Globalizing Highways :
Domestic Roads and Foreign Inputs

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Abstract

This paper investigates the impact of highway upgrades in India on firms' integration into global markets. Using firm-level data from the manufacturing sector and a spatial instrumental variable approach, I find that the upgraded highways increase firms' use of imported inputs. The increase in firms' imports is due to more firms importing, and existing importers using a wider variety of imports in their production. The impact of highways on importing is heterogeneous across firms and depends upon the baseline productivity of firms, the degree of differentiation across their inputs, and their distance from ports. I build a structural model in which better highways lower the fixed costs of adding imported varieties, rationalizing the empirical findings. The model, calibrated to the local context, predicts that the increased variety of imports, resulting from upgraded highways, boosted firms' productivity by 1.5%. While the highways decreased spatial disparity in terms of importing across regions, they increased disparity between firms within sectors.

Keywords: International Trade, Transportation, Firm Behavior, Infrastructure
JEL Codes: F14, F15, L23, O18

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1 Introduction

Throughout history, the expansion of road networks has played a pivotal role in connecting vital commercial centers. For instance, the Grand Trunk Road, which dates back to 330 BC, facilitated trade between commercial hubs from Kabul, in what is now Afghanistan, to Dhaka in modern-day Bangladesh. Previous work has shown that regions with better connectivity trade more (Limão and Venables, 2001; Coşar and Demir, 2016). However, it remains an open question how firms integrate globally in response to changes in the domestic transport environment and how this integration affects firms' productivity. My research investigates how firms' sourcing of inputs changes when a new highway is built that connects their district to a port.

In this paper, I study the Golden Quadrilateral (GQ) highway program, launched by the Indian government in 2001, to help answer the open question. I use empirical analysis and a structural model of firm behavior to understand the effect of the GQ program on firms' use of imported inputs. Further, to quantify the impact of higher importing on firms' productivity, I combine empirical estimates of the effect of transport infrastructure on firms' input decisions with the structural parameters of the model.

My paper's contribution is two-fold. First, I employ a spatial instrumental variable approach to estimate the impact of transport infrastructure on individual firms' importing decisions. Second, I use a model calibrated to the local context to quantify the impact of higher importing on firms' productivity and explain differences in firms' responses.

The main empirical challenge of estimating the effect of the GQ highway upgrades is that the construction or placement of roads is often influenced by local economic conditions of areas between the major nodal cities (Ref: Figure 1 Panel A). For instance, new highway routes are often placed closer to laggard regions in the middle to boost their economic or trading activity. For this reason, it is unlikely that comparing the outcomes of firms near the upgraded highways relative to firms further away from these highways will yield an accurate estimate of the impact.

To address this endogeneity concern, I follow recent studies such as Banerjee et al. (2012) and Faber (2014), and rely on the straight-line instrumental variable (IV) method. The underlying rationale for the instrument is that the shortest route connecting the nodal cities is not determined by the local economic conditions of the intermediate areas but mainly by the location of the nodes themselves. Hence, proximity to the hypothetical shortest path can serve as an instrument for proximity to the highway that was actually constructed. This strategy allows me to obtain an accurate estimate of the effect of highway upgrades on the decisions of firms in neighboring areas. The analysis omits firms in the nodal cities because the routes of upgraded highways are chosen such that they connect these nodal cities which are historical commercial hubs. In addition, I run a placebo test using information on the North-South-East-West(NSEW) highway project. This project was due to begin at the same time as the GQ highways project but its construction was deferred by 3-4 years due to administrative delays. Because of this, the set of firms close to the planned NSEW route serves as a suitable comparison group to check if the impact was driven by the actual construction of the highways and not just the announcement.

Following the highway upgrades, firms could have adjusted their importing activity along two dimensions: the intensive and the extensive margins. The intensive margin refers to the adjustment in *the share of expenditure on intermediate input varieties that the firm already imported* before the highway upgrades. The extensive margin refers to the adjustment in *the number of imported intermediate input varieties*. The results indicate that, in response to improved highways, firms predominantly responded by expanding their variety of imported inputs. This expansion took place among new firms that began importing goods and existing firms that broadened their range of imported inputs. My analysis suggests that the highway program made it easier for firms to access foreign input suppliers through ports.[1] However, there was no measurable impact on the intensive margin of importing. The highways did not alter the choice of firms between domestic and foreign varieties of products that they already imported. This could possibly be because the new highways reduced the (iceberg) costs involved in moving both varieties of the inputs. While the highways made it easier to move imported varieties from the ports, they also made it easier to move input varieties from domestic Indian suppliers. The geographical distribution of domestic suppliers suggests that suppliers of domestic inputs were also located close to the ports and firms' access to them was also improved by the highway upgrades.

The impact of the GQ highways did not affect the importing of all firms to the same degree and depended on the characteristics of individual firms. First, the highways had the largest impact on firms further away from ports. Second, I find that the highways had a more pronounced impact on firms that rely more on differentiated intermediate inputs.[2]

[1]The foreign input suppliers could include freight forwarders that are typically based close to ports. Freight forwarders are firms that are well-connected to foreign suppliers, and source and deliver imported varieties to firms within India. They also help firms with procedures to obtain customs clearances for additional imported varieties that firms would want to use.

[2]Poor road infrastructure is likely to make it harder for firms further away from ports to search for foreign inputs. Firms with differentiated inputs require inputs that are tailored to the production process and entail non-trivial search costs. Improved access through roads would, therefore, make it much easier to access imported inputs for firms that were far away from ports and for firms that used differentiated inputs.

Finally, the expansion of imported input varieties was relatively larger for firms that were more productive within their respective sectors.

To understand how the highway upgrades could have affected firms' decisions between foreign and domestic inputs, I model individual firms' input decisions based on related work (Halpern et al., 2015; Gopinath and Neiman, 2014). In the model, firms require different intermediate inputs to produce output. For each intermediate input, the firm chooses between using a domestic variety or a mix of domestic and imported varieties. Mixing an imported variety into its production allows firms to reduce their marginal costs.[3] However, to access each imported input variety, firms need to pay additional fixed (or search) costs. Therefore, firms would only choose to use an imported variety if the reduction in costs exceeds the additional (fixed) cost the firm needs to pay for accessing the imported input. Given this structure, the optimal mix of inputs, among other factors, depends on the fixed costs incurred by firms to access these inputs, the degree of substitution between foreign and domestic varieties, and the firms' own productivity level.

In the model, upgraded highways reduce the fixed cost of importing inputs for all firms within a sector, as firms now can more easily access imported intermediate inputs through ports. However, I show that the marginal gain from additional import varieties is higher for firms with higher firm-level productivity. Hence, within a sector, high-productivity firms are most likely to respond to a drop in fixed costs.

The empirical results indicate, that within sectors, the degree of impact is larger for firms that are more productive. In addition, the impact was more pronounced for firms that are further away from ports or require differentiated inputs.[4] This suggests that while the highways decreased spatial disparity in importing across locations depending on their proximity to ports, they increased disparity in importing between firms within sectors.

Finally, to quantify how the consequent rise in importing affected firms' production, I calibrate the model to the local context of affected regions before the highways were built. As a part of the exercise, I estimate the elasticities of substitution between domestic and foreign input varieties within various two-digit sectors. I find that the firms' productivity increased by 1.52 % on average purely through the import channel. The model predicts that firms using inputs whose foreign and domestic varieties are less substitutable stand to gain more from additional import varieties. Differentiated inputs typically have less substitutable varieties. I find that firms needing more differentiated inputs saw a gain in productivity of

[3] Firms could gain from importing either through the channel of imperfect substitution between imported and domestic variants or through the channel of lower quality-adjusted prices of imported variants.

[4] Intuitively, the fixed costs of importing would be higher for firms that are further away from ports or require differentiated inputs.

2.07 % through more import varieties while firms needing less differentiated inputs saw a gain of just 1.19 %.

Related Literature

This study contributes to several strands of literature related to roads and trade.

Roads and Economic Activity: Transport infrastructure has received increasing attention from academic researchers due to its importance for economic activity. Studies such as Chandra and Thompson (2000) and Michaels (2008) have found that the US highway system affected different sectors in distinct ways, with some industries benefiting and others losing out as activity relocates. Faber (2014) analyzed the impact of large transport networks in China on the spatial dispersion of economic activity while others (Datta, 2012; Khanna, 2014; Ghani et al., 2015; Abeberese and Chen, 2022) looked at the impact of the GQ network in India on the organization and efficiency of local economic activity. While these studies look at the impact of highway networks on aggregate economic activity within affected regions, this paper studies the impact of such networks on firms through the trade channel, specifically imports.

Roads and Trade: A growing body of literature explores the relationship between domestic road infrastructure and access to international markets. Several studies (Mesquita Moreira et al., 2013; Atkin and Donaldson, 2015; Coşar and Demir, 2016) have studied domestic transport bottlenecks to trade in other developing regions. This paper is closest to Coşar and Demir (2016) that used region-level data and studies how access to international markets is affected by highways in Turkey. While these studies focus on the relationship between transport networks and local regions' access to global markets, this paper focuses on how individual firms within affected regions respond to improved road networks. With detailed firm-level data and a spatial instrumental variable approach, the paper obtains a plausibly exogenous estimate of the impact of highways on firms' importing and shows how the degree of impact differs based on firms' characteristics.

Import Switching and Variety Gains from Trade: Numerous studies have explored the welfare implications of increased foreign product variety for the domestic economy Broda and Weinstein, 2006; Broda et al., 2006; Arkolakis et al., 2008; Blaum et al., 2018. There is also a body of related research that investigates how changes in access to foreign varieties, resulting from nationwide policy changes, affect domestic firms. For instance, Gopinath and Neiman (2014) studies Argentina, Goldberg et al. (2008) examines India, Halpern et al. (2015) investigates Hungary, and Mariscal et al. (2017) explores Colombia to analyze import behaviour changes during various episodes of nationwide changes. While these studies primarily address import switching in the context of exchange rate movements or changes across international borders, my research explores shifts in foreign input access within national borders following the upgrading of some highways.

The rest of the paper is organized as follows. Section 2 gives details on the GQ project, and Section 3 discusses the model to help interpret the results. Section 4 describes the data along with some descriptive statistics. Section 5 and section 6 outline the empirical strategy and results respectively. Section 7 discusses the structural estimation and welfare implications while Section 8 concludes.

2 National Highway Development Program

In India, where maritime transport accounts for more than 90 percent of merchandise trade, access to ports is crucial for internal trading costs. Data from the Indian government shows that the major ports in four cities account for nearly half of India's imports (DGCIS, 2020). According to the World Bank Enterprise survey for India in 2005, over 95 percent of firms in non-metro cities in India used land transport for input supplies. Many reported difficulties in accessing road transport and cited it as an obstacle to their business. Improving access to road infrastructure would help firms in these cities access domestic and imported inputs more easily.

Around 2000, India launched an ambitious large-scale highway upgrade project, the National Highway Development Project (NHDP). According to NHAI estimates, India reportedly spent USD 7 billion on the GQ national highway project. While there were seven phases planned under the NHDP in total, this study focuses primarily on the first two phases of the NHDP project that covered over 13,000 km (8,100 miles): named the Golden Quadrilateral (GQ) and the North-South-East-West (NSEW) corridors (Ref: Figure 1). (MORTH, 2020)

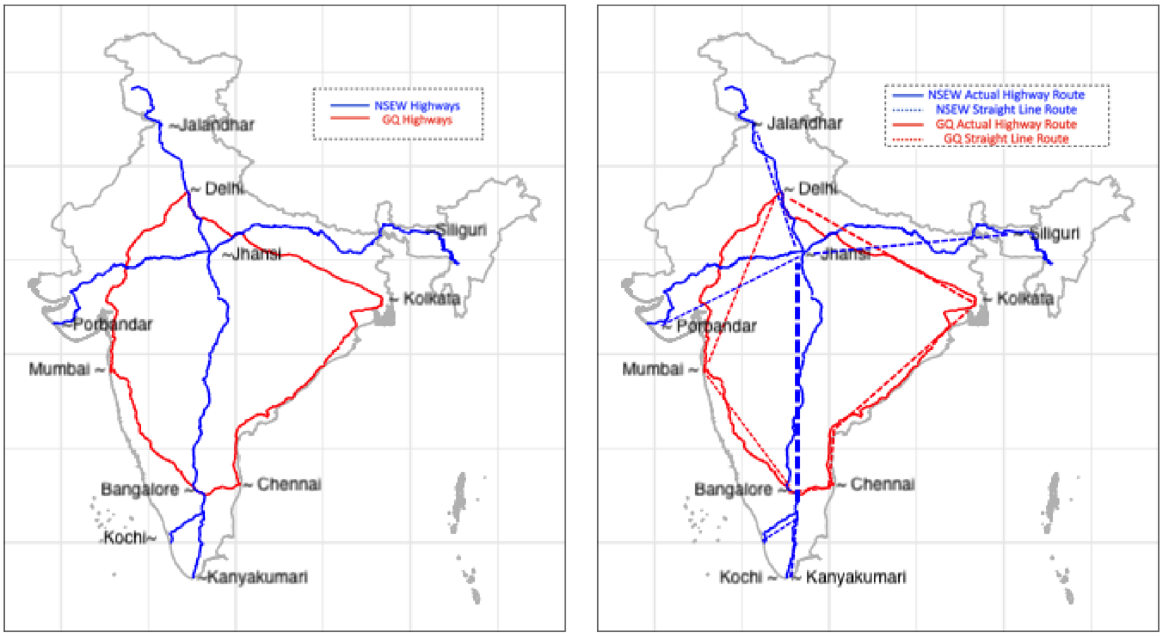
The Golden Quadrilateral corridor consists primarily of four highway sections that connect the major cities and make up a total length of 5,846 km:

- NH19: New Delhi to Kolkata, covering 1,453 km
- NH16: Kolkata to Chennai, covering 1,684 km
- NH48: Chennai to Mumbai, covering 1,290 km
- NH48: Mumbai to New Delhi, covering 1,419 km

The North- South East- West Corridor, on the other hand, runs through the middle of the country and consists of two sections that combine and cover 7,300 kilometres::

Figure 1: NHDP Highways Layout

A: GQ & NSEW Original Layout | B: GQ & NSEW Straight Line Route



Source: Layout of highways obtained from online appendix of Ghani et al. (2015)

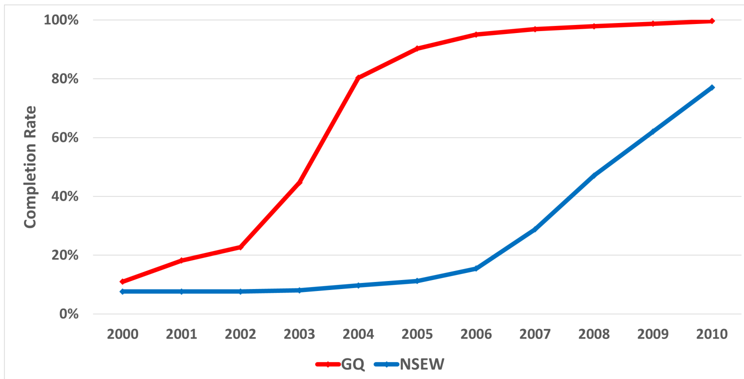
- NH44: North-South from Srinagar to Kochi/ Kanyakumari, covering 4,000 km
- NH 27: East-West from Porbandar to Silchar, covering 3,300 km

Progress of the Projects

Most of the work on these two projects was to be completed under the first two phases of the NHDP. The first phase was approved in 2000 and the second phase in 2003. Progress on each of these projects was reported in the annual report of the National Highway Authority of India (NHAI). The GQ project saw significant progress (see Figure 2) in the early 2000s - over the course of two years (2003 and 2004), the completion rate jumped from around 20 % to more than 80 % and by the end of 2006, more than 95 %.

In sharp contrast to progress in the GQ project, construction under the NSEW project did not take off until much later. It saw less than 10 percent completed by 2004 and another 5 percent completed by 2006. According to estimations made by Ghani et al. (2015), even among the stretches of the corridor that had work completed, a substantial chunk of nearly 40 % overlapped with the GQ corridor. Following several challenges that related to the awarding of contracts, land acquisition and funding, work on the NSEW was delayed and only kicked off much later, after most of the work planned under the GQ project was complete.

Figure 2: NHDP Progress over time



Source: NHAI Annual Reports

3 Theory

This section provides us with a framework to understand exactly how firms choose the optimal quantity and variety of foreign inputs and what impact the use this increased import use has on each firm's production. The model is closely related to the models in related work on import switching (Gopinath and Neiman, 2014; Bøler et al., 2015; Mariscal et al., 2017).

The model considers the decisions made by firms that are heterogeneous in their productivity, and use multiple intermediate inputs to produce a single product. The intermediate inputs chosen could be sourced from domestic and foreign suppliers, each of which involves different costs. Better highways could potentially lower both, the marginal costs associated with foreign and domestic inputs as well as the fixed costs related to accessing foreign input suppliers. Hence, the drop in costs involved would alter the optimal mix of domestic and imported inputs used by individual firms.

The theoretical framework outlined helps us understand how the altered use of imports affects a firm's productivity and how the response varies based on the firm's characteristics. I start by introducing the profit maximization problem of the firm. This is followed by a discussion of the costs and benefits of imports and how imports affect productivity. Finally, I summarise relevant predictions from the model we test through the empirical analysis.

Industry Structure

The sector (or industry) consists of a continuum of firms that engage in monopolistic competition with each other and produce their individual brands. The total demand for the sector's output is given by:

$$U_S = \left[\sum_{i=S} V_i^{1/\eta} Q_i^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{1}$$

where there are different firms within a sector S and Q_i refers to the output of each firm i's variety, V_i refers to preference for each firm i's variety and η is the elasticity of substitution between different varieties.

Firm's Problem

Given a firm's productivity Ω and input prices, the firm chooses its input levels and the number of imported inputs used to maximize its profits. The firm's operational profit is then given by:

$$\pi = \max_{X,L,K,n_i} PQ - P_X X_i - W_L L_i - rK_i - F(n_i) \tag{2}$$

where P_X, W_L, and r represent the marginal (or per-unit) costs associated with intermediates, labor, and capital while n_i refers to the numbers of inputs that the firm chooses to import.

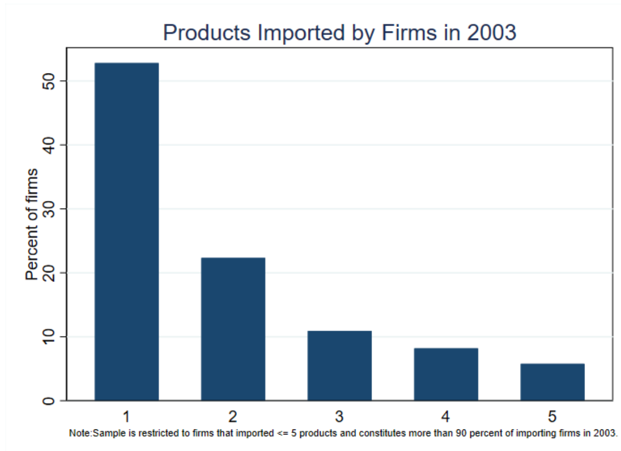
Firms find it incrementally difficult to use more foreign inputs. Figure 3 shows the share of imports divided up by the number of products they import in 2003. The majority of importers import just one product. In addition, the share of importers falls with the number of products. This suggests that in order to use imported inputs, the firm would also have to pay incremental fixed costs every period that increase with the amount number of foreign varieties used. Similar to Gopinath and Neiman (2014) and Bernard et al. (2005), in the setup here, the cost associated with using additional varieties of imports takes the form of a convex cost function $F(n_i)$ where n_i refers to the number of imported varieties used by the firm.

Firm Production

The production structure of the firm combines the optimal amount of labor, capital, intermediates as well as the variety of imported intermediates. Firm i's production follows a Cobb- Douglas Function given by:

$$Q_i = \Omega_i K_i^{\alpha} L_i^{\beta} X_i^{\gamma} \tag{3}$$

Figure 3: Share of Importing Firms by Variety of Imported Products



where Y_i refers to output, Ω_i to Hicks-neutral productivity, L_i to labor employed, K_i to capital, and X_i is the composite of different intermediate goods used by the firm. The intermediate composite X_i can be thought of as a bundle of different goods indexed by j:

$$X_i = \prod_j X_{ij}^{\gamma_j} \qquad \sum_j \gamma_j = \gamma, \tag{4}$$

where γ refers to the Cobb- Douglas share of intermediates and γ_j refers to the importance of good j. For each intermediate good j, the firm makes a decision between using:

- **Home variety only**, in which case the firm only pays the marginal price P_{jh} for each unit
- **Mix of home and foreign variety**, in which case the firm pays the marginal price P_{jm} for each unit and the importing fixed cost, f_j to access the foreign variety.

The firm's demand for intermediate good j can, therefore, be expressed as:

$$X_{ij} = \left[X_{ijH}^{\frac{\theta-1}{\theta}} + \mathcal{I}(im).(B_j X_{ijF})^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}},$$

where $\mathcal{I}(im)$ is a dummy that takes the value if the firm decides to use an imported variety of good j. X_{ijH} and X_{ijF} refer to the quantity of domestic and foreign varieties used in the firm's composite of good j. B represents the quality advantage of the imported variety relative to the domestic variant and θ refers to the elasticity of substitution between foreign and domestic variants.

Gain from Import Variety

Solving the firm's cost-minimization problem, we get the price of a variety that uses both home and foreign varieties as:

$$P_{jm} = P_{jh} * \underbrace{\left[1 + A^{\theta-1}\right]^{\frac{1}{1-\theta}}}_{\text{Import Gain} = e^{-a}}$$

The term within the brackets refers to the change in the associated price of a variety if it includes imports where a refers to the effective (logarithmic) drop in price relative to the domestic price, P_{jh}. The gain is a function of a) level of imperfect substitution, determined by θ; and b) the quality-adjusted relative price, A, given by:

$$A = \underbrace{B_j}_{\text{Import Quality}} * \underbrace{P_{jh}/P_{jf}}_{\text{Relative Price}}$$

For a firm that chooses to import the variety, j, the optimal expenditure share on the imported variety is given by:

$$S = \frac{A^{\theta-1}}{1 + A^{\theta-1}} \tag{5}$$

Import Augmentation of Firm's Productivity

I next show how this import gain would affect the production at the firm- level. For this, let us consider the firm's production function expressed in log form:

$$q_i = \omega_i + \alpha k_i + \beta l_i + \gamma x_i,$$

where the lower case alphabets represent the log form of the respective upper case elements in Equation 3. The intermediates term, x_i can further be represented using the expenditure on intermediates m_i and the price index ρ:

$$x_i = m_i - \rho$$

In case the firm does not use any foreign goods, its input price index would be the same as the domestic price index for the sector, given by ρ_h. If the firm does use imported goods for production, then its price index reduces because imports make production more effective.

The price index, therefore, can be expressed as:

$$\rho = \rho_h - a * G(n_i)$$

where a refers to the per-input reduction in price when imported inputs are used, and $G(n_i)$ is the relative weight of inputs that the firm imports in total intermediate expenditure. Hence, the drop in the price index is the import gain scaled by the weight of goods that have imports. a refers to the intensive margin gain from imports as it is a function of the optimal share of imports in an individual composite good. $G(n_i)$ denotes the extensive margin gain and is a function of the number of imported varieties. The firm's production function can, therefore, be expressed as:

$$q_i = \omega_i + \alpha k_i + \beta l_i + \gamma(m_i - \rho) + \gamma a G(n_i)$$

The productivity of a firm is boosted by imported inputs through the term, $\gamma a G(n_i)$, γ refers to the Cobb- Douglas weight of intermediates in production. It is also important to note that this is a multiplicative term in the original non-log form equation. Hence, this would imply that higher productivity firms, holding other things constant, would benefit more from the use of additional imports.

It is also important to consider the structure of competition within the industry when we think about gains for individual firms. When we solve for each firm's optimal revenue considering the change in quantity and output price, the revenue productivity gain comes out to be $\gamma^* a G(n_i)$[5]. This term represents how a firm's real revenue changes when it incorporates imports instead of just using domestic inputs.

Model Takeaways:

In principle, the highways could lead to a change in the relative quality-adjusted price of an imported variety or a change in the fixed cost paid to use each imported variety. I consider each of these in the following propositions:

Proposition 1:
Relative spending on incumbent imports rises as relative price of import drops
Drop in the relative quality-adjusted price of foreign varieties leads to an increase in the firm's importing along the intensive margin.

[5] $\gamma^* = \gamma * (\eta - 1)/\eta$

First, I consider what happens if the relative quality-adjusted price of an imported variety changes. As Equation 5 shows, in case there is a drop in the relative quality-adjusted price of the imported variety, the optimal share of expenditure on that variety increases. While the share of total expenditure on an intermediate good j does not change.[6] However, within the expenditure on good j, the share that is spent on an incumbent import variety rises with a drop in the quality-adjusted import price.

As pointed out in section 6, there is no evidence of a statistically significant change in the share of intermediate goods expenditure on incumbent imports because of the highway upgrades. This suggests that the quality-adjusted relative prices of imported varieties did not change substantially.

Therefore, for the remainder of the section, I consider how the import decisions of the firms change following a drop in fixed costs. As the additional fixed cost to use an imported variety drops, firms would adjust their variety of imports along the extensive (new importers) and sub-extensive margins (new products), but not along the intensive margin. The relevant predictions from the model are presented below:

Proposition 2: Import variety rises as fixed costs drop

Drop in fixed costs incurred on foreign inputs leads to a higher variety of imports being used.

Let us consider a firm that is making a decision about where or not to import an additional n^{th} product. When this firm makes a choice about mixing in an additional input into its production, it has to trade off the incremental gain from the incremental cost. The firm gains in the form of incremental profits because of an efficiency gain from mixing an imported variety with a local variety for another good. [7] However, in order to access these gains, it has to pay additional fixed costs to find and use this new imported variety. As a result, a firm continues to mix in additional varieties of imports as long as the incremental gain exceeds the incremental fixed costs.

The incremental gain from this import variety can be expressed as the additional profits obtained, given by $\Delta\pi_n$ while the additional fixed cost it has to incur to access the gain is given by f_n. The decision to add in an additional import variety, as discussed, depends on

[6] This share is defined by the relationship in Equation 4.

[7] As discussed earlier, this gain accounts for the marginal costs that firms have to pay for goods of the new imported variety. The two possible channels of gain from importing are gain from imperfect substitution and gain from better quality-adjusted prices.

the following expression:

$$\underbrace{\Delta\pi_n}_{\text{Incremental } \pi \text{ from importing nth good}} \geq \underbrace{f_n}_{\text{fixed cost for importing nth good}}$$

As new highways improve access to the ports, they make it easier for firms to access imported inputs and reduce the associated search costs. Even without any change in the incremental benefit from importing another variety, the drop in the additional fixed cost f_n would lead to more firms deciding to import additional varieties. This can be expressed as:

$$\frac{\partial n}{\partial f} \leq 0$$

Proposition 3: Productive firms gain more from importing
Higher baseline productivity of a firm is associated with a greater amount and variety of imported inputs used by firms.

In the case of the firm just discussed, the additional gain from adding imports to the nth good can be expressed as:

$$\underbrace{\Delta\pi_n}_{\text{Incremental } \pi \text{ from importing nth good}} = \underbrace{\pi_0}_{\text{Profit without importing}} * \left[\underbrace{e^{\frac{\gamma^* aG(n)}{1-\gamma^*}}}_{\text{Gain from n imports}} - \underbrace{e^{\frac{\gamma^* aG(n-1)}{1-\gamma^*}}}_{\text{Gain from n-1 imports}}\right]$$

The incremental profitability of using the n^{th} import, $\Delta\pi_n$ is a function of:

1. **Baseline profitability:** The profit that the firm would earn if it did not use any imported inputs. This increases with the firm's own productivity (=ω).

2. **Gain from using additional n^{th} variety:** The price gain from importing n varieties of inputs as opposed to importing just n-1 varieties.

Firms with higher baseline profitability, π_0, are able to leverage imported inputs to benefit more because the impact of imports on revenue increases with base profitability. As a result, firms that are already more productive are more likely to use imported inputs. They see a larger increase in revenue from using imported inputs while paying the same fixed costs as low-productive firms. This can be shown using the following expression:

$$\implies \frac{\partial}{\partial \omega}\left(\left|\frac{\partial n}{\partial f}\right|\right) \quad \geq 0$$

4 Data

The study uses spatial data from the GQ and NSEW highway projects along with a yearly firm-level panel dataset covering firm activity starting from 2000 to 2008. The following subsections describe these data elements:

4.1 Data covering the Highway Projects

The shape files that were used for tracking the exact route of the highways were obtained from the online appendix of Ghani et al. (2015).[8] This GIS data was combined with geographic data of individual districts from the 2001 national Census to obtain various distance measures using various Geographic Information Systems (GIS) packages available in R.

4.1.1 Construction of the Straight line Instrument

Two sets of distance measures were created using this GIS data of the highway corridors and the census districts of India. First, the distance of each of the district centroids from the nearest point on the actual highway polygon represented by the actual route of each of the projects was calculated. Second, the distance of districts' centroids from the polygon obtained using straight-line approximations of the corridors' routes is estimated.

To construct the straight-line corridor, we approximated each of the selected highway corridors using straight-line segments. For the GQ corridor, we identified the four primary hubs, along with Bangalore, as nodes to create a polygonal approximation of the corridor. Additionally, we included Vijaywada, now a state capital, to ensure that the straight-line approximation from Chennai to Kolkata does not traverse across the sea. The straight-line routes used in this study are akin to those employed in Ghani et al. (2015) Ghani et al. (2015) (see Figure 1 B). For the NSEW corridor, we used straight-line segments connecting Jalandhar, Delhi, Jhansi, Salem, and Kanyakumari (Kochi) to approximate the North-South section, while line segments connecting Porbandar, Jhansi, and Siliguri were used for the East-West section.

[8] The authors, in turn, credit the World Bank Urban Development Unit to put together this dataset. GIS Data from the government includes the exact dates for the start and end of the construction of different sub-units of the project. This data is used to carry out the Staggered Difference-in-Difference analysis.

4.2 Data covering Firm Activity

Data on firm activity is obtained from the Annual Survey of Industry (ASI), conducted by the Indian Ministry of Statistics and Programme Implementation (MoSPI). The data covers information about firms' inputs used, production choices such as capital and labour as well as its output product sales. The survey data also allows us to construct measures of economic integration through imports.

The ASI survey is carried out every year and is representative of organised manufacturing in India. The sample frame of the ASI consists of all industrial units ("factories") registered under the Factories Act, 1948. This includes those that employ 20 or more workers if they do not use power, and those that employ 10 or more if they use power. The whole sample includes:

- census of all factories employing 100 workers or more; and
- survey that randomly samples about a quarter of all other registered factories.

The analysis uses a firm-level panel of manufacturing firms spanning the project implementation. The time period also permits the analysis to include about 3 years of data before construction work under the GQ program went into full swing in 2003 and 5 years of data after the construction with the major chunk of the GQ project was completed.

In the ASI survey, firms are classified under sectors that follow the National Industrial Classification (NIC) code. While the NIC has different levels of disaggregation, the 2- digit level NIC code was used to define a "sector" for purposes of the analysis.

All monetary measures such as those of output, capital imports [9], expenses or inputs are deflated using appropriate sector-level deflators from the National Wholesale Price Index data for India. In addition, as is common with data from surveys, all these outcome variables are winsorized at the 1% / 99% level to prevent outliers from having a substantial bearing on any of the results obtained using this data.

4.3 Descriptive Statistics

Table 1 presents descriptive statistics for some key import-related variables at the firm- level from the pre-treatment year of 2003 , divided as areas near the GQ highway (within 50 km) and areas further away.

[9] According to the World Bank enterprise survey in 2005, out of imported inputs that were used, nearly one-third of foreign inputs, was sourced through intermediaries or distributors on average. However, the information in the ASI survey only captures those foreign imported inputs that were directly sourced and not those that are foreign but sourced locally through distributors.

Table 1: Descriptive Statistics at the Firm- level

Variables	Mean	Std Err.	N	Mean	Std Err.	N
	Firms Near the Highway			Firms Away From the Highway		
Log (Output per worker)	13.43	.02	4,069	13.26	0.01	7,657
Share of firms that import (%)	19.55	0.62	4,069	11.47	0.36	7,657
For Importers						
Log (Deflated Import Value)	11.41	0.06	1,263	11.66	0.05	1,596
Number of Products Imported	2.39	0.05	1,263	2.29	0.04	1,596

Note:All the values were winsorized at 1/99 percentile levels. The values shown here are for 2003, before the highway was upgraded.

The numbers in the table give an idea of the differences in the types of firms on average. Firms closer to the highway, on average, have a larger propensity to import and a higher variety of foreign imports than those further away. In addition, the table shows that the control group is larger than the treatment group in terms of observations or cells. This is because the control group includes more districts while a few lie within the band of 50 km close to the constructed GQ highway project.

5 Empirical Methodology

The placement of infrastructure, whether transport or in another form, is often found to be influenced by local economic activity as it is frequently built or upgraded with the aim of developing specific regions. Hence, the development of transport networks may not be completely independent of the economic needs of a region. For instance, roadways (or railways) may be constructed to pass through more prosperous regions as there is higher demand in those places or they may pass through lagging regions in order to help such regions develop. In the first instance, a correlation between road placement and economic development outcomes is likely to overstate the impact of the infrastructure and in the second case, it would understate that impact. Hence, the economic impact estimates, in either case, would be biased, although in opposite directions.

The endogenous choice of the upgraded highway routes, in a similar manner, could potentially bias the results of the study where they were built to target specific areas. This issue has also been discussed in detail in previous studies mentioned that that explored the relationship between economic activity and the construction of such infrastructure (Chandra and Thompson, 2000). The GQ national highways were built with the primary aim of connecting the four biggest metropolitan cities of India which were established in the nineteenth century, much before the GQ program was planned. This analysis deals with the endogeneity problem using a spatial instrumental variable approach developed to tackle this issue.

Straight-line Instrumental Variable (IV) Method:

The spatial econometric technique employed is the straight-line IV method. As pointed out by Redding and Turner (2015), similar techniques are used in studies analysing the impact of transport changes. The main idea behind this is as follows - if the transport routes were not built to pass by specific intermediate areas but just happened to pass them then it is likely that these areas are close to the highway not because of any economic considerations but just because they happen to lie close to the shortest route (or straight line) connecting two major centres. Therefore, the treatment of having better access to the GQ highway system could be considered exogenous to any characteristics of these intermediate areas.

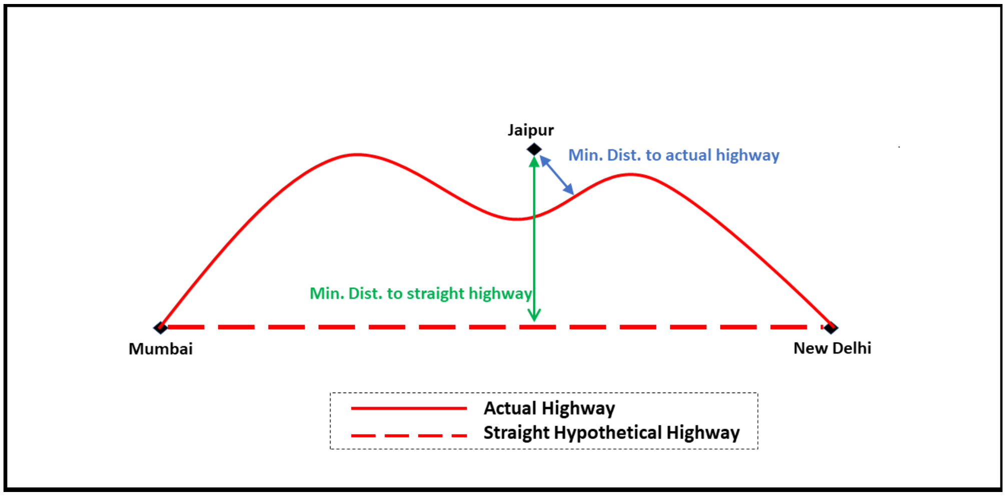
The methodology is implemented in the following manner: First, a hypothetical straight-line network is constructed between the different critical nodes of the transportation network (in this case, the different metropolitan cities). Second, the shortest distance of each area (or district here) from this hypothetical straight-line network is calculated. Third, distance measures are calculated based on the shortest distance computed in the previous step and are used as instruments for distance from the highway. The distance measures are illustrated for a hypothetical scenario in Figure 4.

As outlined in other studies looking at the GQ highway system, areas contiguous to the major terminal hubs were also marked as nodal (Datta, 2012; Khanna, 2014; Ghani et al., 2015). The rationale behind doing this is that the inclusion of these areas, as well as, the nodal centre cities could potentially bias the results. This could happen as these areas were very close to the nodes or hubs and were likely to be directly targeted and impacted by the scheme. Hence, these places have been excluded as a matter of design. The places excluded in this study include areas the nodal cities and their close neighbours - New Delhi (plus Gurgaon, Faridabad, Ghaziabad and Noida), Mumbai (plus Thane), Kolkata, Chennai and Bangalore (plus Bangalore Rural).

Construction of Distance Measure

The treatment groups, in the case of straight-line IV methods, are chosen to include intermediate areas that the highway passes through or places that are very close to the highway.

Figure 4: Illustration of the Distance measures



This analysis looks to include all those districts that are close to the highway and are likely to have borders within 10 kilometres of the constructed (or actual) highway.

As we have district centroids computed from the census, this would be similar to using an equivalent band that incorporated the district centroid of adjoining districts in such a manner that their edge is likely to lie close to the highway. A conservative span of districts was estimated to be close to 40 kilometres assuming the shape of a district would be a circle.[10] Using data from the 2001 national Census, an average span was estimated for Indian districts excluding the metropolitan hubs. A distance of 50 km around the highway was used to identify districts close to the highway network. This threshold includes the radius of a typical district (40 km) and a 10 km buffer around the highway. This identifies those districts which have their centroids within 10 kilometres of the highway path.

Two distance measures are created using the shortest distance from affected districts to the actual highway path and the constructed straight-line path:

- **Near Highway:** Indicating if a firms is <= 50 km from the actual highway
- **Near St-line Highway:** Indicating if a firms is <= 50 km from the st-line highway

In order to gauge how relevant these straight-line measures are as instruments for the

[10]The average area of a district in the sample was found to be around 4,000 sq. km. Thereafter, I assume a circular shape for districts to calculate the mean distance from their centroids. In the case of a circle, that would just be the radius. Given a circular shape, the area of $4000 = 3.14 * (R)^2$ would translate into a value of around 36 km for R - the radius of the average district.

actual distances from highway measures, the relationship between constructed district measures and actual distances from the highways' measures is analysed using data at the level of the variation in distances i.e., district level. Table 2 summarises the relationship between each indicator and the corresponding instrument. As can be seen in the table, each of these relationships is strong and the results are statistically significant. Columns 1 and 2 show that the within - 50 kilometres indicator variables or 'treatment bands' of the GQ and NSEW programs are highly correlated with their corresponding instruments.

Table 2: First-Stage Equivalent

	GQ Dist LE 50 km Actual	NSEW Dist LE 50 km Actual
GQ St-line Dist LE 50 km	0.517***	
	(0.056)	
NSEW St-line Dist LE 50 km		0.539***
		(0.050)
Observations	297	297
R-squared	.22	.28
Mean	.2	.2
F- Stat	83.83	114.34

Note: Standard errors are in parentheses. ***, **, and * indicate statistical significance at the 1, 5, and 10 percent levels, respectively.

5.1 Estimating the Impact: Difference- in- Difference

Leveraging the straight-line distance measure constructed, the analysis follows a difference-in-difference approach with the NSEW program used for placebo testing. The empirical strategy uses the Two-Stage Least Squares (2SLS) estimation where the first stage involves estimating proximity to the actual highway using proximity to the straight line highway as an instrument. For a firm i in sector s and year t, the following equation illustrates the approach of the second stage using firm-level data:

$$Y_{it} = \alpha + \mu_i + \gamma_{st} + \beta \cdot \widehat{NearGQ_i \cdot Post}2004_t + \delta \cdot \widehat{NearNSEW_i \cdot Post}2004_t + \epsilon_{it} \quad (6)$$

where $Post2004_t$ is an indicator variable that captures the time period that follows the treatment and $NearGQ_i$ is the distance measure computed which takes a value of 1 if the firm's district centroid is within 50 kilometres of the GQ route and 0 otherwise. The interaction term is the endogenous variable which will be instrumented using the equivalent interaction term with the exogenous straight-line measure, as discussed earlier. In addition, μ_i represents the firm-level fixed effects term and captures any firm-specific trend while γ_{st} represents the industry x year-specific fixed effects and captures any industry x time-specific trend. Finally, the coefficient β would capture the average impact of the treatment - being close to the constructed highway on the outcome, Y_{it}.[11] As mentioned, Y represents a range of firm-level outcomes covering the propensity to import, the number of products imported and the total value of imports. The error terms could be correlated across years for the same firm within the panel and therefore, the standard errors would be clustered at the firm level.

However, the firms could have reacted to the announcement of the highways and not necessarily the actual construction. This would pose a threat to the identification. Hence, the analysis uses placebo analyses to get additional estimates using the announced NSEW highway program. This program was delayed but meant to be constructed at the same time. The main assumption behind the placebo analysis is that unobserved drivers of economic activity along areas close to the GQ are similar to those areas that are close to the planned NSEW system. As the highways were planned with similar objectives in mind, firms close to the NSEW highway route would serve as a good comparison group for a placebo test. Similar to the GQ treatment, an NSEW treatment term is introduced. The coefficient on this term δ gives us an estimate of the impact of being near the planned NSEW system on the outcome variable Y_{it}. Therefore, δ would serve as a comparison to β, the estimated impact of the GQ program, and allow us to see if there was any impact of being close to the placebo NSEW system which was not constructed until later.

Measurement of Impact

Table 3 presents the difference-in-difference (DiD) estimates for different specifications for the import propensity outcome. Column 1 presents the standard OLS DiD estimate with district and year-fixed effects. However, as discussed earlier, this estimate is likely to be biased downward as the highway design could have been altered to pass through laggard areas with a low potential for import growth. Hence, the next two columns correct for this bias by instrumenting for proximity to the actual highway using proximity to the hypothetical

[11] This assumes that all of the construction took place in this year and the estimate might suffer from some mismeasurement of the treatment because of this assumption. In the empirical analysis section, I also carry out the analysis with a staggered Difference-in-Difference approach which addresses this issue. For this, I consider a firm to be treated in the actual year, not necessarily 2003-04, when its district was connected to the highway.

straight-line highway. Columns 2 and 3 present the IV results based on the specifications discussed in the previous section. Column 2 presents the instrumented DiD estimate for the GQ highway alone while column 3 also incorporates this for the placebo NSEW distance band as well.

Table 3: Impact of GQ Highway on Import Propensity

VARIABLES	(1) OLS	(2) IV/2SLS	(3) IV/2SLS
Near GQ Highway * Post Treat	0.014***	0.020***	0.021***
	(0.005)	(0.005)	(0.005)
Near NSEW Highway * Post Treat			-0.003
			(0.006)
Observations	98,309	98,270	98,270
Pre-2004 mean	.24	.24	.24
Number of plants	23,952	23,913	23,913
Firm FE	Y	Y	Y
Sector * Year FE	Y	Y	Y
First stage F- Stat		2102.65	1923.34

Note: The proximity to the actual GQ and NSEW highways is instrumented using proximity to the hypothetical straight-line GQ and NSEW routes for the IV estimates. Post Treat refers to the firm-year observations after upgrading the GQ highways (2004). Standard errors in parentheses, clustered at the firm level. ***, **, and * indicate statistical significance at the 1, 5, and 10 percent level, respectively.

This table presents several specifications to estimate the impact and compare the estimates. As can be seen, both the OLS and the IV estimates point in the same direction- that is close to the GQ project was associated with an increase in the firm's propensity to import. In addition, the IV impact estimate on output in the second column is very similar to that in the last column when the NSEW placebo is also included. In line with what we would expect, the coefficient on the NSEW project does not show any impact of that project. The specification in the last column will remain our main specification henceforth.

6 Empirical Results

In this section, I use the data and the spatial instrumental variable approach to estimate the impact of highways on firms along different margins. I also consider how the impact varies by individual firms' characteristics, such as productivity, the nature of inputs utilized, and their geographic location.

First, I show that firms increased their use of imported inputs, primarily along the extensive (new importers) and sub-extensive (new products), and not the intensive (existing imports) margin. Second, I show that the impact is more pronounced among firms that used differentiated inputs - i.e., those that require more search costs. Third, the highways had a more notable impact on the importing of firms that are far away from ports. The last two findings indicate that the highways impacted those firms that faced high barriers to accessing foreign inputs. Fourth, I show that within a sector, the impact of increased importing is driven by firms that are more productive. Finally, with the help of event study analysis, we see that the increase in affected firms' importing took place right after the nearest highway was constructed and not before.

FACT 1: *The upgraded highways expanded the variety of foreign inputs that firms used, both by attracting new importers (extensive margin) and by introducing new product varieties from existing importers (sub-extensive margin).*

Table 4: Import Impact of GQ Highway along Different Margins

	(1) Intensive	(2) Extensive	(3) Sub-Extensive	(4) Sub-Extensive
	Ln Share Mat Exp Existing Import Prod	Importer All Firms	Num Imp Prods Existing Importer	Ln Share Mat Exp Evolving Importers
GQ Dist LE 50 km * Post Treat	-0.137	0.022**	0.269**	0.194*
	(0.137)	(0.010)	(0.118)	(0.102)
NSEW Dist LE 50 km * Post Treat	-0.236*	-0.001	0.005	-0.058
	(0.131)	(0.009)	(0.101)	(0.093)
Observations	21,015	94,392	20,483	14,890
Pre-2004 mean		.244	2.588	
Number of clusters	7,095	23,029	3,735	2,854
Firm FE	N	Y	Y	Y
Firm x Prod FE	Y	N	N	N
Prod x Year FE	Y	N	N	N
Sec x Year FE	Y	Y	Y	Y
First stage F- Stat	178.34	1741.7	303.3	210.1

Note: The proximity to the actual GQ and NSEW highways are instrumented using proximity to the hypothetical straight-line GQ and NSEW routes respectively. Post Treat refers to the firm-year observations after upgrading the GQ highways (2004). Standard errors in parentheses, clustered at the firm level. ***, **, and * indicate statistical significance at the 1, 5, and 10 percent level, respectively.

Table 4 looks at the impact of the highway upgrades on different dimensions on the firm's importing decisions. The first column looks at the impact of the highways on the material expenditure share of imports that firms already imported (intensive margin). I do not find evidence of any impact of highways on existing imported products. The next column looks at the impact on the likelihood that a firm would import while the last column looks at the number of products imported by existing importers only. The results from the second and third columns suggest that both, new (extensive margin) and existing importers (sub-extensive margin) adjusted their mix of inputs by importing a larger variety of products. In the last column, I consider firms that changed the number of products imported after the highway upgrades and track how the material share of imports changed for such firms. I find that the highways lead to an increase in the material share of imports for such firms.

It might seem surprising that there isn't any substantial change along the intensive margin of importing. Looking at this through the model, one possible reason could be that the relative prices of imports and domestic inputs did not change. As highways ease access to imports, they also ease access to domestic inputs. When we look at where firms typically source domestic inputs from, evidence suggests there might be substantial overlap between the locations. The distribution of local producers shows that nearly half of the domestic producers come from within 100 km of a port.[12] For firms that were already importing a variety of input, they did not spend a greater share on that input as the import gain a remained unchanged.[13]

FACT 2: *The impact of the upgraded highways on importing varied, based on the type of inputs used by firms. These highways predominantly bolstered the import variety for firms operating in industries that use differentiated inputs, and not so much for those that use homogeneous inputs.*

Table 5 column 1 shows the average impact on importing propensity was 2 percentage points. While upgraded highways led to a greater share of firms importing, the degree of change depended on the nature of inputs used. Table 5's second column shows that the GQ highway program had a positive impact on firms that had either a high or low share of differentiated inputs. However, the impact on firms using a high share of differentiated inputs is more pronounced. [14] Firms with a high share of differentiated inputs refer to those whose inputs need to be customized and are not available as homogeneous goods on commodity exchanges. Hence, such firms would need to incur higher fixed costs in order to

[12] The distribution of local sales in a year is provided in the appendix

[13] This can be seen in the expression 5 from the theoretical framework discussion.

[14] The measure is constructed using the methodology adopted in Boehm and Oberfield (2020). The level of differentiated inputs is constructed based on the major output product produced by the firm. For each product, I define the level of differentiated inputs as the average measure of differentiation, weighted by the expenditure share of intermediate inputs.

Table 5: Impact of GQ Highway on Import Propensity

	(1) Importer	(2) Importer
GQ Dist LE 50 km * Post Treat	0.022**	
	(0.010)	
GQ Dist LE 50 km * Post Treat * Homo Inputs		0.012
		(0.012)
GQ Dist LE 50 km * Post Treat * Diff Inputs		0.032**
		(0.013)
NSEW Dist LE 50 km * Post Treat	-0.001	-0.000
	(0.009)	(0.009)
Observations	94,392	94,392
Pre-2004 mean	.244	.244
Number of plants	23029	23029
Firm FE	Y	Y
Sec x Year FE	Y	Y
Diff x Year	Y	Y
First stage F- Stat	1741.85	1090.48

Note: The proximity to the actual GQ and NSEW highways are instrumented using proximity to the hypothetical straight-line GQ and NSEW routes respectively. Post Treat refers to the firm-year observations after the GQ highways were upgraded (2004). Standard errors in parentheses, clustered at the firm level. ***, **, and * indicate statistical significance at the 1, 5, and 10 percent level, respectively.

find suitable suppliers.[15]

The upgraded highways probably facilitated the movement of people and information, resulting in lower search costs for firms seeking foreign suppliers of inputs that are specific to their business relationships. This could have reduced the fixed cost for firms, especially those requiring intensive supplier search. As related work (Nunn, 2007; Boehm and Oberfield, 2020) highlights, these inputs often require a lot of contact between the seller and the buyer. This is because differentiated or specific- inputs have a lot of heterogeneity in how well they match the needs of their users. Hence, improved highways could make it easier for firms to travel to their input suppliers and reduce the fixed costs involved in finding a good match. These papers show that contract enforcement is important for such inputs. Regular visits through more frequent travel could be thought of as another way to build these supplier relations or reduce friction arising from contract enforcement.

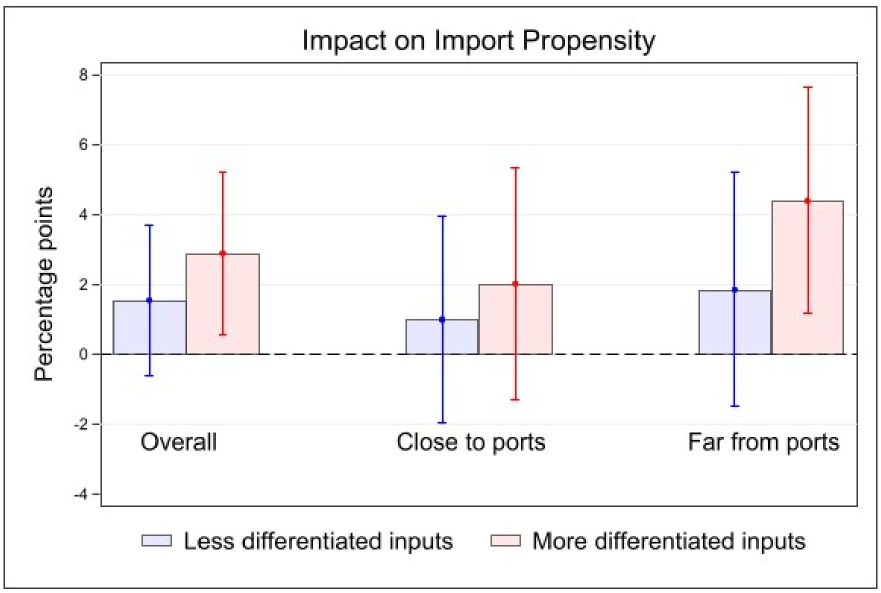
FACT 3: *Proximity to the port affects the degree of highways' impact on importing. The*

[15]As defined in Nunn (2007) which utilizes values for goods from Rauch (1999) and Nunn (2007).

impact was more pronounced on firms that were further away from ports. Among firms far away from ports, the degree of impact was higher for firms using differentiated inputs.

As distance from the port increases, firms are likely to find it harder to access imported inputs. In fact, the travel between the firm and its import supplier should matter more if the firm is looking to source differentiated inputs as they require customization. As these highways potentially ease travel to the ports, firms could spend less effort to look for inputs that they require.

Figure 5: Impact on Import Propensity



In Fig 6, I show how the degree of the highways' impact varies depending on the nature of inputs used, and the distance from ports. The first column, as before, shows the degree of the highway's impact on two groups of firms based on the differentiation of inputs. The next two columns show results for similar regressions but the sample is split into two halves: a) firms close to the port; and b) firms further away from ports. As the table suggests, the impact of the highways was more pronounced among firms further away from the ports. In addition, the degree of impact is higher for firms that use differentiated inputs. This suggests that the highways had the most substantial impact on firms that had to pay the highest cost to reach foreign suppliers, i.e. those far away from ports and using differentiated inputs.

FACT 4: *Within a sector, high-productivity firms leveraged the upgraded highways to diversify their range of imports, while low-productivity firms did not alter their range of imports as much.*

Table 6 looks at the import propensity for different groups of firms according to their baseline productivity ranking within sectors.[16] Firms were divided into two groups, depending on whether they were more- or less- productive within sectors. The first column looks at the average impact of the highway program on all firms, while the last two columns of the table split the sample based on productivity. The second column restricts the sample to firms with low productivity and the third column focuses on those with high productivity.

Table 6: Impact of GQ Highway on Import Outcomes

	(1) Importer All	(2) Importer Low Prod	(3) Importer High Prod
GQ Dist LE 50 km * Post Treat	0.022**	-0.002	0.041***
	(0.010)	(0.014)	(0.015)
NSEW Dist LE 50 km * Post Treat	-0.001	-0.005	0.004
	(0.009)	(0.012)	(0.012)
Observations	94,392	45,784	48,176
Pre-2004 mean	.244	.204	.284
Number of plants	23029	11894	11038
Firm FE	Y	Y	Y
Sec x Year FE	Y	Y	Y
Diff x Year	Y	Y	Y
First stage F- Stat	1741.7	921.34	816.51

Note: The proximity to the actual GQ and NSEW highways are instrumented using proximity to the hypothetical straight-line GQ and NSEW routes respectively. Post Treat refers to the firm-year observations after the GQ highways were upgraded (2004). Standard errors in parentheses, clustered at the firm level. ***, **, and * indicate statistical significance at the 1, 5, and 10 percent level, respectively.

The highways' impact on importing increases with baseline productivity. As Gopinath and Neiman (2014) and Halpern et al. (2015) point out, the import adjustment of firms varies based on firms' size (or productivity). Through the lens of the model, the highway upgrades potentially make it easier for firms to access ports, and so, the firms would need to pay lower fixed costs to access foreign inputs. While the benefits from these imports are higher for more productive firms, the lower fixed cost is the same across firms. Hence, the marginal firm that chose not to use a foreign input earlier could use it now due to the drop in fixed costs. This is more likely to happen among more productive firms as they gain more from adding new imported varieties. As highlighted in section 3, this would result in a greater increase in the variety of imported inputs among more productive firms.

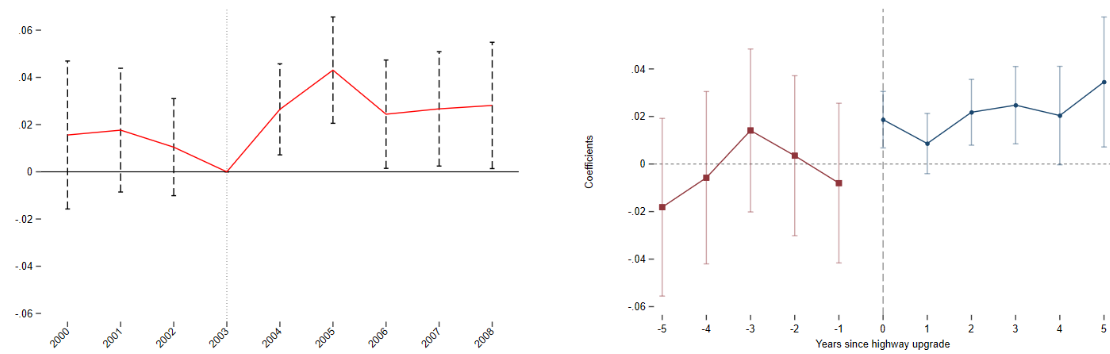
[16] This refers to the ranking based on the firm's productivity before the highways were built.

Trend of Impact: Event Study Analysis

As some of the import-related outcomes for firms were strongly impacted by the construction of the GQ highway, this sub-section looks to analyze the trend of the results on these measures over time. Using two event study analysis techniques, I find that the importing increases following the highway construction and remains stable at a higher level.

Figure 6: Event Study Analysis: Impact on Import Propensity

A: IV DiD B: Staggered DiD



Note: The dashed lines represent 90% confidence intervals.

First, in order to analyze the evolution of the impact estimate, the figure on the left plots the β_t from the Equation 7 for all the years covered in the period, following a similar spatial instrumental variable approach as before. For a given firm i in period t,

$$Y_{it} = \alpha + \mu_i + \gamma_t + \sum_{t=1}^{T} \beta_t \cdot NearGQ_i \cdot Year_t + \epsilon_{it}, \tag{7}$$

All the estimates in Figure 6 are with respect to the reference treatment year of 2003-04 As can be seen from the figure, there was no statistically significant difference in these outcomes in the years before 2003-04. This addresses the concerns of pre-trends which often call into question the validity of DiD estimates. However, following the construction of the highway, these import-related outcomes saw a statistically significant rise for importers near the GQ highway but not for those near the placebo NSEW program highways. This reinforces the earlier discussion that the impact is not driven by being near a planned highway upgrade but by the actual construction of the GQ highway.

Second, recent work on empirical methods has come up with methods to deal with the fact that not all treated units get the treatment at the same time. The figure on the right follows one such method proposed in Borusyak et al. (2021). The staggered difference in difference considers the timing of the treatment being staggered as not all firms got improved highway access in the same year. The method considers firms that I am not yet treated as well as firms that would never be treated as counterfactual. With the help of this counterfactual, a DiD event study is carried out to estimate the impact of highways on firms. As the graph shows, in the five years preceding the highways, there is no statistically significant difference between treated firms' and untreated firms' importing. However, in the period post highway construction, we can see that treated firms have a higher chance of importing.

7 Structural Estimation and Welfare Analysis

The main aim of the exercise is to obtain relevant parameters that allow us to estimate the impact of change in importing behavior on a firm's productivity. The structure of the model allows us to pin down the change in productivity arising specifically from the import channel.[17] It also helps understand how the impact depends on firm characteristics. For the calibration exercise, I estimate structural parameters using firm observations from the districts close to the upgraded highways and in the period preceding the highway upgrade program (2000-2003).

The main aim of the calibration exercise is to estimate the relevant structural parameters: per-product import gain a, the weight of intermediates γ and the relative weight of different products imported $G(n)$. As explained earlier in the section, the product of these, $a\gamma G(n)$, determines the revenue productivity benefit that firms derive from the use of imported benefits. In addition, I also use the structural parameters to estimate the elasticity of substitution between foreign and domestic inputs within a two-digit sector. Firms in sectors whose inputs are less substitutable stand to gain more from additional import varieties.

Steps Involved:

I estimate these parameters separately for each sector at the NIC-2 digit level (which corresponds to ISIC Revision 3 classification):

1. Estimating γ^*:

In order to estimate γ^*, we make use of the Cobb- Douglas relationship between revenue

[17]As prior research has shown, firms can benefit from better roads through various channels such as improved market access, local spillovers from re-organized manufacturing activity, etc.

and total expenditure on intermediates:

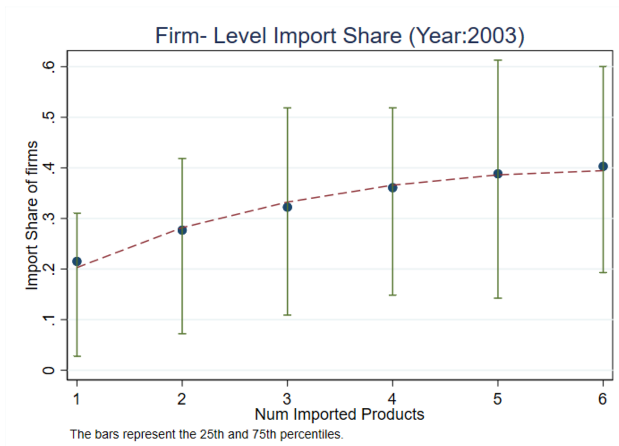
$$E\left(\frac{M_{it}}{R_{it}}\right) = \gamma^* \tag{8}$$

For each sector, I calculate the weighted average of the share of intermediate expenditure in total revenue to estimate the sector-specific γ^*.[18]

2. Estimating G(n):

For this, we make use of the relationship between firms' import expenditure share and the number of products imported. Figure 7 describes how the import share varies with the number of products imported by a firm across all Indian manufacturing firms in 2003.

Figure 7: Average Import Share as a Function of Import Variety



The total relative share of import expenditure increases with each product but the increase tapers off as firms saturate their production with imported inputs. Hence, G(n), for each sector, can be represented by:

$$G(n) = \begin{cases} \bar{G}\left(1 - \left[1 - (n/\bar{n})^{\lambda}\right]^{1/\lambda}\right) & \text{if } n < \bar{n} \\ \bar{G} & \text{otherwise} \end{cases} \tag{9}$$

where $\bar{n}$ refers to the maximum number of goods imported by firms and $\bar{G}$ refers to the optimal share of tradable goods in total intermediate expenditure if the firm uses imported

[18]This is similar to the approach originally used in Gandhi et al. (2020).

inputs in all its goods. In order to estimate G(n), I make use of the following relationship:

$$\frac{M_{it}^F}{M_{it}} = S.G(n) + \epsilon_{it} \tag{10}$$

where S refers to the expenditure share of tradable intermediates in total intermediates, and G(n) refers to the relative weight in tradables of the inputs that the firm chooses to import. Hence, $S, G, \bar{G}, \lambda \in (0, 1)$. I carry out non-linear least square regressions to estimate each sector's λ and S.

3. Estimating a**:**

I next make use of Equation 3 and solve for the optimal revenue of the firm considering the industry structure. This gives me the following relationship:

$$r_i - p = \frac{1}{\eta}q + \frac{1}{\eta}\nu_i + w_i^* + \alpha^* k_i + \beta^* l_i + \gamma^*(m_i - \rho) + \gamma^* a G(n_i)$$

However, to ensure that I find the true unbiased estimates of the coefficients from the equation, I carry out the production function estimation procedure proposed in Olley and Pakes (1996). This procedure allows me to obtain plausibly unbiased estimates of the production function parameters including $a\gamma^*$. In addition, the first two demand-related terms on the right-hand side, are proxied for using demand growth within the firm's sector and district as well as the log total output for other firms within the firm's sector and district.

I then plug in the estimated G(n) for each firm from the previous step into this. From the equation, we can see that the coefficient of G(n) is $a\gamma^*$. Dividing this by the sector-specific γ^* estimated from the first step, I obtain an estimate of a, the average per-production price gain from importing.

With an estimate of a and S, I use Equation 14 to estimate the elasticity of substitution between foreign and domestic varieties of the same good for different sectors.

I summarize the sector-wise results of this estimation exercise in the context of manufacturing firms in the non-nodal cities of India before the highways were built (2000-04). In order to obtain confidence levels for each estimate, I carry out a bootstrapping exercise, clustered at the firm level. I pick out 100 draws without replacement randomly dropping 1/3 of the firms at the sector- level in every draw.

It can be seen that, on average, the per-product import gain is 0.36. In other words, if a firm switches from purely domestic to a composite of domestic and imported varieties, it sees a per-product reduction in its price index of 30.3 % (1- $e^{-0.36}$) per product of that good.

Table 7: Summary of Estimated Parameters

ISIC Code	Sector	a	γ^*	S	λ	θ	$\bar{G}$	# firms
15	Food & Beverage	0.27	0.79	0.27	0.02	2.19	0.86	3223
16	Tobacco	3.51	0.40	0.06	0.80	1.02	0.84	168
17	Textiles	0.44	0.72	0.37	0.66	2.05	0.79	2029
18	Apparel	0.06	0.62	0.45	0.70	10.56	0.85	206
19	Leather	0.15	0.77	0.31	0.71	3.39	0.85	436
20	Wood	0.09	0.78	0.65	0.42	12.15	0.81	203
21	Paper	0.05	0.71	0.33	0.29	9.45	0.61	513
23	Coke	0.27	0.53	0.62	0.34	4.41	0.82	101
24	Chemical	0.40	0.60	0.39	0.62	2.25	0.76	2018
25	Rubber	0.31	0.67	0.32	0.56	2.27	0.83	635
26	Non-metallic	0.08	0.60	0.36	0.28	6.94	0.45	1064
27	Basic metals	0.17	0.69	0.26	0.01	2.74	0.75	1177
28	Fabricated metal	0.47	0.69	0.40	0.65	2.10	0.82	860
29	Machinery & equi	0.40	0.60	0.29	0.61	1.83	0.88	1387
31	Electrical machi	0.33	0.68	0.36	0.65	2.35	0.89	663
32	Radio TV	0.18	0.54	0.58	0.71	5.84	0.91	240
33	Medical	0.15	0.58	0.46	0.62	4.99	0.87	365
34	Motor vehicle	0.37	0.60	0.35	0.59	2.18	0.86	555
35	Other transport	0.08	0.55	0.42	0.98	7.76	0.76	519
36	Furniture	0.29	0.67	0.42	0.57	2.92	0.78	322
	Total	0.36	0.72	0.32	0.59	2.18	0.83	

Note: The estimates presented are the sample-weighted median values from the bootstrapping exercise clustered at the firm level.

Welfare Analysis

In order to estimate the welfare implications of the highways through the import channel, I consider how these highways affected the productivity of different sectors and firms within the sectors. The structural parameters (γ, a and $G(n)$) were estimated for each two-digit sector using firm observations in the affected areas before the highways were built. γ remains fixed as we do not anticipate any change in the relative share of different goods to produce a particular product. While a could have changed, we did not see any change in the intensive margin. This suggests that there is no change in parameter a. Hence, we focus on the increased import variety used by firms and how it affected $\gamma a G(n)$ through $G(n)$.

We are not interested in merely how highways affect firms' output productivity, but in how highways impact their earnings or revenue. For this, I convert the quantity productivity gain $\gamma aG(n)$ into revenue productivity gain by incorporating the demand elasticity of each sector η. Hence, the revenue gain is given by $\gamma^* aG(n)$. Finally, to estimate the impact, we run a similar IV DiD approach using estimated parameters to obtain the outcome variable of revenue gain which increases with the firm's import variety, n. Using this procedure, I find that the average revenue productivity gain:

- **for all firms**, is 1.52%
- **for firms with differentiated input sectors**, is 2.07%
- **for firms with non-differentiated input sectors**, is 1.19%

Finally, in order to quantify the total gain to firms as a result of these highways, I try to estimate the total monetary gain to firms through the import channel. To carry out this, I multiplied the total estimated revenue of manufacturing firms in affected regions before the highway upgrades with the estimated increase in revenue productivity. This amounts to USD 1.3 billion. Ghani et al. (2015) report that the Indian government budgeted USD 7 billion for the GQ project. This suggests that the increase in firms' earnings over the next 5-6 years exceeded the total budget spent by the Indian government on the GQ highway project. While this back-of-the-envelope calculation does not consider all the implications of the highways, it helps us get an estimate of how important is the gain through the import channel relative to the amount invested in the GQ project.

8 Conclusion

Domestic transport infrastructure has a high potential to integrate firms into the global economy and, thereby, help them benefit through better and cheaper inputs, especially in developing economies. Road networks like this are being built more frequently now than in the past. With the aim of promoting trade, China is rejuvenating its historical Silk Route corridor through the ambitious Belt and Road Initiative (BRI). [19] The paper looks to leverage India's ambitious large-scale Golden Quadrilateral highway project as a natural experiment to estimate the impact of upgrading domestic roads on the import activity of importing firms. As the terminal nodes of the projects were also trading hubs, it could potentially improve firms' access to foreign inputs.

However, as is often the case with such infrastructure projects, the analysis is complicated by the endogenous relationship between infrastructure placement and a region's economic

[19] The project includes an estimated $200 billion of investments in roads across 60 countries

needs or potential. To overcome the problem of endogeneity, the study uses a cutting-edge spatial instrumental variable approach. In addition, the analysis also uses an alternate highway that got delayed to create a placebo and test the results obtained.

The GQ highway program had a positive effect on firms' use of foreign inputs. Firms increased their import usage predominantly through the increase in the variety of imports used, possibly because upgraded highways reduced firms' fixed costs to look for suitable suppliers. However, the impact varied based on firms' baseline productivity levels, firms' distance from ports, and the differentiation across their inputs. The program increased imports relatively more more firms further away from ports and those that used more differentiated inputs. Within sectors, the program had a larger impact on firms with higher productivity in terms of their imports. Hence, the highways affected the inequality in importing, albeit, in different ways. First, it decreased the inequality across regions by increasing importing relatively more for remote firms that imported less earlier. Second, it increased inequality within sectors by increasing importing among more productive firms that imported more earlier.

The findings of this study would have important implications for India as well as other developing countries. Many developing countries in Africa, Asia, Latin America, and Eastern Europe are also undertaking massive transport infrastructure investment through international aid organizations as well as the China-led Belt and Road Initiative. Given huge investments in other highway projects that the government has committed to, these findings help understand the impact on imports of firms within these countries. As countries look to boost their manufacturing and tap into global value chains, it is crucial that firms have better access to foreign markets to help them grow. If targeted well, such projects could prove to be complementary in allowing the manufacturing sector to access higher-quality inputs from abroad that would help improve their productivity. The highways also allow a broader range of firms to access international markets and enhance their production.

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9 Appendix

9.1 Districts close to the Upgraded Highway

Table 8: List of districts in the treatment band of 50 km

STATE	DISTRICT	STATE	DISTRICT
ANDHRA PRADESH	EAST GODAVARI	ORISSA	DHENKANAL
ANDHRA PRADESH	KRISHNA	ORISSA	GANJAM
ANDHRA PRADESH	VISAKHAPATNAM	ORISSA	JAJAPUR
ANDHRA PRADESH	VIZIANAGARAM	ORISSA	KHORDHA
ANDHRA PRADESH	WEST GODAVARI	ORISSA	RAYAGADA
BIHAR	ROHTAS	RAJASTHAN	ALWAR
GUJARAT	DOHAD	RAJASTHAN	DAUSA
GUJARAT	NAVSARI	RAJASTHAN	TONK
GUJARAT	SURAT	TAMIL NADU	KANCHEEPURAM
GUJARAT	VALSAD	TAMIL NADU	THIRUVALLUR
HARYANA	REWARI	TAMIL NADU	VELLORE
JHARKHAND	BOKARO	UTTAR PRADESH	ALIGARH
JHARKHAND	DHANBAD	UTTAR PRADESH	BARABANKI
JHARKHAND	GIRIDIH	UTTAR PRADESH	BULANDSHAHAR
JHARKHAND	HAZARIBAGH	UTTAR PRADESH	CHANDAULI
JHARKHAND	KODARMA	UTTAR PRADESH	ETAH
KARNATAKA	BELGAUM	UTTAR PRADESH	FAIZABAD
KARNATAKA	DHARWAD	UTTAR PRADESH	JAUNPUR
KARNATAKA	KOLAR	UTTAR PRADESH	LUCKNOW
KARNATAKA	TUMKUR	UTTAR PRADESH	RAE BARELI
MADHYA PRADESH	JHABUA	UTTAR PRADESH	SULTANPUR
MADHYA PRADESH	MANDSAUR	UTTAR PRADESH	UNNAO
MADHYA PRADESH	RATLAM	UTTAR PRADESH	VARANASI
MAHARASHTRA	RAIGARH	WEST BENGAL	BANKURA
MAHARASHTRA	SANGLI	WEST BENGAL	HAORA
MAHARASHTRA	SATARA	WEST BENGAL	HUGLI
ORISSA	BALESHWAR	WEST BENGAL	NORTH TWENTY FOUR PARGANA
ORISSA	CUTTACK	WEST BENGAL	PURULIYA
		WEST BENGAL	SOUTH TWENTY FOUR PARGAN

9.2 Additional details about Firm Production

Firm i's production follows a Cobb- Douglas Function given by:

$$Q_i = \Omega_i K_i^{\alpha} L_i^{\beta} X_i^{\gamma} \tag{11}$$

where Y_i refers to the output,Ω_i refers to the Hicks-neutral productivity, L_i refers to labor employed, K_i to capital and X_i is the composite of different intermediate goods used by the firm. The intermediate composite X_i can be thought of as a bundle of different goods indexed by j:

$$X_i = \prod_j X_{ij}^{\gamma_j} \qquad \sum_j \gamma_j = \gamma$$

where $\sum_j \gamma_{ij} = \gamma_i$, γ_i refers to the Cobb- Douglas share of intermediates and $\gamma_i j$ refers to the importance of good j.

Each intermediate good j, is modelled as a composite of domestic and foreign varieties:

$$X_{ij} = \left[X_{ijH}^{\frac{\theta-1}{\theta}} + (B_{ij} X_{ijF})^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}$$

where X_{ijH} and X_{ijF} refer to the quantity of domestic and foreign varieties used in the firm's composite of good j. B_{ij} represents the quality advantage of the imported variety relative to the domestic variant. Solving the firm's cost minimization problem, the effective price of this composite good P_{ij} is given by::

$$P_{ij} = \left[P_{jH}^{1-\theta} + (B_{ij} P_{jF})^{1-\theta} \right]^{\frac{1}{1-\theta}}$$

The price-adjusted quality advantage of the foreign good can be represented as:

$$A_{ij} = B_{ij} * P_{jH} / P_{jF} \tag{12}$$

We assume this advantage to be the same across all firms within a sector, which implies $A_{ij} = A$. The effective price index can then be written as:

$$P_{ij} = P_{iH} \left[1 + A^{\theta-1} \right]^{\frac{1}{1-\theta}} \tag{13}$$

The drop in the price index of the composite good relative to a purely domestic composite represents the per-product import gain, a, and can be defined as the log reduction in the price index:

$$a = \frac{log\left[1 + A^{\theta-1}\right]}{\theta - 1} \tag{14}$$

From this, it can be seen that as $\theta \in (0, \infty)$, the gain increase with the price-adjusted quality of foreign goods and decreases with the degree of substitution between foreign and domestic varieties, θ. Given the degree of substitution and the price-adjusted quality advantage, the optimal import expenditure share of a composite good comprising of both foreign and domestic variants is given by:

$$S = \frac{A^{\theta-1}}{A^{\theta-1} + 1}$$

The price index of a composite good can then be defined as:

$$P_{ij} = P_{jH}e^{-a} \tag{15}$$

Given that intermediates are themselves a Cobb- Douglas aggregate of different goods, it can be shown that total expenditure on intermediates, M or $P_X X$ can be expressed as:

$$M = \prod_j \left(\frac{P_{ij}X_{ij}}{\gamma_j/\gamma}\right)^{\gamma_j/\gamma} \tag{16}$$

where γ_j/γ represents the weight of each good in total intermediates. In addition, we define $G(n_i)$ as the relative total weight of inputs that the firm imports:

$$G(n_i) = \sum_{j \in n_i} \frac{\gamma_j}{\gamma} \tag{17}$$

Firms derive the same per-product gain from importing different goods and pay the same fixed cost regardless of the product use. Hence, they would first import the input with the highest expenditure weight and then if it chooses to import more, it would move in decreasing order based on the weight of the remaining goods.

Substituting P_{ij} from equation 15 and $G(n_i)$, we get:

$$M_i = \varrho e^{-aG(n_i)} X_i^{1/\gamma} \tag{18}$$

$$X_i = \left[\frac{M_i}{\varrho} e^{-aG(n_i)}\right]^{\gamma} \tag{19}$$

where ϱ represents the domestic Cobb- Douglas input price index given by:

$$\varrho = \prod_j \left(\frac{P_{ih}}{\gamma_j / \gamma} \right)^{\gamma_j / \gamma} \quad (20)$$

The firm's production function can, therefore, be expressed in log form as:

$$q_i = \omega_i + \alpha k_i + \beta l_i + \gamma x_i \quad (21)$$

$$q_i = \omega_i + \alpha k_i + \beta l_i + \gamma (m_j - \rho) + \gamma a G(n_i) \quad (22)$$

where the lower case alphabets represent the log form of the respective upper case elements in Equation 11, x_i is expressed as in 18 and $\rho = log(\varrho)$.

Industry Demand

The demand for an industry's output is given by:

$$U_S = \left[\sum_{i=S} V_i^{1/\eta} Q_i^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \quad (23)$$

where there are different firms within a sector S and Q_i refers to the output of each firm i's variety and η is the elasticity of substitution between different varieties. The share of each firm's output in the total industry output is given by:

$$\frac{Q_i}{Q} = V_i \left(\frac{P_i}{P} \right)^{-\eta}$$

This relationship can be rewritten to express as firm's revenue as:

$$\frac{R_i}{P} = \frac{P_i Q_i}{P} = Q^{1/\eta} V_i^{1/\eta} Q_i^{(\eta-1)/\eta} \quad (24)$$

9.3 Estimating Trade Costs as Implicit Taxes

Firms' use of foreign inputs is often seen to be affected by domestic trade frictions (Atkin and Donaldson, 2015). The domestic costs on inputs are often modelled as an additional cost that firms have to pay on inputs, similar to tariffs or value-added taxes on goods. The acquisition of these inputs would be affected by the ease with which these can be acquired through transport links. With the upgrade of the highways, one would expect it to become easier for firms to access highways and use foreign inputs. The analysis models the trade cost as an implicit tax on goods similar to Hsieh and Klenow (2009).

In order to estimate these implicit costs, I use the method in Chaurey et al. (2019) which builds on the cost minimization approach to measuring firm-level price markups used in De Loecker and Warzynski (2012). The implicit tax can be thought of as an extra cost borne by firms in addition to the prices reported. The method is based on the property of a Cobb- Douglas production function that the revenue-share of expenditures on inputs remains constant if the technology remains constant. This implies that the overall share of a factor expenditure (implicit tax plus explicit expenditure) remains constant. Hence, any rise (or fall) in the explicit expenditure share of a particular input would correspond to a drop (or rise) in the factor's implicit tax. This method also allows the estimation of similar implicit taxes (or policy costs) for different production factors and comparing them with each other and across time.

Details of the method:

Let us consider a firm i's production Q with variable factors of production, labor L and domestic materials D, imported materials M and fixed capital K. We assume that the production function is Cobb-Douglas with Constant Returns to Scale. This implies that the firm's technology does not alter much during the period considered.

The firms cost minimization problem in period t is as follows:

$$\begin{aligned} \min_{L_{it},M_{it},D_{it},K_{it}} \quad & (\tau_{it}^{L}P_{it}^{L})L_it + (\tau_{it}^{M}P_{it}^{M})M_{it} + (\tau_{it}^{D}P_{it}^{D})D_it + (\tau_{it}^{K}P_{it}^{K})K_{it} \\ \text{s.t.} \quad & Q_{it} = A_{it}L_{it}^{\alpha_L}M_{it}^{\alpha_M}D_{it}^{\alpha_D}K_{it}^{\alpha_K} \end{aligned} \tag{25}$$

Here Q_{it} is the level of production that the firm is trying to minimize costs for. P_{it}^{L}, P_{it}^{M} , P_{it}^{D} and P_{it}^{K} are the price of inputs respectively. We assume that these input prices can vary across firms, but cannot be affected by the firm (that is, the firm acts as a price taker in factor markets). τit^L, τit^M, τit^M and τit^K are the implicit taxes on inputs.

It can be shown that the firm's first order condition for labor and material are as follows:

$$\begin{aligned} \tau_{it}^L \rho_{it} = & \frac{\alpha^L}{\kappa_{it}^L}; \tau_{it}^M \rho_{it} = & \frac{\alpha^M}{\kappa_{it}^M} \\ \tau_{it}^D \rho_{it} = & \frac{\alpha^D}{\kappa_{it}^D}; \tau_{it}^K \rho_{it} = & \frac{\alpha^K}{\kappa_{it}^K} \end{aligned} \tag{26}$$

Here, $\rho_{it}(= P_{it}/\lambda_{it})$ is the firm's output price markup. αs are the elasticities of output with respect to inputs. κ_{it}^L, κ_{it}^M, κ_{it}^D and κ_{it}^K are the expenditures on individual inputs, respectively, divided by the firm's revenue.

Dividing the two first order conditions, we see that the optimal ratio of input expenditures is inversely proportional to the implicit input taxes:

$$\frac{\tau_{it}^M}{\tau_{it}^K} = (\frac{\alpha^M}{\alpha^K})(\frac{\kappa_{it}^M}{\kappa_{it}^K}) \tag{27}$$

Normalizing the implicit tax on capital to 1 - in other words, redefining τ_{it}^L as the relative implicit tax on imported - and taking logarithms, we see that:

$$log(\tau_{it}^M) = log(\frac{\alpha^M}{\alpha^K}) + log(\frac{\kappa_{it}^M}{\kappa_{it}^L}) \tag{28}$$

As can be seen from the previous equation, the first term is time- invariant, Hence, in a firm- level panel regression , the first log- term will get absorbed in the firm- fixed effects as it is time-invariant. Hence, the impact on relative implicit cost can be identified using the within-firm changes in expenditure shares on different inputs.

$$\Delta log(\tau_{it}^M) = \Delta log(\frac{\kappa_{it}^M}{\kappa_{it}^L}) \tag{29}$$

Impact on Implicit Taxes for Different Inputs

This sub-section looks at the estimated implicit taxes on different outcomes. Given that the GQ program connects ports to different parts of the country, it should be the case that products from these ports should be most affected. In comparison, we would also expect the upgraded highways to make it easier to access goods from other parts of the country that might not lie directly on the highways but would pass through the highways nonetheless. However, factors such as land would not be expected to be affected much by improvements in inter-region connectivity programs. The following Table 9 looks at the impact of the GQ program on different inputs:

Table 9: Impact on Implicit Tax on Diff. Factors

VARIABLES	(1) IV/2SLS Implicit Tax Import Input	(2) IV/2SLS Implicit Tax Domestic Inp	(3) IV/2SLS Implicit Tax Labour	(4) IV/2SLS Implicit Tax Land
Near GQ Highway * Post Treat	-0.194**	-0.063**	-0.042*	-0.035
	(0.077)	(0.031)	(0.024)	(0.047)
Near NSEW Highway * Post Treat	0.079	0.036	0.050**	0.016
	(0.062)	(0.027)	(0.021)	(0.042)
Observations	98,915	95,065	96,534	73,317
Firm FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y

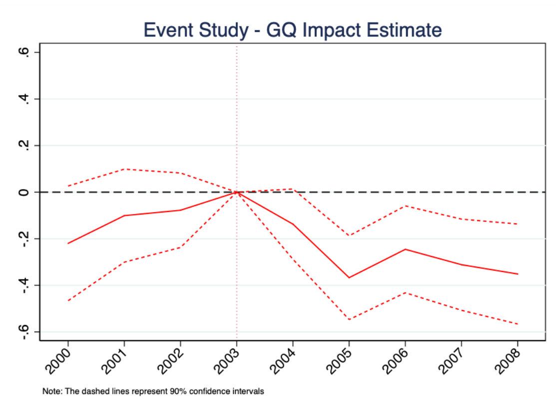
Note: The proximity to the actual GQ and NSEW highways are instrumented using proximity to the hypothetical straight-line GQ and NSEW routes respectively. Post Treat refers to the firm-year observations after the GQ highways were upgraded (2004). Standard errors in parentheses, clustered at the firm level. ***, **, and * indicate statistical significance at the 1, 5, and 10 percent levels, respectively.

Table 9 shows that, in line with the expectations, the GQ program affects both, goods from the ports and goods from the rest of the country. While the program reduced implicit taxes on foreign goods by 19.4 percent, it reduced the implicit taxes on domestic goods by a more modest 6.3 percent. However, as expected, there is not as much of an impact of the highway upgrades on land which is an immobile fixed capital. The following figure also shows distribution of the impact over time. As the figure 8 shows, the implicit cost of imports drops down following the construction of he GQ highway and stays fairly stable at that level [20]. Hence, as a result of the highways, total prices (including implicit taxes) firms paid for foreign inputs fell more than those for domestic inputs. This implies that the price of foreign inputs relative to domestic inputs (p_F/p_H) dropped.

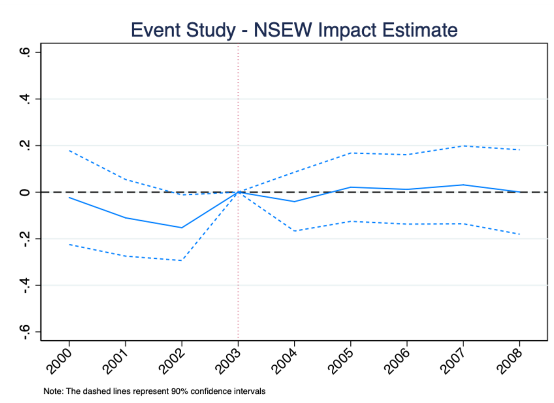
[20]The trend of this impact is measure using the Empirical specification covered at the end of this section.

Figure 8: Impact on Implicit Tax on Imported Inputs

A: Treatment: GQ



B: Placebo: NSEW



Note: The dashed lines represent 90% confidence intervals

9.4 Geographic Distribution of Domestic Input Suppliers

Figure 9: Impact on Implicit Tax on Imported Inputs