpoint, commercial, check, check point, check post, customs, office.

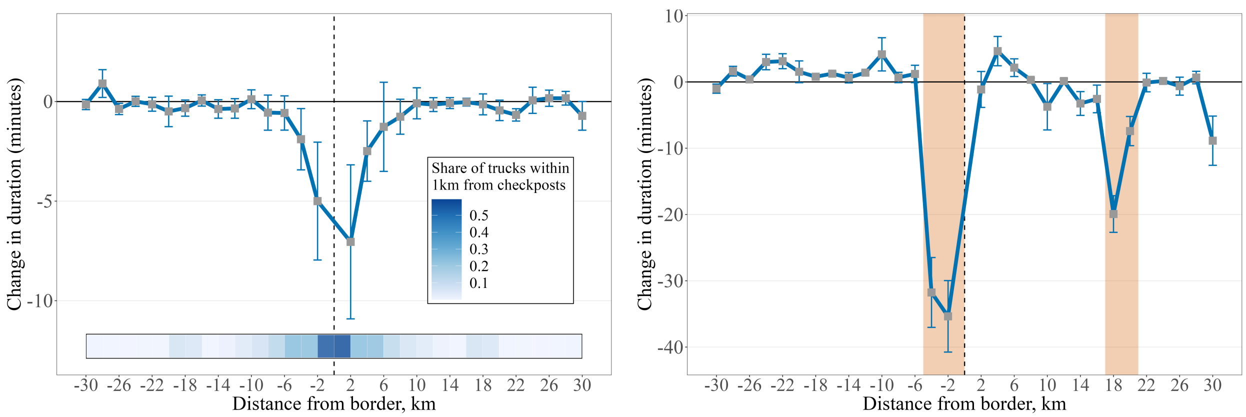
[14] Border-crossing journeys are directed so that driving from state A to state B and driving from state B to state A are two distinct values of c.

are also those where checkposts are most prevalent: more than 50% of trucks go past a checkpost within 2 kilometers of the border-crossing point. The time spent in rings farther from the border is mostly unchanged, suggesting that faster border crossings are not offset by slower driving elsewhere during the truck's journey.

Figure 3: Changes in driving duration by distance to border

(a) Nationwide outcomes

(b) Example from Uttar Pradesh-Bihar border



NOTES: Panel A depicts the changes in driving duration for all border-crossing areas in the estimation sample. Panel B depicts the changes in driving duration for a border-crossing area on the border between Uttar Pradesh and Bihar that is on the Golden Quadrilateral highway. The depicted durations are for journey from Uttar Pradesh to Bihar: bins with a negative distance to the border are in Uttar Pradesh. The pink shading denote distance bins that are within 3 kilometers of a checkpost.

Figure 3b shows that the average change potentially masks substantial heterogeneity attributable to heterogeneity in checkpost locations across border-crossing areas. It depicts $\hat{\beta}_r$ from equation (1) estimated for a border-crossing area between Uttar Pradesh and Bihar. While the nationwide average shows duration declines only in the rings closest to the border, Figure 3b shows substantial declines at two places: the four kilometers adjacent to the border on the Uttar Pradesh side and at a location 20 kilometers inside the state of Bihar. Duration fell by almost an hour for the former and about a half hour for the latter. As indicated by the pink shading, there are checkposts at each of these locations. Border-crossing journeys into Bihar became faster in part because delays at a checkpost 20 kilometers inside Bihar declined substantially.

4.2 Empirical specification

We estimate the effect of the border-tax reform on truck speeds using event studies and difference-in-differences comparisons. The event-study approach is a before-and-after comparison of border-crossing events. The difference-in-differences design compares changes in the duration of border-crossing events (BCE) to changes in other parts of the same truck journey that we denote auxiliary events (AE). The estimating equations are

$$y_{itc}^{\text{BCE}} = \alpha_c^{\text{ES}} + \sum_{j=-5,\ j\neq -1}^{5} \beta_j^{\text{ES}} \times \mathbf{1}\{t - t_c^* = j\} + \epsilon_{itc} \tag{2}$$

$$y_{itc}^{\text{BCE}} - y_{itc}^{\text{AE}} = \alpha_c^{\text{DiD}} + \sum_{j=-5,\ j\neq -1}^{5} \beta_j^{\text{DiD}} \times \mathbf{1}\{t - t_c^* = j\} + \epsilon_{itc}, \tag{3}$$

where y_{itc} denotes the duration of border-crossing journey i in quarter t at border-crossing area c and t_c^* denotes GST implementation at area c. β_j^{ES} and β_j^{DiD} are the event-study and difference-in-differences estimates of the GST effect on border-crossing durations j quarters after GST implementation.

We define these border-crossing events and auxiliary events using proximity to both the border and located checkposts. We define a border-crossing event as pings within 10 km elapsed distance of a border-crossing ping and pings within 3 km elapsed distance of a checkpost. We define an auxiliary event as pings within 20 km of border or 6 km of the checkpost that are not part of the border-crossing event. Figure 4 illustrates an application of these definitions to a crossing of the Maharashtra–Madhya Pradesh border. The left panel illustrates the geographic and temporal precision of the GPS pings as the truck travels along Asian Highway 47 (AH47) and crosses the state border at the center of the map. The right panel shows how we assign these pings to border-crossing and auxiliary events. The treated segments are near the state boundary and the RTO border checkpost 28km from the border-crossing point.[15] We outline the construction of the sample of border-crossing and auxiliary events in Appendix B.3.

We use these definitions with the goal of delineating treatment and control groups given the data available. Ideally, we would designate treated segments of a truck's border-crossing journey as those exposed to tax-collection enforcement absent GST reform. Our located checkposts are highly informative in this regard, but incomplete for two reasons. First, Google Maps users may not catalogue all checkposts: 12% of the border-crossing areas do not have a located checkpost within 50 km (Appendix Table B.4). Second, some tax-compliance mechanisms are not physically stationary, such as so-called "flying squads". Therefore, we assume that unobserved checkposts and mobile enforcement mechanisms take effect within 10 km of the border-crossing point and designate all segments in this area as treated.[16] We define auxiliary events as proximate segments of the same border-crossing journey to capture journey-specific confounders such as road quality and traffic conditions.

[15] User-submitted comments about the RTO Check Post MP/MH Border Sendhwa on Google Maps range from "no good" to "Worst RTO in MP" to "the worst and highest level of corruption in entire India".

[16] An over-inclusive definition of border-crossing events is preferable because the outcome variable is journey duration, not event-level average speed. Classifying some auxiliary events as border-crossing events would not bias the estimate of β_j^{DiD}.

Figure 4: One truck journey across the Maharashtra–Madhya Pradesh border

(a) Route (b) Treatment and control observations

Notes: The figure depicts a truck journey that crosses the Maharashtra-Madhya Pradesh border at the center of the map. The left panel shows the GPS pings for this journey; each dot represents a distinct ping. The right panel shows the pings that constitute border-crossing (treatment) events and auxiliary (control) events. Border-crossing events are pings within 10 km elapsed distance of the border or within 3km elapsed distance of a checkpost. Auxiliary events are pings within 20 km of the border or 6 km of the checkpost that are not part of the border-crossing event.

4.3 Changes in border-crossing times

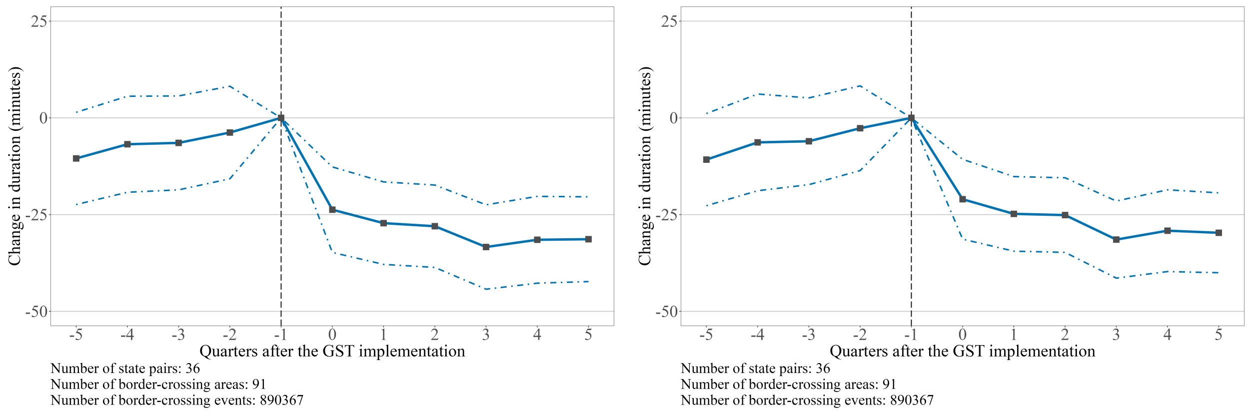
Figure 5 depicts the quarter-by-quarter estimates of how the border-tax reform affected the duration of border-crossing journeys. In both panels, there is no evidence of a trend in duration prior to the implementation of GST. In the first quarter after the reform, there is a substantial decrease in the amount of time spent near state borders and located checkposts. The nationwide average is a decrease of about 25 minutes. This reduction in duration persists over the following five quarters. There is no evidence of a meaningful change in border-crossing times upon the introduction of the e-Way Bill system a year after the GST reform. Speeds on the auxiliary/control segments of the same border-crossing truck journeys are largely unchanged, so the difference-in-differences estimates in Panel B are similar to the before-after comparisons for the treated segments in Panel A.

As described in the introduction, the complicated vagaries of the pre-reform Indian tax system meant that the nationwide border-tax reform might have heterogeneous consequences across the country. Heterogeneous implementation of the new tax system is evident: the state of Odisha abolished its checkposts three months early on April 1, 2017, while the state of Karnataka is accused of still operating checkposts five years later.[17] For about 100 border-crossing areas, we

[17] See Nirmalya Behera, "States should follow Odisha's move to abolish check gates for GST: Adhia," *Business Standard*, 9 June 2017 and Christin Mathew Philip, "5 years after GST, RTO checkposts still thrive in Karnataka,"

Figure 5: Border-tax reform reduced border-crossing duration by 25 minutes

(a) Event-study estimates (b) Difference-in-differences estimates



NOTES: This figure depicts the estimated change in the average border-crossing time relative to the second quarter of 2017. The left panel presents estimates of β_j^{ES} from equation (2); the right panel presents estimates of β_j^{DID} from equation (3). Quarter "0" is the third quarter of 2017. GST took effect nationwide on July 1, 2017. Standard errors are clustered by quarter-by-area pairs.

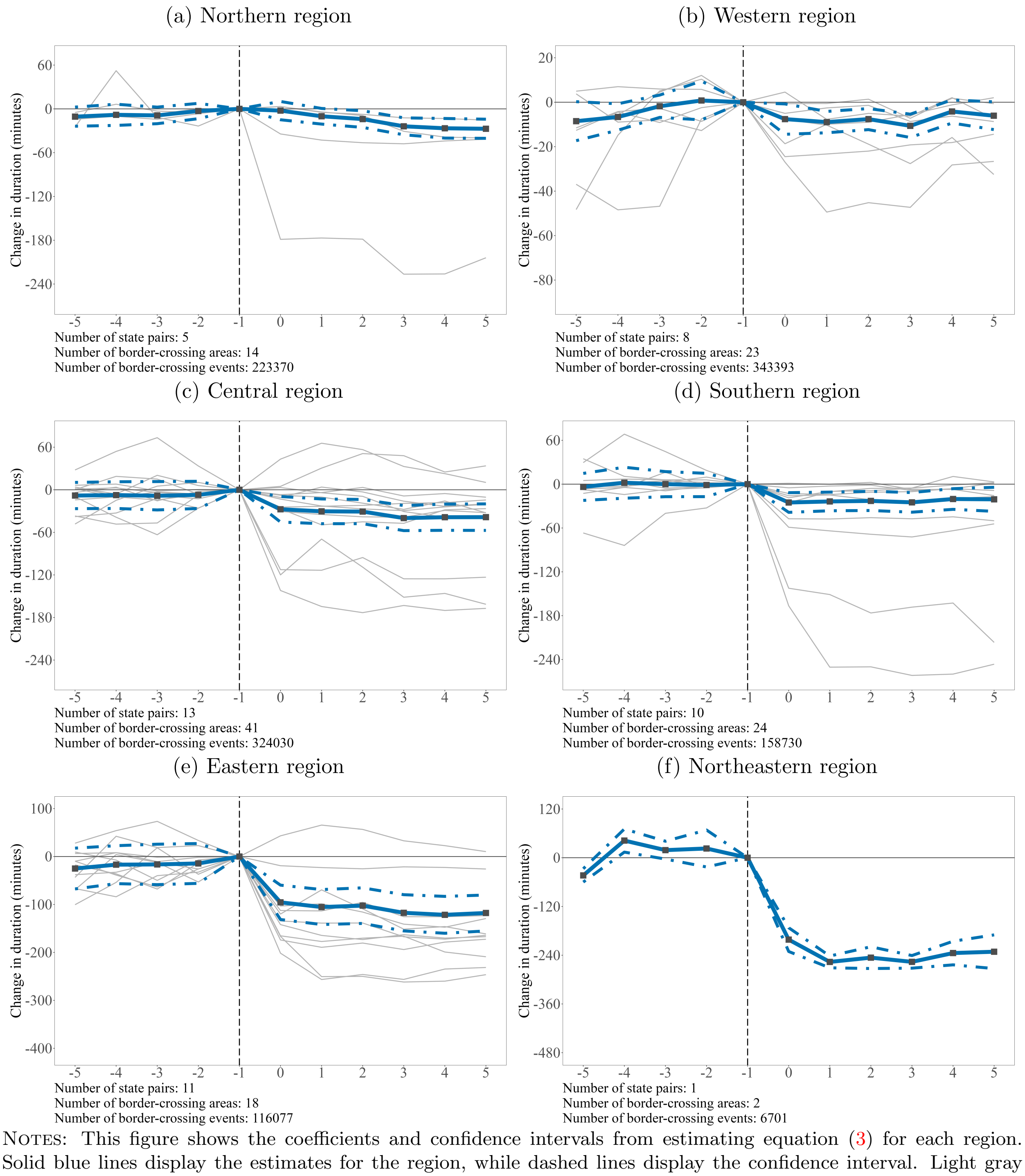
observe a sufficient number of truck journeys that we can estimate place-specific changes in border-crossing durations. Figure 6 depicts region-specific and crossing-specific estimates of equation (3), which show considerable variation.

There is considerable regional heterogeneity in the border-crossing speed improvements realized after GST took effect, with eastern states showing the largest gains. In the western region, the average gain is on the order of 10 minutes. The average improvements in the northern, central, and southern regions are closer to a half hour. Border-crossing areas in eastern and northeastern regions show substantially larger improvements, with border-crossing times reduced by about two hours on average. This pattern of improvements aligns with the Ministry of Road Transport and Highways (2019) description of pre-reform heterogeneity, in which pre-reform border crossings were fastest in the south and west and slowest in the east.

After corroborating these patterns of improved border-crossing times using alternative data sources in Sections 4.4 and 4.5, we use the place-specific estimates of improved border crossing times to estimate the effect of the border-tax reform on household expenditure in Section 5.

Times of India, 7 July 2022.

Figure 6: Difference-in-differences estimates of effects by region

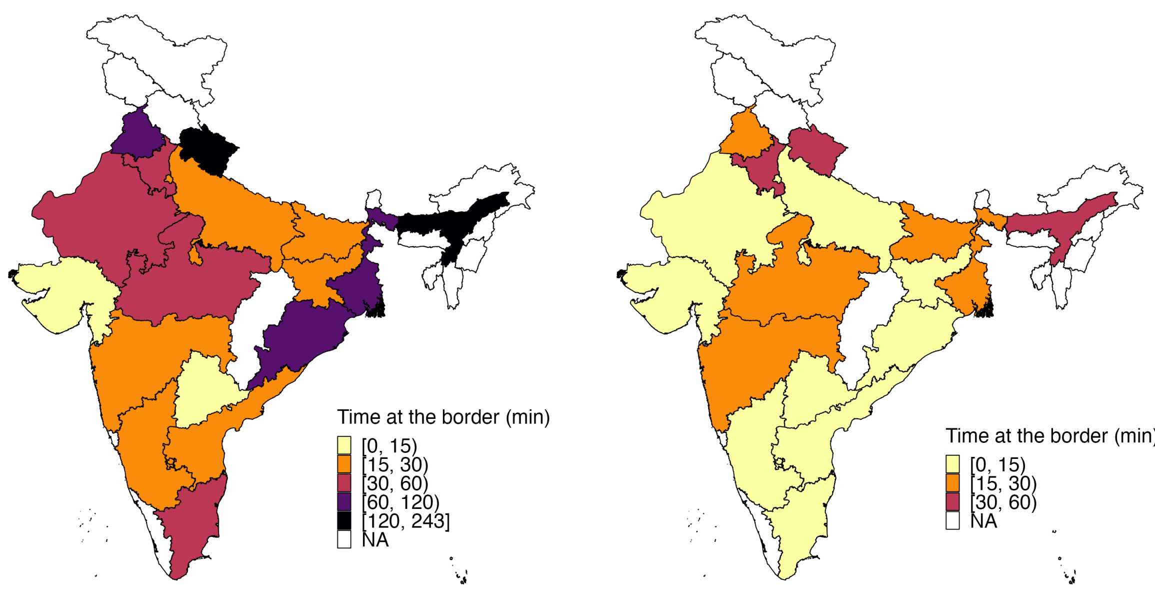


Notes: This figure shows the coefficients and confidence intervals from estimating equation (3) for each region. Solid blue lines display the estimates for the region, while dashed lines display the confidence interval. Light gray lines display the estimates for each state-pair border located within the region. Standard errors are clustered by border-crossing area and quarter-year cells. The regions are defined in accordance with Zonal Councils of India.

4.4 Changes in border-checkpost delays in trucking logs

As an alternative measure of the length of stoppages at border checkposts, we use data from a relay-trucking firm that classifies the nature of stops. Since these data distinguish stops at border checkposts from stops related to drivers taking a break or encountering traffic jams, they address potential measurement concerns that arise when examining all delays trucks encounter near state borders. We examine those observations in which the "event" is a border crossing, which constitute about 6% of events (see Table B.2). We contrast the length of border stoppages before and after the implementation of GST in July 2017.

Figure 7: Border-crossing times before and after GST (truck event logs)



NOTES: These maps depict average border crossing times when entering each state recorded in the three months before and after GST was implemented in July 2017 (April-June in left panel and August-October in right panel). Each map summarizes approximately 90,000 border-crossing events at 52 border checkposts that had at least 10 crossings both before and after GST implementation.

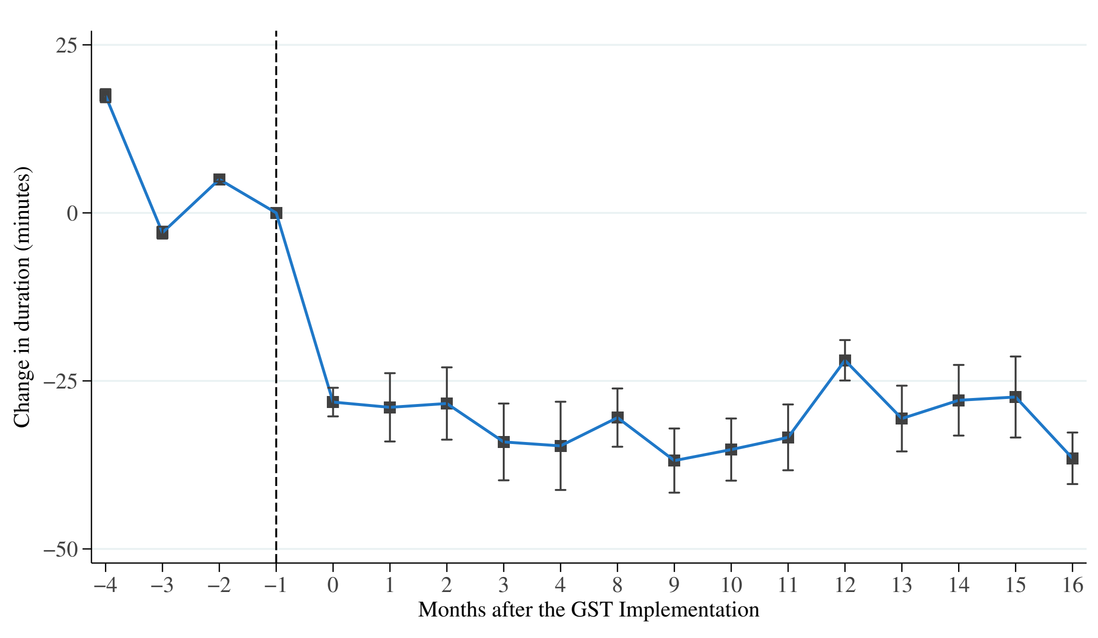
To illustrate the heterogeneity experienced across different checkposts, we depict state-level variation in stoppage times at border checkposts in Figure 7.[18] The left panel depicts the average number of minutes trucks stopped at a border checkpost when entering each state during the three months prior to the implementation of GST, while the right panel depicts these times for August through October 2017. While we do not have data for all states, it is clear there was substantial heterogeneity in stoppage times at border checkposts. For example, in the months prior to July 2017, the average wait time at border checkposts entering Maharahstra was about 20 minutes, while the time to enter Madhya Pradesh was almost double and the time to enter Uttarakhand was more than two hours. The right panel of Figure 7 shows that the waiting time at border checkposts

[18]We observe stoppages at 57 distinct border checkposts in the relay-trucking firm data. Figure B.1 in the appendix depicts the geographic locations of the checkposts included in the relay-trucking firm dataset.

dropped notably after GST was implemented. For example, the average stoppage time to enter Uttarakhand fell from over two hours to 35 minutes.

Figure 8 depicts the results of regressing the number of minutes spent at a border checkpost on a monthly dummy variable and a checkpost fixed effect. GST took effect in July 2017, denoted month "0", and we express change relative to June 2017, month "-1". The average time spent at a border checkpost fell by 32 minutes after GST took effect (see regression in Table B.5). This decrease is quite large relative to the pre-GST average of about 53 minutes spent at border checkposts. Almost the entire improvement was realized immediately: border crossings were 28 minutes faster in July 2017.

Figure 8: GST reform reduced border-crossing duration by half hour in truck event logs



NOTES: This figure shows the coefficients and 95% confidence intervals estimated by regressing the number of minutes a truck spent at a border checkpost on a dummy for each month observed in 2017 and 2018 and a checkpost fixed effect. Month "0" is July 2017, when GST took effect. Data for months 5 through 7, December 2017 through February 2018, are unavailable. The sample mean of the border-crossing duration in June 2017 is 53.2 minutes. Standard errors are clustered by month.

4.5 Changes in border-checkpost delays in retrospective survey

Data from the GPS tracking firm and the relay-trucking firm show consistent estimates of the effect of GST reform on border-checkpost delays. A potential caveat is that these data sources may not be representative of the logistics sector as a whole. Indeed, the survey data show only 41% of truck drivers report using GPS devices. To address this concern, we analyze the delays reported in our truck driver surveys and test if the results vary between GPS users and non-users.

The majority of drivers report that the GST reform improved their driving experiences in response to qualitative questions, and this assessment likely reflects driving conditions rather than earnings effects. Specifically, most drivers indicate that the GST reform shortened their trips, though it had little effect on their earnings.

Using checkpost-level delay information reported by truck drivers in the survey, we estimate that GST reduced the average delay by about one-third. Table 2 shows that checkpost removal under GST led to an approximately 26-minute reduction in delays at checkposts (column 1). Most of this reduction occurred at checkposts that are near state borders: border checkposts had a 33-minute reduction in delays (column 2). We obtain similar estimates when including driver and checkpost fixed effects (columns 3 and 4).

Table 3 shows that these estimates are not driven by GPS-using truck drivers. The first column of Table 3 is identical to the first column of Table 2. The subsequent columns show that the driver-reported declines at checkposts after GST reform were statistically similar for drivers using GPS devices and non-users. If anything, the point estimate suggests that GPS-using truck drivers experienced smaller improvements in border-crossing times.

Table 2: GST reduced delays at border checkposts (retrospective survey data)

	(1)	(2)	(3)	(4)
GST	-25.81	-5.701	-14.15	-13.91
	(5.551)	(7.592)	(5.928)	(5.744)
Border checkpost		47.26	19.23	18.78
		(8.892)	(11.55)	(11.39)
GST × Border checkpost		-32.85	-25.89	-26.27
		(10.77)	(8.607)	(8.328)
Constant	84.44	55.70	75.24	75.69
	(4.685)	(5.953)	(7.645)	(7.573)
Observations	3,681	3,681	3,681	3,523
R-squared	0.006	0.016	0.553	0.547
Driver FEs			Yes	Yes
Checkpost FEs				Yes

Notes: This table reports coefficients estimated by regressing the checkpost-level delay in minutes on a dummy indicating whether GST has been implemented. The regression in column 1 pools across all checkposts. The regressions in columns 2 through 4 include a dummy that indicates whether a checkpost is near a state border and itsthe interaction with the GST dummy. The regressions in column 3 and 4 include a driver fixed effect. The regression in column 4 includes a checkpost fixed effect. The sample includes data from all drivers in the truck-driver survey who reported taking the same route before and after GST was introduced. Observations with reported delays of 30 hours or more (99^{th} percentile) are omitted. Robust standard errors are in parentheses.

Table 3: GST reduced delays similarly for GPS users and non-users (retrospective survey data)

	(1)	(2)	(3)	(4)
GST	-25.81	-34.76	-33.71	-33.71
	(5.551)	(6.569)	(5.553)	(5.325)
GPS user		-1.625		
		(9.452)		
GST × GPS user		19.23	8.028	8.050
		(11.30)	(9.409)	(9.168)
Constant	84.44	85.22	87.03	87.12
	(4.685)	(5.944)	(3.678)	(3.585)
Observations	3,681	3,681	3,681	3,523
R-squared	0.006	0.008	0.552	0.545
Driver FEs			Yes	Yes
Checkpost FEs				Yes

NOTES: This table reports coefficients estimated by regressing the checkpost-level delay in minutes on a dummy indicating whether GST has been implemented. The regression in column 2 includes a GPS-user dummy. The regressions in columns 2 through 4 include the interaction between the GST and GPS-user dummies. The regressions in columns 3 and 4 include a driver fixed effect. The regression in column 4 includes a checkpost fixed effect. The sample includes data from all drivers in the truck-driver survey who reported taking the same route before and after GST was introduced. Observations with reported delays of 30 hours or more (99^{th} percentile) are dropped. Robust standard errors are in parentheses.

5 Effect of border-tax reform on consumption

In this section, we evaluate the consequences of faster border crossings for household expenditure. We compare changes in household expenditures across districts that experienced different changes in border-crossing times. To do so, we estimate each district's exposure to the GST reform using a market-access approach. Using India's road network and observed border-crossing times, we compute how the reform changed the time required to travel between each pair of districts in India and how it changed each district's access to potential customers and suppliers in every other district. Our results show that, after the reform, household expenditure increased in districts where GST improved market access more.

To measure consumption, we use data on household expenditures from the Centre for Monitoring Indian Economy (CMIE). These biannual data cover about 500 of India's more than 600 districts. We study the 359 districts with at least 100 households surveyed in each period from 2015 to 2019.[19] We omit three periods (July 2016 through December 2017) from the estimation sample to address two potential concerns about transient events that might confound the analysis. First, India's

[19]The covered districts are depicted in the map in Figure 9. We cover no districts in the northeastern states of Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura.

demonetization in November 2016 had large short-run effects on economic activity (Chodorow-Reich, Gopinath, Mishra, and Narayanan, 2020). Second, comparisons of the two halves of 2017 may be complicated by staggered implementation of the GST reform.[20] Robustness checks that include these periods in the estimation sample show that our results are not particularly sensitive to these potential confounders.

To summarize the effect of the GST reform on a district's trading opportunities, we first compute how trade costs between pairs of districts declined with faster border crossings. We begin by computing travel times between pairs of districts by applying the fast-marching-method algorithm of Sethian (1996) to a map of the Indian road network using average driving speeds and observed border-crossing times.[21] We compute travel times for both the pre-GST and GST periods using the same road speeds. The only source of changes in travel times is the variation in border-crossing times. Given travel times, we compute trade costs using

$$\tau_{odt} = 1 + \gamma(\text{travel time}_{odt})^{\rho},$$

where o denotes an origin district, d denotes a destination district, and t denotes the pre-GST or GST regime. Following Baum-Snow, Henderson, Turner, Zhang, and Brandt (2020) and Alder (2016), we set $\rho = 0.8$ and calibrate γ so that the median pre-reform trade cost is 1.25.

Following Donaldson and Hornbeck (2016), we then use a first-order approximation of market access:

$$\text{MA}_{ot}^{t_0} \equiv \sum_{d \neq o} (\tau_{odt})^{-\theta} N_d^{t_0},$$

where t denotes a half-year, θ is the trade elasticity, and $N_d^{t_0}$ denotes a measure of pre-GST economic activity in base period $t_0 < 2017\text{H}2$. The latter component means that changes in our measure of market access over time stem solely from changes in trade costs, $\Delta \text{MA}_{ot}^{t_0} = \sum_{d \neq o} N_d^{t_0} \Delta(\tau_{odt})^{-\theta}$. Our benchmark measure of district-level economy activity is the total amount of night-time lights in the district in $t_0 = 2016$ in annual satellite imagery.[22] We set the trade elasticity θ to 4.

Most of the changes in market access over time are cross-state variation: regressing $\Delta \ln \text{MA}_{ot}^{t_0}$ on a set of state dummies yields R^2 of 0.96. This is unsurprising: differences in trade-cost changes stem from differences in proximity to border-crossing areas that experienced different changes in crossing times. The within-state variation in market-access changes stems from within-state geographic

[20] For example, Odisha abolished its checkposts in April 2017 rather than July 2017.

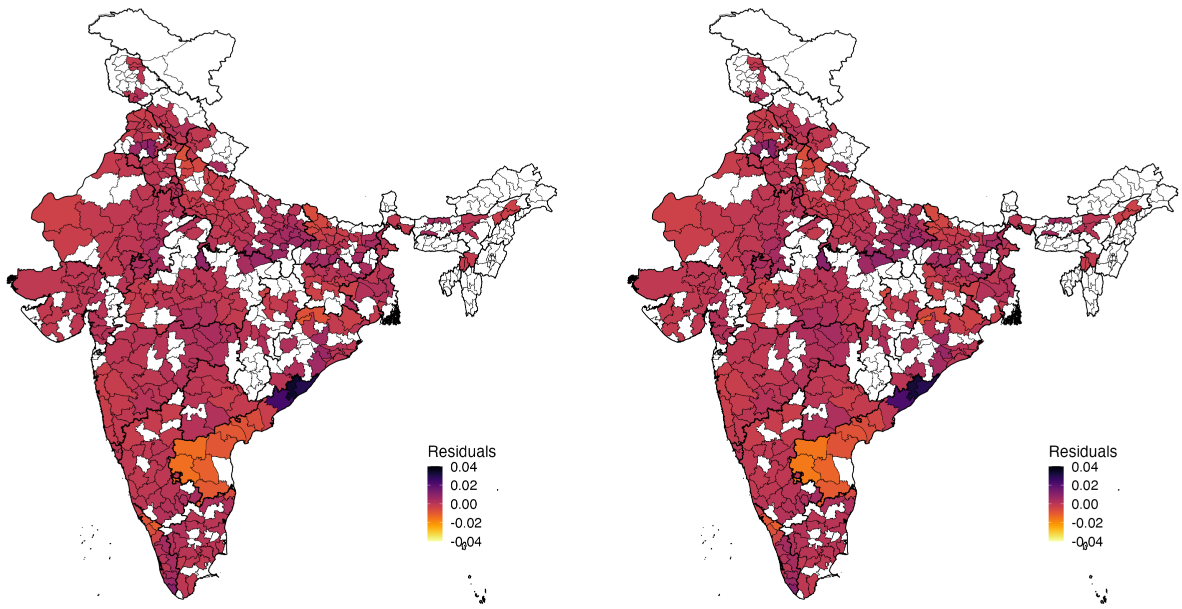
[21] Using GIS software, we project the road network created by International Steering Committee for Global Mapping (ISCGM) and Survey of India on a 2933 × 3214 pixel image of India. We assign a speed to each road pixel based on its type: major highway (45 kmph), highway (40 kmph), or secondary road (25 kmph). We assign a speed of 5kmph to pixels without roads. For pixels that are on a state border, we add the times required to cross state borders based on our estimates from the GPS data. If a pixel is located on a border between two states that is covered by the GPS data, we assign the border-crossing time of the nearest border-crossing point that is located along the same border. If a border pixel is located on a border between two states that is not covered by the GPS data, we assign the nationwide average border-crossing time.

[22] Night-time lights are a popular proxy measure for subnational GDP (Elvidge, Baugh, Kihn, Kroehl, Davis, and Davis, 1997; Henderson, Storeygard, and Weil, 2011). We use the Visible Infrared Imaging Radiometer Suite (VIIRS) Day-Night Band data from the National Oceanic and Atmospheric Administration.

variation: central districts are farther from borders with other states than peripheral districts and states with multiple neighboring states often have multiple border-crossing areas that can experience different changes. Figure 9 depicts the within-state variation in $\Delta \ln \mathrm{MA}_{ot}^{t_0}$ for the districts in our estimation sample. For the majority of districts, the residual in $\Delta \ln \mathrm{MA}_{ot}^{t_0}$ varies from -0.01 to 0.01, which is quite modest.[23]

Figure 9: Within-state variation in change in market access $\Delta \ln \mathrm{MA}_{ot}^{t_0}$

(a) Night-time-lights-based $\Delta \ln \mathrm{MA}_{ot}^{t_0}$ (b) Population-based $\Delta \ln \mathrm{MA}_{ot}^{t_0}$



NOTES: These maps depict within-state variation in changes in market access for the districts in the sample used to estimate equation (4). They show the residuals from a regression of $\Delta \ln \mathrm{MA}_{ot}^{t_0}$ on a collection of state dummy variables. The left panel shows the values of $\Delta \ln \mathrm{MA}_{ot}^{t_0}$ for the nightlights-based measure of market access. The right panel shows the values of $\Delta \ln \mathrm{MA}_{ot}^{t_0}$ for the population-based measure of market access.

We estimate the effect of the market access on the log expenditure using the following equation:

$$\ln Y_{ot} = \beta \ln \mathrm{MA}_{ot}^{t_0} + \mu_o + \Gamma_{s(o),t} + \epsilon_{it}, \tag{4}$$

where Y_{ot} is average household expenditure in district o at time t, $\ln \mathrm{MA}_{ot}^{t_0}$ is the market-access measure defined above, μ_o is a district fixed effect, and $\Gamma_{s(o),t}$ is a state-time fixed effect. We include state-time fixed effects to account for the GST reform harmonizing initially heterogenous state-level taxes, as those changes could be correlated with the changes in border-crossing times. The coefficient of interest is β. We cluster standard errors by district.

Table 4 shows that household expenditures increased in districts with improved market access. The baseline estimate of the market-access elasticity of household expenditure in column 1 is roughly

[23] This variation is substantially smaller than the variation in market access used in prior studies. For example, in Donaldson and Hornbeck (2016) the residualized county-level log change in market access induced by the introduction of railroads varies from -0.2 to 0.2. Part of this larger magnitude is attributable to Donaldson and Hornbeck (2016) using a larger value of θ, which they set to 8.

Table 4: Household expenditures increased in districts more exposed to faster border crossings

	(1)	(2)	(3)	(4)	(5)
log market access (lights)	3.91		3.91	2.52	2.47
	(1.62)		(1.62)	(1.21)	(1.22)
log market access (pop)		3.96			
		(1.67)			
Observations	2,505	2,505	2,484	3,582	3,552
R^2 Adj.	0.848	0.848	0.845	0.848	0.848
Within R^2 Adj.	0.004	0.004	0.004	0.002	0.002
Demonetization control					Yes
Exclude small states and union territories			Yes		
Include Jul-Dec 2016 and 2017				Yes	Yes

NOTES: This table reports OLS estimates of equation (4). The dependent variable is Y_{ot}, average household expenditure in district o at time t. Column 3 excludes small states and union territories from our estimation sample (Chandigarh, Dadra and Nagar Haveli and Daman and Diu, Delhi, Jammu and Kashmir, Goa, and Puducherry). Standard errors are clustered by district.

four, $\hat{\beta} \approx 4$. Given the range of market-access improvements caused by faster border crossings, this estimate implies that faster border crossings raised household expenditure by 0.16% to 0.64% across the range of districts. Column 2 shows a very similar estimated elasticity when we use population in 2011 rather than nightlights in 2016 as the measure of pre-GST economic activity in our approximation of market access. Column 3 excludes small states, for which the changes in border-crossing times may be noisier, and reports a similar estimated elasticity. In columns 4 and 5, we include observations for July 2016 through December 2017 in the sample, controlling for district-level exposure to the November 2016 demonetization in column 5. These yield somewhat smaller estimated elasticities, $\hat{\beta} \approx 2.5$. Overall, the positive effect of faster border crossings on household expenditure is robust to different specifications of market access and different estimation-sample inclusion criteria. Our results therefore suggest that there are substantial returns to removing barriers to interstate trucking.

6 Conclusion

We study intranational barriers to trade in the context of India's introduction of the Goods and Services Tax in July 2017. Our analysis quantifies the impact of the removal of checkposts at state borders within India using GPS movement data, trucking logs, and driver surveys. All three suggest substantially faster border crossings after the GST was implemented. Using the geographic precision of the readings from the on-board GPS devices, we find considerable heterogeneity across regions of India with border-crossing areas in eastern and northeastern regions showing substantially large improvements in border checkpost delays. We then evaluate the economic consequences of faster border crossings and show that household expenditures rose in districts where GST improved market access more. Thus, our results suggest that the reduction in interstate trucking times resulting from the GST reform had notable economic consequences.

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Appendix – For Online Publication

A Policy background appendix

This section provides a brief background and summary of GST reform in India. Before GST was implemented, the Indian Central government and state governments both had rights to tax goods and services. We summarize the key differences that are relevant to our study. Until 2016, the Indian Constitution provided each state the right to levy and collect state taxes on goods manufactured within the state (*intra-state*), irrespective of the location where they were consumed. The *interstate* trade of goods was taxed only by the Central government under the Central Sales Tax (CST), even though it was administered by the state governments along with other state taxes. The Central government also imposed excise taxes and administered it separately.

This multi-layered central, state, and local tax structure made the taxation of goods and services highly complex with multiple taxes and cascading of taxes. The administration, monitoring, and enforcement of taxes was also costly. Over decades, state border checkposts became the critical—and often only—physical point-of-contact between trucks carrying goods and government officials seeking to ensure compliance with various state and central tax laws.

A.1 The prevailing tax system before GST

India moved from the traditional system of taxing goods to a Value Added Tax (VAT) system in 1990s and 2000s. VAT was first introduced at the Central level (CENVAT) in 1986 and it gradually covered all commodities by 2002-2003. For states, on the other hand, the transition of state sales taxes to a VAT system was more complicated. To coordinate the VAT transition for states, an Empowered Committee of State Finance Ministers was formed in 1999. The Committee helped harmonize tax rates and eliminate the rate competition among states. The states began implementing VAT in 2005 and completed it soon after.

Even after India's major VAT tax reforms, many taxes were not subsumed. Particularly, several Central taxes including customs duty were not included in CENVAT. In addition, taxes levied on interstate trade remained separate under India's Central Sales Tax (CST). Likewise, state VAT also excluded indirect taxes on goods and services, such as luxury and entertainment taxes. There was also a residual cascading due to CENVAT being taxed by states and services being kept out of VAT system.

Most of these taxes, including the CST, were administered by the state in which a particular sale originated. State commercial tax department officials ran state border checkposts to levy taxes and verify documents. Over time, the central and various state governments developed an online system to decouple tax payments from checkposts. However, even when traders had paid taxes online, they were still required to stop and show documents to prove compliance at each state border checkpost. There was also a provision of a Transit Pass for trucks passing through intermediate states while transporting goods from the origin to the destination state, which was viewed as necessary to curb evasion of state taxes. Truck drivers were required to show their transit passes at state border checkposts at the point of entry as well as at the point of exit. Due to multiple taxes and forms, these checkposts also provided a great deal of discretion to local officials. Truckers were also often asked to pay bribes at these checkposts. For all of the reasons described above, border checkposts in India were long regarded as an impediment to trade.

A.2 GST implementation

The Indian government had long proposed a GST policy reform to address these concerns. It first announced the plan to introduce GST in the Central budget of 2007–2008. The initial target date was April 1, 2010. The Union Finance Minister also requested the Empowered Committee of State Finance Ministers to jointly work on a road map for GST implementation. The Empowered Committee of State Finance Ministers was later replaced by the GST Council. The Indian government put the Goods and Services Tax into effect on July 1, 2017.

Three main factors caused delay in GST implementation. First, the central and state governments disagreed on revenue sharing and how states should be compensated by the central government for any fiscal losses due to the new system. The central and state governments eventually agreed on a mechanism in 2016. Second, a new taxation infrastructure was needed before GST replaced the existing tax system. The central government developed an online portal called Goods and Services Tax Network (GSTN) to provide services to taxpayers. GSTN started onboarding taxpayers in November 2016. Third, at least 50% states were required to ratify the GST bill due to taxation rights given to states in the Indian constitution. Once states reached a consensus on GST's implementation, commodities to be excluded from GST (e.g., alcohol), and on the potential compensation by the central government, the ratification by state assemblies quickly followed.

A.3 Major changes under GST

GST replaced multiple taxes under the Central Goods and Services Tax (CGST), the State Goods and Services Tax (SGST), and the Integrated Goods and Services Tax (IGST). The CGST and SGST are imposed on intrastate supply of goods, while IGST is imposed on interstate supply of goods.

GST subsumed a multitude of different taxes and unified final tax rates on goods and services across the country into four tax slabs with rates of 5, 12, 18, and 28 percent, with some essential commodities exempt.

The taxes that were and were not subsumed by GST follows:

- **Central taxes covered under GST:** Additional duties of excise, central excise duty, excise duty levied under the medicinal and toiletries preparation act, additional duties of excise levied on textiles and textile products, additional duties of customs including countervailing duties and special additional duty of sustoms, service tax, surcharges and cesses, and central sales tax .

- **State taxes covered under GST:** State VAT/sales tax, purchase tax, entertainment tax (Other than those levied by local bodies), luxury tax, entry tax, taxes on lottery, betting and gambling, surcharges and cesses, and taxes on advertisements.

- **Taxes not covered under GST:** property tax and stamp duty, electricity duty, excise duty on alcohol, basic customs duty, and taxes on crude petroleum, diesel, petrol, aviation turbine fuel and natural gas.

In addition to unifying tax rates across states, the new GSTN portal replaced the previous central and state-specificpayment systems to streamline the process for taxpayers (including online registration, filing of returns, and making payments). As part of GSTN, the government reformed the transportation permit (waybill) system governing interstate trade. While the earlier waybill system could be accessed online, generating a waybill was a complex process subject to state-specific rules and often burdensome paperwork. The GST council introduced the electronic waybill (e-Way Bill) system to streamline and harmonize this process. Transporters create transportation permits by filing for an e-Way Bill through the GSTN portal, producing a unique transaction number (GSTIN number) that is made available to the transporter, supplier, and recipient. The e-Way Bill system was formally introduced on April 1, 2018, nine months after the implementation of GST, and was made mandatory for all interstate trade from June 2018.[24] While the e-Way Bill aims to facilitate cross-state shipping under GST, government officials are still allowed to stop vehicles at border checkposts for physical verification of conveyance and the e-Way Bill for all interstate trade.

The Indian central government projected GST would be a transformative reform that would lead the country to a unified and simpler tax system, akin to the economic integration achieved in the European Union in early 1990s. In addition to simplifying the tax structure, eliminating the cascading of taxes, and implementing the value added tax system in its entirety, the government also presented it as a reform that would enhance the ease of doing business in India.

The abolition of border checkposts, which were made largely redundant by GST, became a signature part of the reform, likely because it would be immediately visible to businesses. The central government issued a directive to states to abolish checkposts with immediate effects. Since checkposts were primarily run by state governments, compliance varied, but checkposts were by and large abolished or reduced in scope across the country. 19 states and 2 union territories officially abolished checkposts when GST went into effect on July 1st 2017: Andhra Pradesh, Arunachal Pradesh, Bihar, Chhattisgarh, Delhi, Goa, Gujarat, Haryana, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Puducherry, Rajasthan, Sikkim, Tamil Nadu, Telangana, Uttarakhand, Uttar Pradesh, and West Bengal. The state of Odisha abolished its checkposts earlier in April 2017. The remaining 8 states (Assam, Himachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Punjab, and Tripura) abolished checkposts in the months after GST implementation.

However, despite the abolition of checkposts, border crossings were still subject to some delays for a number of reasons. First, officials could still stop trucks and check compliance under GST

[24]The e-Way Bill is mandatory for goods exceeding a value of 50,000 rupees (about 600 US dollars).

and check their e-Way bill. That said, there was little room for discretion compared to the pre-GST period. Second, GST did not directly affect other checkposts, such as those of the Regional Transport Office or Forest Department. Third, GST excluded alcohol products that remained under state excise tax rules. State officials could, therefore, still stop and check trucks for tax evasion on alcohol products.

Finally, as a long-term goal, the government also intended for GST to enhance tax compliance by bringing more businesses into the formal economy. Furthermore, the reduced complexity of the tax system, and digitization of processes and records, was viewed to help curb tax evasion and increase transparency.[25]

[25] Source: https://gstcouncil.gov.in/brief-history-gst

B Data appendix

B.1 Summary statistics

Table B.1: Trucks in 2015–2018 data

N years a truck is observed	N trucks	% of trucks
1 year	8,998	30.9
2 years	8,185	28.1
3 years	5,969	20.5
4 years	5,939	20.4
All years	29,091	100

NOTES: This table reports the number of trucks that appear in the GPS tracking firm data from 2015 to 2018.

Table B.2: Events in relay-trucking firm data

Event	Number	Percent
Toll	1,889,179	38.90
Driving	882,206	18.17
Pitstop	674,896	13.90
Border	289,642	5.96
(Un)loading	83,357	1.72
Fuel	78,281	1.61
Touching	63,168	1.30
Traffic	63,377	1.31
Near Hub	26,335	0.54
Breakdown	12,815	0.26
Puncture	11,306	0.23
Parking	13,032	0.27
No Entry	11,117	0.23
Workshop	7,213	0.15
Other	750,027	15.45
Total	4,855,951	100

NOTES: This table lists the frequency of each event type reported in trucking logs from the relay-trucking firm.

Table B.3: GPS device usage among surveyed truck drivers

	Share	Count
A. *Driver age*		
18-25	.4	205
26-30	.45	277
31-40	.4	565
41-50	.41	349
51-60	.35	110
over 60	.32	22
B. *Driver education*		
No formal schooling	.34	241
Up to 5th standard	.33	409
Up to 10th standard	.46	674
12th standard or diploma	.47	160
Graduate and above	.36	44
C. *Employer fleet size*		
< 5 trucks	.37	496
5-10	.51	187
10-20	.38	123
20-50	.52	135
50-100	.51	51
more than 100	.55	135
Not reported	.31	401
Total	.41	1,528

NOTES: This table reports the share of respondents who said their truck uses a GPS tracking device by respondent characteristics. The "count" is the number of respondents who reported each characteristic, the "share" is the average value of the GPS dummy variable for those with that characteristic.

B.2 Border-crossing areas in GPS data

We examine border-crossing journeys by selecting journeys in which a truck drives at least 20 kilometers within one state and then enters another state and drives at least 20 kilometers within that state. This criterion excludes truck journeys in which GPS pings appear in different states because the roadway is proximate but parallel to the border or because the borders are irregularly shaped.[26] For each border-crossing journey, we average the latitude-longitude coordinates of the two consecutive pings that are located in different states. We group these border-crossing points together using the density-based spatial clustering of applications with noise (DBSCAN) algorithm in which a core point has at least 300 border-crossing points within 1 kilometer. Figure 2a depicts the resulting border-crossing areas.

Table B.4: Border-crossing areas and checkpost locations

		% with no match in T km distance					
	N	T = 10	T = 20	T = 30	T = 40	T = 50	T = 100
Located checkposts	329	32.2	19.8	12.2	3.6	2.4	0.3
Border-crossing areas	174	39.1	27.0	20.7	15.5	12.1	3.4

NOTES: This table describes the proximity of checkposts we located in Google Maps and border-crossing areas in terms of the distance between each location and its nearest counterpart. The first row reports the share of the 329 checkposts for which there is no border-crossing area within a given distance. For example, 32.2% of located checkposts do not have a border-crossing area within 10 kilometers. The vast majority of checkposts do have a border-crossing area within 100 kilometers because we located checkposts using a Google Maps query centered on these border-crossing areas, The second row reports the share of the 174 border-crossing areas for which there is no located checkpost within a given distance. For example, 39.1% of border-crossing areas have no located checkpost within 10 kilometers.

[26] A notable example of the latter is the union territory of Puducherry, which is made up of four small non-contiguous enclave districts that are hundreds of kilometers apart.

B.3 Sample selection for GPS data analysis

This section describes the criteria for including GPS-based truck movements in our empirical analysis. We first apply a set of filters to define border-crossing areas, described in Appendix B.2. Then, we impose additional filters that define samples for the analysis of border-crossing journeys in Section 4.1 and the event-study analysis in Sections 4.2 and 4.3.

First, we describe the filters we use to construct the sample of border-crossing journeys. After identifying consecutive pings in different states, we exclude border-crossing pings that are within 45 kilometers of each other. Then, for each selected border-crossing ping, we take all pings within 30km of the elapsed distance of it. We impose four filters to ensure that border-crossing journeys are well behaved:

1. We select a border-crossing journey only if a truck spends at least 95% percent of the total time within 250 meters of major roads. To define a major road, we use the classification of roads from OpenStreetMap. We consider the following types of roads as major: motorway, trunk road, primary road, and secondary road.

2. We compute the rank correlation between the elapsed distance and the geodesic distance to a border-crossing ping. We select border-crossing journeys where the rank correlation is higher than 0.95. This ensures that trucks do not drive in circles either before or after crossing a border.

3. We define a reversal as a series of pings that "move" away from the truck's last ping of the journey. We select border-crossing journeys for which the longest reversal is below 3 kilometers. This ensures that trucks do not drive in circles either before or after crossing a state border.

4. Sometimes, trucks make long stoppages (for food/sleep/warehouse/repair) either before or after crossing the border. We select a border-crossing journey if the duration of long stoppages is less than 10 hours. We detect long stoppages by applying the DBSCAN algorithm to a set of selected pings with $\epsilon = 100$ meters and MinPts = 1.

Next, we describe the filters that we use to construct the sample of border-crossing events. First, we detect checkpost-crossing pings. To do so, we collect a truck's pings within 750 meters of a check post, transform the labeled pings into a line, and check whether that line intersects the 300-meter buffer around the checkpost. If the line does intersect the buffer, denote the ping closest to the checkpost as the checkpost-crossing ping. Once we detect checkpost-crossing pings, we map them to border-crossing pings. We assign a checkpost-crossing ping to the closest (by elapsed driving distance) border-crossing ping that is within 85 kilometers. We then apply an additional set of filters to select border-crossing and auxiliary events:

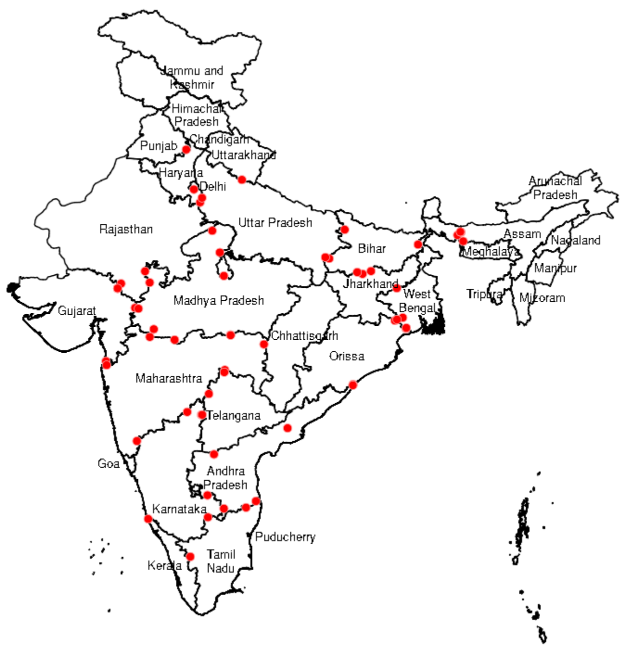
1. We make sure that each border-crossing event is sufficiently far from the previous and the next border-crossing events. We do this by checking whether the intersection of pings that belong to those border-crossing events is empty.

2. We apply criteria 1-3 from the filtering rules in the list above.

3. We modify criterion 4 in the list above. We select all border-crossing journeys with long-stoppage durations of less than 24 hours. Our choice of the threshold is motivated by a large number of long stoppages in the eastern states. If we choose a lower threshold for a long stoppage, we exclude too many border crossings in West Bengal–Assam border.

B.4 Border crossings in relay-trucking firm data

Figure B.1: Border checkposts in relay-trucking firm logs



Notes: This maps depicts the state border checkposts observed in the relay-trucking firm data.

Table B.5: GST reduced delays at border checkposts (truck event logs)

	(1)	(2)	(3)	(4)
GST	-32.17	-32.0	-33.88	-22.42
	(2.329)	(2.465)	(3.155)	(3.127)
Monthly linear trend			0.209	-0.968
			(0.257)	(1.291)
Constant	54.33	54.25	54.63	49.13
	(2.331)	(2.679)	(2.600)	(1.621)
Observations	289,642	289,642	289,642	144,152
R-squared	0.00514	0.0364	0.0364	0.0663
Checkpost FEs		Yes	Yes	Yes

Notes: This table reports coefficients estimated by regressing the number of minutes a truck spent at a border checkpost on a dummy indicating whether GST has been implemented. The regressions in columns 1 through 3 include all 2017 and 2018 observations, whereas the one in column 4 includes only 2017 observations. The regressions in columns 2 through 4 include checkpost fixed effects. The regressions in columns 3 and 4 include a monthly linear time trend. Standard errors, clustered by month, are in parentheses.