Policy Research Working Paper 10066

Trade, Transport, and Territorial Development

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Abstract

The spatial distribution of economic activity is known to depend on trade costs, both international and domestic. This paper examines the interplay between these external and internal trade costs using a model of trade and production that is tested with the organized manufacturing sector data for India from 1989 to 2009. The analysis establishes that the trade liberalization episode of the early 1990s helped spread manufacturing away from the primary region (districts closest to ports) to the secondary region between 1994 and 2000. Such dispersion of activity away from the primary to the secondary region was driven by high internal trade costs that insulated manufacturers from import competition. This trend reversed post-2000, a period of massive decline in internal trade costs, attributed to the Golden Quadrilateral highway upgrades. During this period, the districts along the highway network in the secondary region gained market access and manufacturing activity, while those off the network lost. Irrespective of the period, or the nature of trade costs, manufacturing activity in the interior region (districts farthest from ports) remained depressed, thereby emphasizing the importance of complementary conditions in driving territorial development.

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Trade, Transport, and Territorial Development *

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1. Introduction

Geography plays a significant role in determining the distribution of economic activity across space. In particular, the suitability of a region to engage in domestic and international trade is critical in influencing spatial concentration of people and economic activity (Henderson et al., 2018). Recent trade liberalization episodes in some countries have enhanced spatial concentration within countries. In China, for instance, the decline in international trade costs enabled export-oriented industries to emerge close to ports at the expense of other regions (Coşar and Fajgelbaum, 2016) and pushed remote regions to specialize in agricultural products (Baum-Snow et al., 2017).[1] This has inevitably led many researchers to conclude that greater openness to trade may lead to skewed regional development (Kanbur and Venables, 2003).

Using establishment-level data from the Indian organized manufacturing sector covering the period 1989-2009, we examine whether a decline in *external* trade costs, triggered by the trade liberalization episode of the 1990s, affected the spatial distribution of economic activity, and the role that *internal* trade costs played in shaping such spatial dynamics. We then explore whether the subsequent decline in internal trade costs brought about by the large scale construction and upgrade of highways during 2000s, the Golden Quadrilateral (GQ) project, may have affected spatial development.

To analyze how internal geography interacts with international trade to affect regional growth, we group Indian districts into three regions, based on their distance from the nearest major port (air or sea): the primary region (districts within 200 kilometers of the nearest port), the secondary region (districts between 200 to 400 kilometers from the nearest port) and the interior region (districts located farther than 400 kilometers from the nearest port). At the outset, we note three key stylized facts on spatial development in India.

STYLIZED FACT 1: *During 1989-2009, organized manufacturing activity was highly concentrated in a few districts, mainly in the primary region.*

STYLIZED FACT 2: *Between 1994 and 2000, there was a strong reallocation of manufacturing activity away from the primary to the secondary region; however, this temporary dispersion in activity reversed post-2000.*

STYLIZED FACT 3: *The interior region lagged behind in all aspects of manufacturing activity irrespective of the time period.*

[1] Historically too, regional development could have been shaped by international commerce. Globally, the distribution of employment is skewed toward the coasts: according to the United Nations, over half of the global population lived within 200 kilometers of a coastline in 2001 (http://www.oceansatlas.org/subtopic/en/c/114/).

These patterns suggest that while a decline in *external* trade costs itself was associated with a redistribution of activity from primary to secondary regions, a decline in *internal* trade costs was correlated with greater concentration. To explain this pattern of territorial development in India, we develop a model featuring two countries, a home country and the rest of the world (ROW), where the former has multiple regions. In particular, the home country is characterized by a region designated as a port, the primary region, and all international trade must pass through this region.

Our model shows that the impact of a decline in external trade cost (of importing) on regional activity depends on the internal trade cost (distance from the port). A decline in import cost potentially raises competition for domestic manufacturers. Nonetheless, regions farther from the ports, the non-primary regions, remain protected by high internal trade costs. This could stimulate a reallocation of manufacturing activity from the primary region to non-primary regions. Similarly, a decline in internal trade costs has two opposing effects on the activity of the non-primary region: while it increases the demand for its products by other regions due to lower domestic cost of trade, it also reduces protection from imports, thereby depressing activity. The overall effect depends on the initial level of internal trade costs.

Using a difference-in-difference strategy on Indian organized manufacturing data, we find that the average growth rate of activity (output, employment and plant count) in the secondary region was higher relative to the primary region in the period immediately following the trade liberalization reforms that sharply reduced import tariffs. We also show that the relatively higher growth rate in the secondary region during this period was observed for industries experiencing larger tariff cuts. This result on spatial reallocation is consistent with our model that reallocation of activity away from primary regions is driven by high internal trade costs that insulates manufacturers in non-primary regions from trade competition.

The pattern of spatial reallocation reversed during the period 2000-09, coinciding with the timing of construction and upgrade of the "Golden Quadrilateral" (GQ) highways that may possibly have altered the internal trade costs.[2] Manufacturing activity in secondary and interior regions grew slower on average than their counterparts in the primary region during this period. Within the secondary region, however, those along the GQ highway network grew faster. Although lower internal trade costs reduce attractiveness by inducing higher competition in districts that fall along the network, it also enhances market access by providing opportunities for greater expansion. The net outcome is an interplay of these two opposing forces. The activity in the interior region, even with the districts connected on the GQ highways, remained

[2]The GQ highway project sought to improve connectivity between the four major metropolitan areas of India – Delhi, Mumbai, Kolkata and Chennai.

depressed, thereby implying that a decline in internal trade cost did not benefit the hinterlands. This suggests that complementary conditions, usually missing in remote areas, are needed to make a potentially viable place-based intervention work in practice (Grover et al., 2022).

Our work is related to two broad strands of literature on the impact of internal and external trade costs on the spatial distribution of activity within countries. These papers show that economic integration across international borders is associated with spatial re-organization of economic activity within national borders (Hanson, 1996; Fan et al., 2011; McCaig and Pavcnik, 2013; Coşar and Fajgelbaum, 2016; Fajgelbaum and Redding, 2021).[3] This paper examines the impact of a sharp decline in import tariff rates on reallocation of organized manufacturing across regions. Unlike most of the existing research, we do not find an increase in spatial concentration coinciding with globalization.

Most research on the impact of a decline in internal trade costs shows the average effect for the country, rather than separating the effects by types of regions (Banerjee et al., 2020). There are a few papers, however, that find that remote regions lose activity due to competition when connected with advanced regions (Faber, 2014; Baum-Snow et al., 2020; Lall and Lebrand, 2020). We examine the impact of a national highway improvement project on the distribution of activity within India. Our findings of a re-allocation of activity within the secondary region towards districts that are on the highway network is consistent with Faber (2014), while the result on the relative contraction in activity in the interior region districts, irrespective of the district location along the highways network, is aligned with the work of Baum-Snow et al. (2020) on China.

The theoretical literature studying the interaction of international trade and internal geography is rather sparse. Krugman and Elizondo (1996) and Behrens et al. (2006) develop models in the spirit of the new economic geography literature with two regions within a country. The model in our paper is closest in spirit to Coşar and Fajgelbaum (2016). Using a Ricardian framework, Coşar and Fajgelbaum examine the effect of external and internal trade costs on the spatial distribution of production within a country, where a continuum of regions in the country differ in terms of access to a port. A key feature of the above-mentioned models is that labor mobility *across regions* explains the re-allocation of manufacturing activity in response to a change in trade costs. Given the evidence of limited labor mobility across districts within

[3]In Mexico, the participation in global value chains (GVC) through the maquiladora program encouraged clustering around the US-Mexico border (Hanson, 1996). Evidence from China suggests that inland-coastal disparity increased with trade openness (Fan et al., 2011) and increased concentration of export-oriented and labor-intensive industries in primate locations (Coşar and Fajgelbaum, 2016). Manufacturing growth in the coastal areas of Vietnam during the 1990s coincided with international integration (McCaig and Pavcnik, 2013). In Argentina, rapid export-led economic development in the late-nineteenth century involved major changes in the distribution of economic activity across sectors and regions (Fajgelbaum and Redding, 2021).

India, we shut down this channel in our model (Munshi and Rosenzweig, 2016; Kone et al., 2018). Instead, internal and external trade costs shape economic activity in our model through movement of labor across sectors *within a region*.

The rest of the paper is organized as follows. In Section 2, we describe the data and present some stylized facts about the spatial distribution of organized manufacturing in India. Motivated by these facts, Section 3 develops a model of production and trade that combines both internal and external trade costs. In Sections 4 and 5, we provide evidence that is supportive of the model. Section 6 concludes.

2. Spatial Distribution of Organized Manufacturing in India: Stylized Facts

2.1 Data

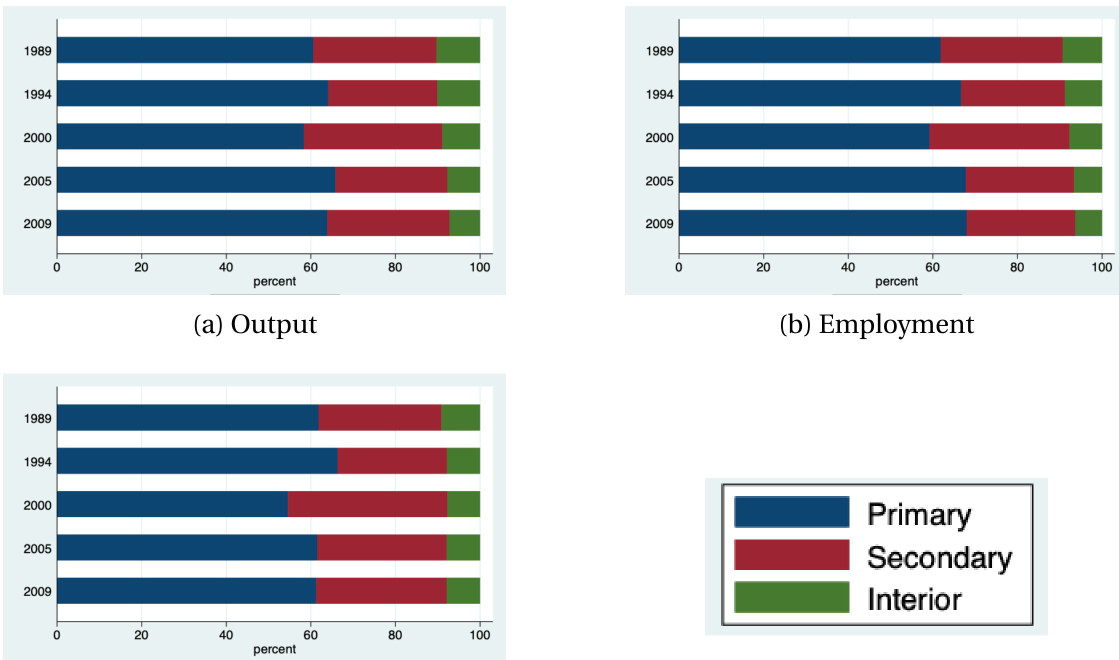
We use the same plant level information as much of the prior research on the Indian economy, including Duranton et al. (2015) and Ghani et al. (2016). Our main data source is the Annual Survey of Industries (ASI), the annual survey of organized sector manufacturing plants undertaken annually by the Central Statistical Organization, a department in the Ministry of Statistics and Program Implementation, Government of India. We use information on real output, employment and the number of plants for the following years: 1989, 1994, 2000, 2005 and 2009. These plant-level variables are aggregated to the level of a district (details in Appendix B). Following a routine data cleaning exercise, we have an unbalanced panel of an average of 344 districts per year.

We complement the manufacturing data from ASI with population data from the 1991 Census. This data is used to create district-level weights when running the regressions. External trade cost is measured using data on output tariff and effective rate of protection (ERP) from Topalova and Khandelwal (2011), while internal trade cost is measured as distance from the GQ highways.

2.2 Stylized Facts

We classify Indian districts into three regions based on their distance from the nearest seaports and airports: (a) *primary*, the group of districts located within 200 kilometers from ports; (b) *secondary*, the districts located between 200 and 400 kilometers from ports; and (c) *interior*, the group of districts located more than 400 kilometers from ports.[4] Using this geographical classification, we document three stylized facts on the spatial distribution of organized manufacturing activity during the period 1989-2009.

Stylized fact 1: *During 1989-2009, organized manufacturing activity was highly concentrated in a few districts, mainly in the primary region (Figure 1).*This pattern remains similar over the sample period. Given the persistence in the concentration of manufacturing activity, the foreseeable problem of "places left behind", that is, lagging regions, looms large for policymakers.



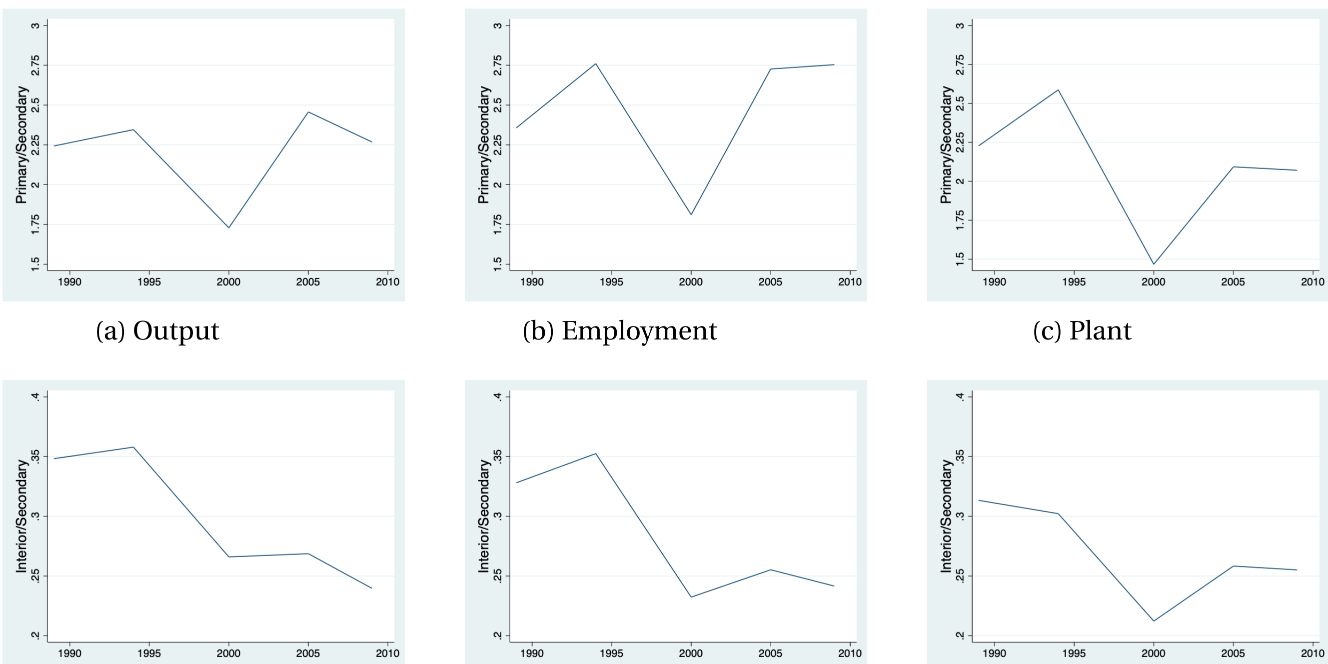
(a) Output (b) Employment (c) Plant

Figure 1: Distribution of output, employment and plant

The figure shows share of output, employment and number of plants across three different regions over the period 1989-2009.

[4]The seaports are Chennai, Cochin, Haldia, Goa, Kandla, Kolkata, Mumbai, New Mangalore, Nhava Sheva, Paradip, Tuticorin and Visakhapatnam. The airports are Bangalore, Calicut, Chennai, Cochin, Delhi, Goa, Hyderabad, Kolkata, Mumbai and Tiruvananthapuram. The seaports together accounted for 93 percent of the total volume of sea cargo during 1989-90 (Bose, 2001) while the airports accounted for almost 99 percent of air cargo during 1999-2000 (Airport Authority of India). There is large variation in the distance of districts from the nearest port, with the median district being located at more than 300 and 500 kilometers from the nearest airport and seaport respectively.

Stylized fact 2: *Between 1994 and 2000, there was a strong reallocation of manufacturing activity away from the primary to the secondary region; however, this temporary dispersion in activity reversed post-2000. (Figure 2 panels a-c).* Prior to the reforms (1989-94) manufacturing activity increased the most in the primary region, relative to both secondary and interior ones. In the period immediately following the reforms (1994-2000), however, this pattern changed. For example, relative to the primary region, the annualized output growth rate in the secondary region was 4.3 percentage points higher. Finally, in the period 2000-2009, the primary region regained dominance and the secondary region experienced much more modest growth, with a 6.2 percentage point difference in growth rates between the two regions.



(a) Output (b) Employment (c) Plant

(d) Output (e) Employment (f) Plant

Figure 2: Economic activity across regions over time

The plots show output, plants and employment in the primary and interior regions of India as a share of the corresponding variables in the secondary region.

Stylized fact 3: *Relative to the secondary region, the share of manufacturing activity in the interior region remains depressed, and is in fact falling (Figure 2 panels d-f).* Irrespective of the period, the interior continued to perform poorly. The share of manufacturing output declines monotonically as we move towards the interior region (and much faster than the decline in population). In 1989, the interior region accounted for more than 20 percent of the population but just 10 percent of output.

3. A spatial model of production

We now develop a spatial general equilibrium model that explains the observed stylized facts on the location and evolution of manufacturing activity.

3.1 Assumptions

The economy consists of $C+1$ regions, labeled $j = 0, ...C$. Labor is the only factor of production with location j being endowed with L_j units of labor. There are two sectors in the economy: manufacturing (M) and agriculture (A). Labor is mobile across sectors *within* a region, but not across regions.

Our assumption on labor mobility warrants some explanation. Models of economic geography typically assume labor to be mobile across locations within a country (Krugman, 1991). We deviate from this assumption because of the following reasons. First, labor mobility among those with lower skills is low in India, despite large differences in real wages across space (Munshi and Rosenzweig, 2016). They find that compared to countries at similar stages of development, a much smaller fraction of the less-skilled male workforce migrates in India.[5] In related work, Kone et al. (2018) find that movement of labor across Indian states is limited. Second, our model is not so much about trying to understand the equilibrium distribution of population across space, but rather, is about trying to examine how a given spatial distribution of economic activity is affected by changes in trade costs. We believe that labor mobility across space, while an important element, is not critical for this exercise.

Preference and Technology . Each worker in region j, who is also a consumer, has the following preference over the two goods:

$$u_j = \left(\frac{c_j^M}{\gamma}\right)^{\gamma} \left(\frac{c_j^A}{1-\gamma}\right)^{1-\gamma},$$

where $c_{M,j}$ and $c_{A,j}$ correspond to per-capita consumption of the manufactured and agricultural good respectively in region j, and $0 < \gamma < 1$ is the share of manufactured goods in the

[5]Strictly speaking, Munshi and Rosenzweig (2016) document that the rural-urban migration in India is low. But they also document very high rural-urban real wage gaps. This suggests that rural workers, who are typically low-skilled, do not move to arbitrage away real income differences.

consumer's total expenditure. γ is assumed to be uniform across regions.

The homogeneous agricultural good in region j is produced one-to-one from labor, $Y_j^A = L_j^A$, where L_j^A is the (endogenous) amount of labor employed in the agricultural sector of region j.[6] Let P_j^A be the price of the agricultural good. The manufactured good is a CES aggregate of multiple varieties. Denoting the number of varieties produced in j by H_j, the manufactured aggregate in j is given by:

$$Y_j^M = \Big[\sum_{i=0}^{C} H_i x_{ij}^{1-\frac{1}{\sigma}}\Big]^{\frac{\sigma}{\sigma-1}},$$

where x_{ij} is the amount of a variety produced in region i and used in j and $\sigma > 1$ is the elasticity of substitution.[7] The manufacturing price index is $P_j^M = \Big[\sum_{i=0}^{C} H_i p_{ij}^{1-\sigma}\Big]^{\frac{1}{1-\sigma}}$, where p_{ij} is the price of a variety that is produced in i but consumed in j. Each variety is produced using an increasing returns-to-scale technology with the labor used for producing each variety, l_j, being given by:

$$l_j = \alpha + \beta x_j, \tag{1}$$

where $x_j = \sum_k x_{jk}$. The above production function implies fixed and variable labor requirements of α and β respectively. The total amount of labor employed in the manufacturing sector is then given by $L_j^M = H_j \times l_j$.

Trade Costs . The agricultural good is freely traded across regions while the manufactured varieties face both internal and external trade costs. We impose the following geography on the regions: the C regions labeled $1, ..., C$ are regions within the Home country while region 0 corresponds to the rest of the world (ROW). Region 1 is the international gateway or port – all international trade between the home country and ROW has to pass through this region. To ensure that region i receives 1 unit of a manufactured variety, region j must ship $\exp\{\tau_{ij}\}$ units where τ_{ij} satisfies

$$\tau_{ij} = \tau_{ji} = t_n d_{ij}, \forall i, j \neq 0 \tag{2a}$$

$$\tau_{01} = t_x + a, \qquad \tau_{10} = a, \tag{2b}$$

$$\tau_{0j} = t_x + a + t_n d_{1j}, \qquad \tau_{j0} = a + t_n d_{1j}, \forall j \neq 1. \tag{2c}$$

[6]For simplicity, we assume uniform productivity across regions in this sector.
[7]Given the preference, the aggregate price index in region j is given by

$$P_j = (P_j^M)^{\gamma}(P_j^A)^{1-\gamma}.$$

with $\tau_{ii} = 0$. This formulation of trade costs incorporates a number of assumptions.[8] First, trade costs take the iceberg form, where a fraction of goods that are shipped from the origin "melts away" before reaching the destination. Second, trade costs are symmetric within the home country (Assumption a). This is a reasonable assumption, provided there are no region-specific trade barriers within the country. In particular, such an assumption is usually valid if internal trade costs are pure transportation costs.[9] We assume that this transportation cost has two components: d_{ij}, capturing the physical distance between regions i and j, and t_n, capturing the cost per unit of distance. The latter would depend on the quality of roads, the mode of transportation, internal geography, etc.[10] Third, for trade between ROW and the port, only the external trade cost applies (Assumption b). We note that the external trade cost could be a combination of policy and non-policy barriers. Accordingly, we separate this cost into two components: $a > 0$, which is the symmetric cost of moving goods from the port to the ROW, and t_x, an additional cost of importing goods faced by home country consumers. t_x could capture import tariffs imposed by the home government. Finally, for any domestic region other than the port that wants to import, both external as well as internal trade costs must be incurred (Assumption c). Thus, there is an inherent asymmetry between the port and the remaining regions at home. In the context of our model, a lowering of external and internal costs are captured by a lower t_x and t_n respectively.

3.2 Equilibrium

Free trade in the agricultural good implies that its price must be equalized across regions. Setting the agricultural good as the numéraire, $P_j^A = 1$. Furthermore, as long as the agricultural good is produced in every region, the nominal wage, which is pinned down by the price of this good, will be equal to one as well. Due to immobility of labor, the real wage will not equalize across regions, however.

In equilibrium, a constant fraction γ of consumer expenditure is spent on the manufactured good. Assuming balanced budget (aggregate income equals aggregate expenditure) at the regional level, region j's consumption of a manufactured variety produced in region i is then given by

$$x_{ij} = p_{ij}^{-\sigma}(P_j^M)^{\sigma-1}\gamma L_j, \tag{3}$$

[8] We also assume that $d_{ij} + d_{jk} \geq d_{ik}$.

[9] Although, in the presence of elevation, the cost of traveling between two points may not always be symmetric.

[10] Such costs could be significant in India as the effect of distance on trade costs is typically much higher in developing countries relative to their developed counterparts (Atkin and Donaldson, 2015). As shown by Van Leemput (2021), internal trade costs in India, on average, make up around 40 percent of total trade costs.

where L_j is the nominal income in region j. A firm in region i selling its product in region j chooses price p_{ij} so as to maximize profits. This yields the standard result whereby price as a constant mark-up over cost: $p_{ij} = \frac{\sigma}{\sigma-1}\beta\tau_{ij}$.

Free entry . There is free entry in the manufacturing sector. Firms enter region i until their total variable profits equals the fixed cost of production. This gives rise to the following free-entry condition for region i:

$$\frac{1}{\sigma}\sum_j p_{ij}x_{ij} = \alpha, \tag{4}$$

where we have used the result that under CES preferences, revenue is σ times profit.

Zero aggregate profit . At the aggregate, all profits of manufacturing firms are paid out to workers. The zero aggregate profit condition for region i is

$$H_i\sum_j p_{ij}x_{ij} = L_i^M. \tag{5}$$

The term on the left-hand side is the total revenue of all manufacturing firms in region i while the right-hand side term is total wage income of workers employed in the manufacturing firms.

Labor market-clearing . The total demand for labor must equal total supply. Using $L_i^M = H_il_i$ and replacing l_i using equation (1), the labor market-clearing condition for region i is

$$H_i(\alpha + \beta x_i) + L_i^A = L_i. \tag{6}$$

Combining (4) and (5), we have

$$H_i = \frac{L_i^M}{\sigma\alpha}. \tag{7}$$

The measure of varieties in region i is proportional to the amount of labor employed in the manufacturing sector. Replacing x_{ij} and p_{ij} in (4), we have

$$\sum_j \tau_{ij}^{1-\sigma}(P_j^M)^{\sigma-1}L_j = \kappa\alpha\beta^{\sigma-1}/\gamma, \tag{8}$$

where $\kappa = \sigma^\sigma(\sigma-1)^{1-\sigma}$. Using P_j^M, p_{ij} and (7), we also have

$$(P_j^M)^{\sigma-1} = \kappa\alpha\beta^{\sigma-1}\Big(\sum_k L_k^M\tau_{kj}^{1-\sigma}\Big)^{-1}. \tag{9}$$

Finally, replacing P_j from (9) in (8), we get

$$\sum_j \tau_{ij}^{1-\sigma} L_j \Big(\sum_k L_k^M \tau_{kj}^{1-\sigma} \Big)^{-1} = 1/\gamma. \tag{10}$$

(10) is a set of $C+1$ equations in $C+1$ unknowns, the L_i^Ms. The amount of labor employed in the manufacturing sector in each region is a function of the entire matrix of trade costs as well as the total labor endowments in each region. This is a key insight of general equilibrium spatial models: a change in the trade cost between two regions could affect trade and production in a third region by changing the latter region's relative attractiveness for firms. This effect is captured by the aggregate manufacturing price index P_j^M. Appendix A discusses how to compute welfare in this model. Next, we conduct comparative static exercises with respect to two key model parameters.

3.3 Comparative statics

Our main interest lies in two parameters: t_x, the cost of importing goods and t_n, the internal transportation cost. The non-linearity of (10) implies that obtaining the response of equilibrium objects to changes in trade costs analytically is not possible except in special cases. Accordingly, we resort to numerical simulation for our next set of results.

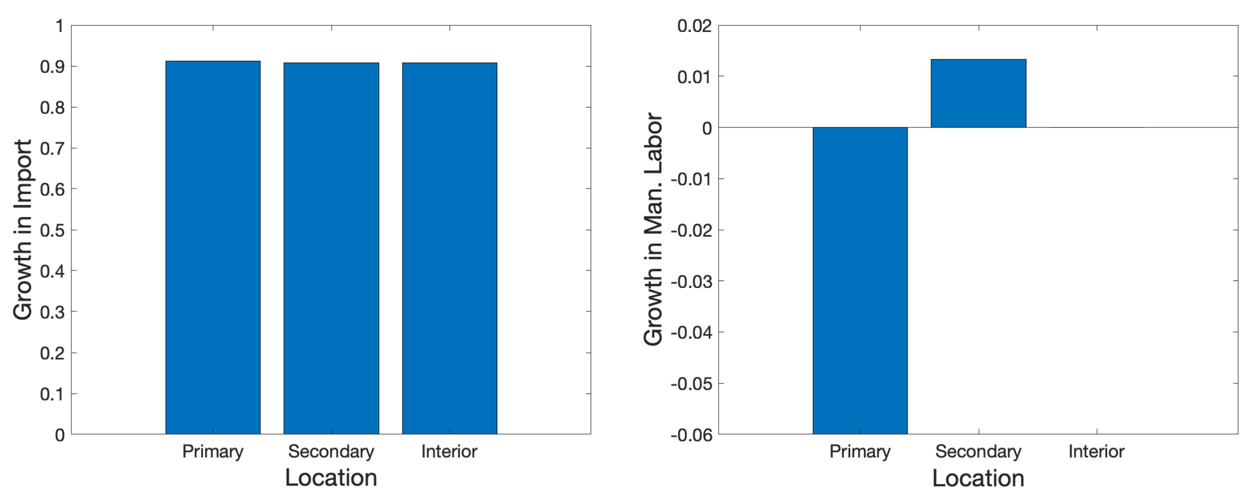


Figure 3: Reduction in external trade cost

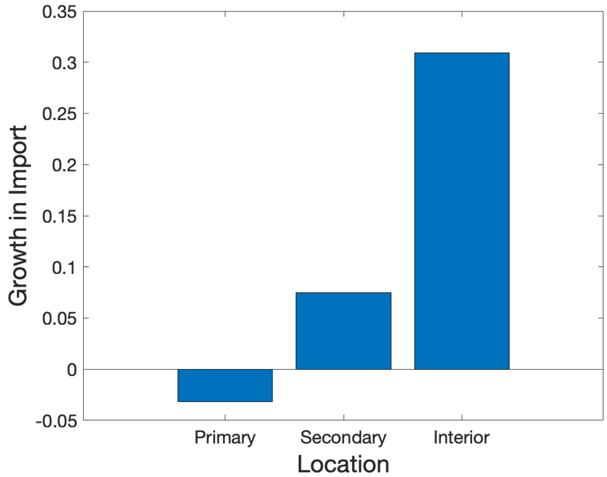
To relate our results to the empirical findings in the paper, we simulate a model with four regions, including ROW. To facilitate comparison with the empirical section, we label the three home regions as primary (region 1, closest to the ROW), secondary (region 2) and interior (region 3, farthest from the ROW). We choose labor allocation across the regions in such a way that the two countries, home and ROW, have the same amount of labor. In the first exercise, we reduce the external trade cost, t_x, holding everything else constant. The results are shown in Figure 3.

A decline in t_x, the cost of import, causes imports to rise in every home region. A sufficient statistic for both manufacturing output and the number of firms is labor employed in the manufacturing sector. Consequently, we focus on how manufacturing employment changes in response to a shock. The effect of a lower t_x on employment is not uniform. While it falls in the primary region, manufacturing employment actually rises in the secondary region. Finally, there is no discernible effect in the interior region.

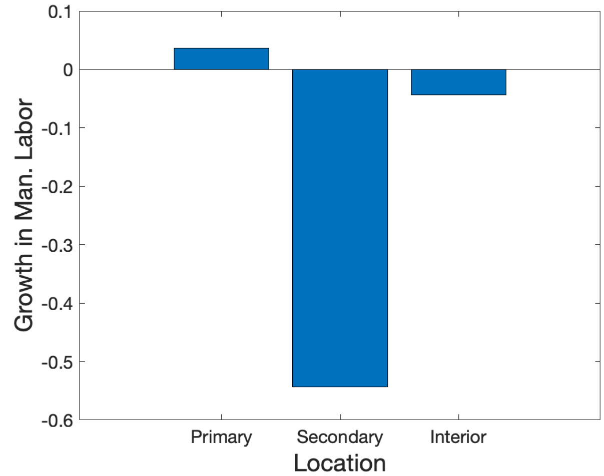
Why does manufacturing employment change so differently despite import growth being very similar across the three regions? This is because the share of imports in the three regions' consumption bundles for manufactured goods is different, with this share being significant for the primary region and decreasing monotonically as we move away from the ROW. Consequently, a growth of imports by, say, 10 percent, has a much bigger effect on competition (captured by the aggregate price index) in the primary region compared to the secondary or interior regions. This causes firms to exit and manufacturing employment to decline in the primary region. At the same time, while imports increase, the lower number of firms in the primary region leads to lower competition in the secondary region, resulting in firm entry and higher employment.

In the second exercise, we reduce the internal trade cost, t_n, holding everything else constant. Parts a and b of Figure 4 shows the results when the trade cost is lowered marginally starting from an initial high level. Now the effect on imports is significantly different across regions. A decline in internal trade cost brings the secondary and interior regions closer to the ROW while the primary region is unaffected. This results in an increase in import in both the secondary and interior regions, while import in the primary region actually declines.[11] The primary region experiences a growth in manufacturing employment while the other two regions experience a decline. The magnitude of this decline is, however, not the same in the secondary and interior regions. As discussed earlier, the share of imports in the interior region's total consumption of manufactured goods is quite small. Accordingly, the decline in internal trade costs continues to have a small effect on manufacturing employment in this region. This is not true of

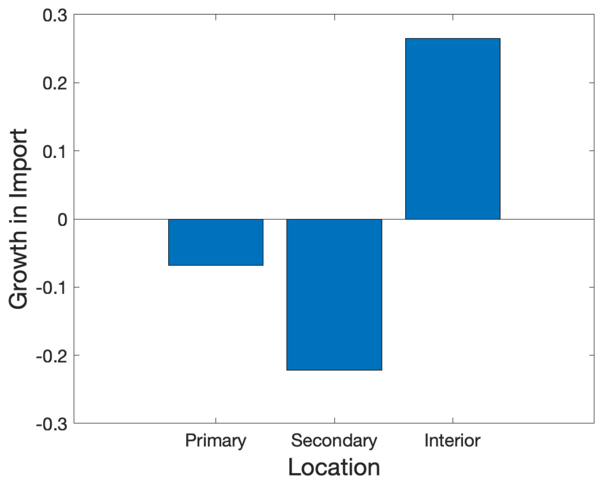
[11] This is the third market effect. As the potential market of ROW expands due to lower costs of trading with the secondary and interior regions, trade with the primary region falls.



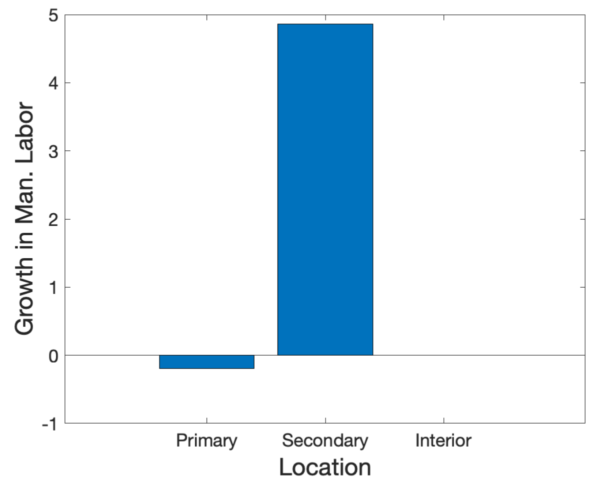
(a) Imports (high initial t_n)



(b) Labour (high initial t_n)



(c) Imports (low initial t_n)



(d) Labour (low initial t_n)

Figure 4: Reduction in internal trade cost

the secondary region where the percentage fall in manufacturing employment is much higher.

The results are different when the decline in internal trade cost happens from a low initial level. This is shown in parts c and d of Figure 4. In this case, imports decline while manufacturing employment rises significantly in the secondary region. Interestingly, as in the previous case, the effect on the interior region is negligible. Thus, unlike the secondary region, lower internal trade cost fails to spur manufacturing activity in the interior region.

3.4 Discussion

The model of production and trade presented above generates the following predictions: (a) Following a lowering of import costs, there will be a reallocation of manufacturing activity away from locations close to international ports. (b) As internal trade costs are lowered starting from a high level, some manufacturing activity will shift back to locations close to the same ports.

One of the findings in Section 2 indicated that over the period 1994-2000, there was a shift in manufacturing activity, as captured by real output, employment and number of plants, away from the primary to the secondary region. This trend, however, was reversed in the following decade. What could have caused these shifts? Interestingly enough, the Indian economy witnessed two significant economic events during this time. The first was the trade reform that was instituted post-1991, along with a host of other reforms meant to make the Indian economy more "pro-market". The second was an ambitious highway improvement exercise that began in 2001, with the objective of improving connectivity between the four largest cities of the country: Delhi, Mumbai, Kolkata and Chennai.

In the next section, we examine whether a part of the movement of economic activity away from ports during 1994-2000 can be explained by a decline in external trade costs due to tariff liberalization. In the following section, we examine whether a part of the reverse movement during 2000-2009 can be explained by lower internal trade costs caused by the high improvement project.

4. Evidence on Decline in External Trade Costs

Prior to 1991, India's trade regime was highly protectionist, with no clear rules governing licensing, import tariffs and quotas (Panagariya, 2004).[12] The high cost of engaging in trade during this period reduced the country to a virtual autarky. Quantitative restrictions, for instance, were associated with high import tariffs such that the unweighted average tariff in 1991 was more than 110 percent. Following a balance-of-payments crisis, the government implemented comprehensive reforms in 1991 across sectors, including liberalization of both foreign trade and foreign direct investment. Although import licensing was abandoned with the reforms, import

[12] Import licensing was characterized by a number of restrictions on import specification, the ability to transfer ownership (licenses were confined primarily to end-users) and "indigenous availability" which warranted that if a product was available domestically in sufficient quantity, it could not be imported. (Bhagwati et al., 1975).

tariffs did not decline until 1993.[13] The unweighted mean tariff declined from 80 percent in 1993 to around 30 percent by 1997. While tariffs continued to drop even after 1997, the decline was much more gradual.[14] Decline in tariffs was followed by growth in import of goods and services by an average 9.2 percent during 1990-2000 compared to 5.9 percent during the previous decade (Panagariya, 2004).

4.1 Specification

In this section, we investigate the impact of import liberalization on spatial reallocation of manufacturing activity. To this end, we adopt a difference-in-difference methodology and compare the growth in manufacturing activity in districts located in the secondary and interior regions with those in the primary region. To establish causality, we carry out the comparison for 1994-2000, the period during which import was substantially liberalized, and the periods before (1989-94) and after (2000-09) the episode.[15] The following is our baseline empirical specification:

$$\Delta y_{irt} = \alpha_r + \alpha_t + \beta_{rt}(\alpha_r \times \alpha_t) + \epsilon_{irt}, \tag{11}$$

where Δy_{it} is the log change in manufacturing activity y (output, employment, plant count) in district i located in region r and period t; α_r are the dummies for the three regions (primary, secondary and interior); α_t is a full set of period dummies (1989-94, 1994-2000 and 2000-09); and ϵ_{irt} is an error term that is orthogonal to the explanatory variables. To allow for serial correlation of the error term within a district over time without imposing too much structure on the form of this correlation, we cluster ϵ_{irt} at the district level.[16] Because the specification in (11) includes a constant, the reference category is the primary region during the period 1989-94. The region dummies then control for systematic, time-invariant differences in growth rates between the primary and the other two regions during 1989-94. The period dummies, on the other hand, control for common, time-variant shocks to all the districts relative to 1989-94.[17] In the benchmark case, we use a balanced panel of 310 districts, with 120, 100 and 65 districts in the primary, secondary and interior regions respectively.

[13] Tariffs declined between 1991 and 1992 but then went back to 1991 levels in the following year. This happened because of a worsening balance-of-payments position during 1992-93, causing the government to restrict imports in order to preserve foreign exchange.

[14] The fact that median tariffs display a similar pattern suggests that this decline was not caused by just a few industries.

[15] For brevity, we combine the periods 2000-05 and 2005-09 but report results for the two periods separately in the Appendix.

[16] Because we are analyzing data that is spatial in nature, one concern is that economic activity might be correlated across nearby districts (Conley, 1999). When we allow spatial correlation by clustering standard errors at the state level, the results obtained are similar.

[17] Notice that the time-invariant district fixed effects get differenced out because we consider growth rates.

The coefficient of interest is β_{rt} which represents the impact in a given region and period, relative to the reference category. For instance, a positive and statistically significant value of $\beta_{Secondary,1994-00}$ implies that on average, the *change* in the growth rate of manufacturing activity in the secondary region between 1994-00 and 1989-94 was higher relative to the corresponding change in the primary region over the same period. [18]

4.2 Results

The results for our baseline specification are presented in Table 1. Column (1) shows the results for output, while column (2) repeats the same with state-period fixed effects to control for different underlying state-level attributes, including legislation and policies of Indian states during this period. The next four columns repeat this specification for employment and plant count. Our results suggest that: *One*, the three regions did not have very different growth rates in the pre-liberalization period, i.e., 1989-94.[19] *Two*, the positive and significant coefficient on the interaction between the period 1994-2000 and the secondary region suggests that the secondary region grew faster than the primary region during 1994-2000. Over a six year period, the average cumulative growth rate in the secondary region's output was 59 percentage points higher than that in the primary region, while the corresponding increase in employment and plant count is 62 and 72 percent respectively. *Three*, output and employment in the interior region did not grow any faster than the primary region in the period immediately after the trade liberalization. Therefore, as far as output and employment is concerned, there was reallocation away from both primary as well as interior regions towards the secondary region during 1994-2000. *Four*, in the following period i.e., 2000-09, however, we see a reallocation of output and employment back to the primary regions at the expense of the secondary region, with the statistical significance of the result being contingent on the inclusion of state-period fixed effects. While the sign on the coefficients suggests that there was a corresponding reallocation of plants as well, the results are not statistically significant.[20]

The above noted patterns in Indian manufacturing hold for a wide range of aggregate outcomes. In Table 4 in Appendix D, we consider value-added, buildings, materials, land and total labor cost.[21] For each of these measures of manufacturing activity, there was reallocation away

[18]This specification already accounts for pre-trends; in the event the two regions grew at the same rate during 1989-94, a positive coefficient would suggest that during 1994-00, the secondary region grew faster than the primary region in absolute terms

[19]This is given by the coefficients on the secondary and interior regions.

[20]These results are robust to regression specification run separately for the periods 2000-05 and 2005-09 (See Table 6 in Appendix D).

[21]Materials measure the total value of raw materials, components, chemicals and packing materials used by a plant in the production process. Total labor cost includes wages and salaries, other benefits to employees, such as

Table 1: Port access and economic activity

	ΔOutput		ΔEmployment		ΔPlant	
	(1)	(2)	(3)	(4)	(5)	(6)
Secondary	-0.10	-0.01	-0.19	-0.10	-0.21	-0.13
	(0.24)	(0.23)	(0.19)	(0.20)	(0.18)	(0.18)
Interior	-0.00	-0.07	-0.13	-0.08	-0.34*	-0.36
	(0.31)	(0.46)	(0.22)	(0.37)	(0.18)	(0.30)
1994-00 × Secondary	0.59*	0.63*	0.62**	0.60**	0.72***	0.74**
	(0.33)	(0.37)	(0.26)	(0.30)	(0.26)	(0.31)
1994-00 × Interior	0.01	0.37	0.10	0.20	0.50*	0.67
	(0.39)	(0.62)	(0.29)	(0.47)	(0.26)	(0.45)
2000-09 × Secondary	-0.43	-0.72**	-0.25	-0.52*	-0.17	-0.40
	(0.30)	(0.31)	(0.27)	(0.29)	(0.24)	(0.24)
2000-09 × Interior	-0.67*	-0.83	-0.38	-0.58	0.11	-0.01
	(0.40)	(0.54)	(0.32)	(0.46)	(0.27)	(0.42)
State-period FE	No	Yes	No	Yes	No	Yes
Observations	930	930	930	930	930	930
R^2	0.05	0.08	0.06	0.09	0.06	0.08

The dependent variable is cumulative growth rate of output, employment and plants at the district level, weighted by district-level population in 1991. The omitted category is the primary region during the period 1989-94. *, ** and *** correspond to significance level at 10, 5 and 1 percent respectively. Standard errors are clustered at the district-level.

from the primary towards the secondary region, during the period immediately following trade liberalization during 1994-2000, but these patterns reversed in the following period 2000-09, when manufacturing activity reallocated back to districts in the primary region at the expense of those in the secondary region.

The result that following trade liberalization manufacturing activity dispersed away from primary to secondary regions is in sharp contrast to the prevailing literature which finds a relative increase in activity, following a decline in external trade costs, in the regions connected with international markets (Hanson, 1996; Fan et al., 2011; McCaig and Pavcnik, 2013; Coşar

bonuses, contributions to social security and welfare funds.

and Fajgelbaum, 2016; Fajgelbaum and Redding, 2021). What explains the difference in the results for India? Our model in Section 3 argues that while decline in import tariffs trigger competition and tend to reduce activity in all regions, secondary and interior regions have the ability to shelter firms from this competition if domestic trade costs are high. In the case of India, the results presented in Table 1 seem to support the hypothesis that the latter effect dominates in secondary regions.

There are possibly concerns in making this argument convincingly because it does not rule out the possibility that the districts in the secondary region had grown relatively faster than those in the primary region during 1994-2000 because of some other developments in the economy. The inclusion of state-period fixed effects reduces such possibilities, but does not rule them out completely.

To address this concern, we exploit variation in tariff cuts across industries during the trade liberalization episode. Each of the 59 three-digit industries for which we have information show a decline in tariffs ranging from roughly 30 percent to as much as 80 percent. These tariff cuts, especially until 1997, were uncorrelated with industry characteristics and hence, can be taken to be exogenous (Topalova and Khandelwal, 2011).[22] If the reallocation away from primary regions during 1994-2000 were caused by increased import competition, then we should expect the effects to be stronger for industries that experienced larger import tariff cuts during this period.

Our findings in table 2, where we separate the effects for industries with above and below the tariff changes, attests to this hypothesis. Manufacturing activity increased in the secondary regions during the 1994-2000 period only for industries exposed to large tariff cuts. Such differences in relative growth between the two groups of industries is not present in earlier or later periods, providing further support that the observed reallocation was caused by higher import competition. These findings are also robust to using effective rates of protection (ERP) of industries (see Table 5 in Appendix D), that measure the net effect of changes in tariffs after accounting for declines in tariffs for intermediate inputs as well.[23] Enhanced ability of industries

[22] Topalova and Khandelwal (2011) show that tariff changes between 1987 and 1997 were uncorrelated with a number of industry-level characteristics that could proxy for the strength of political economy forces such as total employment, average wage, degree of concentration, etc.

[23] Given the possibility that industries could have simultaneously been exposed to changes in both final product and input tariff cuts, ERP of an industry m is defined following (Corden, 1966; Topalova and Khandelwal, 2011):

$$ERP_m = \frac{\text{output tariff}_m - \text{input tariff}_m}{1 - \sum_n \gamma_{mn}},$$

where γ_{mn} is the share of input n in the total sales of output m, and the input tariff for industry m is defined as

$$\text{input tariff}_m = \sum_n \gamma_{mn} \times \text{output tariff}_m.$$

Table 2: Port access, output tariffs and economic activity

	ΔOutput		ΔEmployment		ΔPlant	
Change in Tariff	Large	Small	Large	Small	Large	Small
	(1)	(2)	(3)	(4)	(5)	(6)
Secondary	-0.15	-0.04	-0.23	-0.08	-0.23	-0.16
	(0.30)	(0.28)	(0.25)	(0.22)	(0.20)	(0.18)
Interior	-0.31	0.19	-0.24	-0.01	-0.35	-0.22
	(0.55)	(0.47)	(0.40)	(0.41)	(0.34)	(0.30)
1994-00 × Secondary	0.99*	0.39	0.88**	0.38	0.89**	0.59**
	(0.51)	(0.40)	(0.41)	(0.32)	(0.40)	(0.29)
1994-00 × Interior	0.55	-0.04	0.55	0.01	0.91	0.48
	(0.81)	(0.64)	(0.64)	(0.52)	(0.57)	(0.42)
2000-09 × Secondary	-0.46	-0.57	-0.25	-0.43	-0.29	-0.26
	(0.39)	(0.38)	(0.32)	(0.33)	(0.30)	(0.25)
2000-09 × Interior	-0.27	-1.04*	-0.35	-0.49	-0.24	-0.02
	(0.66)	(0.59)	(0.47)	(0.53)	(0.46)	(0.42)
Observations	864	897	864	897	864	897
R^2	0.08	0.06	0.09	0.07	0.07	0.09

The dependent variable is cumulative growth rate of output, employment and plants at the district level, weighted by district-level population in 1991. Industries are grouped into Large (larger than median rate of change in final product tariff between 1993 and 1997) and Small. *, ** and *** correspond to significance level at 10, 5 and 1 percent respectively. All regressions include state-period fixed effects. Standard errors are clustered at the district-level.

to access cheaper imported inputs through the primary region had minimal effect in moving industries towards the primary region connected with international gateways.

Although we exploit variation across regions within the same group of industries, it is possible that these industries are not spread uniformly across space. Thus, even though tariff cuts did not have a spatial dimension, the fact that industries may have locational attributes (e.g. for historical or geographical reasons industries may be agglomerated or co-located) means that tariff cuts may have worked through the spatial dimension as well. For instance, it is possible that industries that grew faster after trade liberalization were disproportionately located in the secondary region. In that case, the observed differences in regional growth rates could simply be driven by difference in growth rates across industries and would be uncorrelated with increased import competition. On the contrary, we find that there is no correlation between the post-liberalization growth in three-digit industries (1994-2000) and their pre-liberalization share of output in the secondary region (Figure 5 in Appendix C). Given the pre-reform trends in spatial concentration of activity in primary regions, we are less concerned about the spatial element that may be contributing to the endogeneity of reforms and rely on Topalova and Khandelwal (2011) who have convincingly argued that tariff cuts in India during 1989-2000 were rather exogenous.

To check for the sensitivity of our results, we repeat the specification in (11) with alternative samples, region classification and methodology for clustering standard errors. Our results remain robust to using unweighted regressions and a sample with unbalanced panel of districts (Tables 7 and 8 in Appendix D); alternative distance thresholds for defining regions (Tables 9 and 10 in Appendix D); classification of industries based on the absolute changes in the import tariffs rather than the rate of change of the import tariffs between 1993 and 1997 (Table 11 in Appendix D). In all cases, our main result on the reallocation of manufacturing activity away from the primary towards the secondary region in the period immediately following trade reforms and a reversal in the following period continue to hold across various robustness checks. We believe that this may be driven by the larger internal trade cost across districts in India that we examine next.

5. Evidence on Decline in Internal Trade Costs

India went through massive highway upgrades starting from the 2000s.Conceived in 1999, the Golden Quadrilateral (GQ) highway upgrades began in 2001, and was 95 percent complete by the end of 2006. The GQ network connects four major cities of Delhi, Mumbai, Chennai, and Kolkata (the nodal districts) and is the fifth-longest highway in the world. Several studies, such as Ghani et al. (2016), have subsequently documented the importance of the GQ upgrades for the development of Indian manufacturing along the highway system; none, however, has examined how the decline in internal trade costs – brought about by GQ upgrades– affects regions with differential access to ports.

5.1 Specification

The model in Section 3 predicts that as internal trade costs fall, economic activity may shift towards port locations. A decline in domestic trade cost reduces protection from trade competition that non-primary regions provide to domestic industries, thereby making them relatively less attractive. This hypothesis is borne out in the Indian data at the aggregate level during 2000-09 (Stylized Fact 2) and in the evidence provided in Table 1, which shows a relative decline in output, employment and plant count in the Secondary region during 2000-09. Unlike in the model, however, internal trade costs did not fall uniformly but rather for a subset of districts across all the regions that got connected along the GQ network. This can lead to re-allocation *within* each region as districts that experience a lower internal trade cost due to two opposing forces: while districts along the highway network are not protected from import competition,they benefit from increased market access due to better connectivity. The overall outcome on reallocation within (and across) regions depends on the net of the two effects.

We define districts "on GQ" as those that are within the 10 kilometer range of the highway network.[24] Given that a large part of GQ passes along the coast, it is not surprising that 38 of 68 "on GQ" districts are in the primary region. Following the empirical specification in the previous section, we additionally introduce a third dummy variable, GQ status, and include the full set of double interaction terms and the triple interaction terms of the form Period $\times$ Region $\times$ GQ status. As before, we allow the coefficients to be region, period and GQ-status specific. Specifically, we run the following regression:

$$\begin{aligned}\Delta y_{irgt} = \alpha_r + \alpha_t + \alpha_g + \beta_{rt}(\alpha_r \times \alpha_t) + \beta_{gt}(\alpha_g \times \alpha_t) + \beta_{gr}(\alpha_g \times \alpha_r) \\ + \beta_{rgt}(\alpha_r \times \alpha_g \times \alpha_t) + \epsilon_{irgt},\end{aligned} \tag{12}$$

where α_g is a dummy variable that takes a value of one if the district is on GQ.

5.2 Results

Our estimations in Table 3 suggests that following key points: *First*, prior to GQ upgrades, economic activity in secondary region did not vary by their location on a potential highway network. Said differently, there were no pre-trends in economic activity within the secondary region. While output, employment and plant count in off-GQ districts of the secondary region grew faster than their counterparts in the primary region pre-GQ upgrades (coefficient on *1994-00*$\times$*Secondary*), these growth rates were the same when measured relative to those on GQ (coefficient on *1994-00*$\times$*Secondary* $\times$ *On GQ* is not significantly different from zero).

Second, while activity in the secondary region declined relative to the primary region after GQ upgrades, the effect was heterogeneous across districts based on their location along the

[24] Table 12 in Appendix D shows the distribution of districts across regions and GQ status that results from this classification.

highway network. In the period following the GQ upgrade (2000-09), the off-GQ districts in the secondary region, on average, experienced a decline in manufacturing activity relative to their counterparts in the primary region, while those on the GQ network grew. For example, the coefficient of -1.05 on the interaction term *2000-09*×*Secondary* under column 2 suggests that after 2000, employment in off-GQ districts in the secondary region grew slower relative to their counterparts in the primary region. The growth of the "on GQ" districts in secondary regions is evident in the sum of the coefficients for the triple and double interaction terms for employment $((-1.05 + 1.34 = 0.29)$. As hypothesized above, this suggests that during 2000-09, there was a reallocation *within* the secondary region, such that economic activity moved towards districts along the GQ network. The positive effect on districts along the network in secondary regions suggests that the expansion in market access may have played a dominant role.

Third, irrespective of the location along the GQ network, manufacturing activity in the interior region declined during 2000-09 relative to the primary region in 1994-2000. These results are indicative of the fact that the GQ did not spur economic activity in the interior region in the same way that it did in the primary or secondary region. Although transport connectivity brings overall welfare gains, our results highlight the distributional consequences whereby remote regions in a country lose at the expense of border or coastal regions, as has also been in the case of China (Baum-Snow et al., 2017).

As with any infrastructure development project, the GQ highways are also subject to endogeneity concerns in the placement of highways. Specifically, the simultaneous upgrades of the GQ highways and the reallocation of manufacturing activity from the secondary to the primary region merely suggests an association and not causality. Several existing studies that have dealt with these concerns. While Datta (2012) relies on a differences-in-differences approach, where changes in relevant outcomes for firms affected by GQ are compared to changes in outcomes for other firms, Ghani et al. (2016) and Khanna (2016) use the straight-line instrumental variables (IV) to address endogeneity. To ascertain causality, this strategy exploits the design of the GQ upgrades that primarily connected the nodal districts in a straight line pattern, consistent with cost-minimization.[25] Following the approach in Khanna (2016) and Ghani et al. (2016) we find that IV specifications generally confirm the OLS findings and in most cases, the null hypothesis that the OLS and IV results are the same cannot be rejected (Table 13 in Appendix D).

We also exploit the staggered timing of GQ upgrades to ascertain causation on realloca-

[25] Nodal districts include Delhi, Mumbai, Kolkata and Chennai and their contiguous suburbs (Gurgaon, Faridabad and Ghaziabad for Delhi; Thane for Mumbai).

Table 3: Port access, highways and economic activity

	Δ Output	Δ Employment	Δ Plant
	(1)	(2)	(3)
Secondary	0.07 (0.33)	0.08 (0.27)	0.07 (0.23)
Interior	-0.10 (0.50)	0.03 (0.40)	-0.29 (0.32)
1994-00 × Secondary	0.75 (0.49)	0.72^{*} (0.40)	0.67^{*} (0.40)
1994-00 × Interior	0.68 (0.67)	0.34 (0.52)	0.65 (0.49)
2000-09 × Secondary	-1.06^{**} (0.41)	-1.05^{***} (0.37)	-0.80^{**} (0.34)
2000-09 × Interior	-1.19^{*} (0.61)	-1.06^{**} (0.49)	-0.27 (0.49)
On GQ	0.15 (0.28)	0.22 (0.25)	0.31 (0.23)
1994-00 × On GQ	0.07 (0.44)	0.21 (0.36)	-0.14 (0.36)
2000-09 × On GQ	-0.42 (0.35)	-0.64^{*} (0.34)	-0.50^{*} (0.30)
Secondary × On GQ	-0.17 (0.57)	-0.46 (0.50)	-0.47 (0.38)
Interior × On GQ	0.36 (0.95)	-0.20 (0.73)	0.06 (0.48)
1994-00 × Secondary × On GQ	-0.33 (0.75)	-0.29 (0.67)	0.13 (0.56)
1994-00 × Interior × On GQ	-1.36 (1.11)	-0.41 (0.89)	-0.05 (0.67)
2000-09 × Secondary × On GQ	0.85 (0.70)	1.34^{**} (0.62)	1.01^{**} (0.50)
2000-09 × Interior × On GQ	1.12 (1.05)	1.38 (0.91)	0.47 (0.69)

The dependent variable is cumulative growth rate of output, employment and plants at the district level. "On GQ" is an indicator variable that takes a value of 1 if a district lies within 10 km of GQ. The omitted category is the primary region not on GQ during 1989-94. *, ** and *** correspond to significance level at 10, 5 and 1 percent respectively. Nodal districts are included. All regressions include state-period fixed effects. Standard errors are clustered at the district-level.

tion within secondary region. Grouping "On GQ" districts into two categories: those that were "treated" early (before March 2003) and those that were treated later (Ghani et al., 2016), we confirm that the GQ caused a spatial reorganization of manufacturing within the secondary region (See Table 14 in Appendix D).[26]

6. Conclusion

In this paper, we explore how the interaction of external and internal trade costs affects the distribution of manufacturing activity across regions within India by examining the effect of two policy interventions during the period 1989-2009. These include the trade liberalization episode of the early 1990s and the construction and upgrade of the large scale Golden Quadrilateral (GQ) highway program during the 2000s. Using data from the organized manufacturing sector, we establish three key findings. *First*, trade reforms in India helped disperse economic activity to secondary regions, but for the wrong reasons – incompetent manufacturers moved to these regions seeking protection from import competition. *Second*, massive infrastructure investments in transport costs were successful in spreading manufacturing activity. Overall there was reallocation toward the primary region and only districts along the network benefited within the secondary region. *Third*, economic activity in the interior region remained depressed and is in fact falling, irrespective of changes in external or internal trade costs. Our economic geography model of trade and production supports these results.

Reduction in transport costs may create spatial winners and losers. Reducing economic distance in the secondary regions and hinterland may possibly also lead to a decline in local activity. For remote locations, improved connectivity implies better access to markets, but also removes protection from outside competition for local producers. As our work suggests, activity in remote regions remains depressed even when connected by the GQ highways. Improvements in transport connectivity are often not enough to support economic development in less attractive locations. Complementary conditions such as the quality of local amenities, connectivity with ports and the strength of comparative advantage in the export sector are key factors in determining the gains across regions. Domestic policies that support spatial mobility of labor and investment in such complementary factors can mediate potential trade-offs between spatial efficiency and equity within countries, and allow for faster development.

[26]For this exercise, we only looked at the period 2000-05 because 95 percent of the GQ already been completed by 2006. Because none of the districts that were treated early belonged to the interior region, we cannot do a similar analysis for this region.

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Appendix

A. Model: Additional Results

Welfare

Let us use X_{-0j} to denote the total purchase of manufactured varieties by region j from all regions other than 0. $\lambda_{-0j} = X_{-0j}/\gamma L_j$ is then the share of manufactured goods that region j buys from all internal regions. Observe that

$$X_{-0j} = \sum_{i \neq 0} H_i x_{ij}.$$

Using (3) and (5), we have

$$X_{-0j} = \Delta (P_j^M)^{\sigma-1} \gamma L_j \sum_i L_i^M \tau_{ij}^{1-\sigma},$$

where Δ is a constant. Welfare in region j, which is captured by the real wage, is then given by

$$\frac{1}{(P_j^M)^\gamma} = \Big(\frac{\Delta}{\lambda_{-0j}} \sum_i L_i^M \tau_{ij}^{1-\sigma} \Big)^{\frac{\gamma}{\sigma-1}},$$

where $\lambda_{-0j} = X_{-0j}/\gamma L_j$ is the share of manufactured goods that region j buys from all *internal* regions. The average real wage in the home country, W, is then

$$W = \sum_{j \neq 0} \frac{L_j}{L} \frac{1}{P_j} = \sum_{j \neq 0} \frac{L_j}{L} \Big(\frac{\Delta}{\lambda_{-0j}} \sum_i L_i^M \tau_{ij}^{1-\sigma} \Big)^{\frac{\gamma}{\sigma-1}}.$$

Under autarky, the average real wage is

$$\bar{W} = \sum_{j \neq 0} \frac{L_j}{L} \Big(\Delta \sum_i \bar{L}_i^M \tau_{ij}^{1-\sigma} \Big)^{\frac{\gamma}{\sigma-1}},$$

where $\bar{L}_i^M$ is the manufacturing employment in region i under autarky. This allows us to write the gains from trade in the home country, $W/\bar{W}$, as

$$\frac{W}{\bar{W}} = \sum_{j \neq 0} \omega_j \Big(\frac{1}{\lambda_{-0j}} \Big)^{\frac{\gamma}{\sigma-1}} \Phi_j,$$

where

$$\omega_j = \frac{L_j \Big(\sum_i \bar{L}_i^M \tau_{ij}^{1-\sigma} \Big)^{\frac{\gamma}{\sigma-1}}}{\sum_j L_j \Big(\sum_i \bar{L}_i^M \tau_{ij}^{1-\sigma} \Big)^{\frac{\gamma}{\sigma-1}}}, \qquad \Phi_j = \left(\frac{\sum_i L_i^M \tau_{ij}^{1-\sigma}}{\sum_i \bar{L}_i^M \tau_{ij}^{1-\sigma}} \right)^{\frac{\gamma}{\sigma-1}}.$$

Suppose the home country has only one region. Denoting this region by 1 and assuming that $\gamma = 1$, the gains from trade reduce to

$$\frac{W}{\bar{W}} = \Big(\frac{1}{\lambda_{11}} \Big)^{\frac{1}{\sigma-1}}.$$

This is the familiar expression for gains from trade that is obtained in a wide class of models (Arkolakis et al., 2012). Once we introduce multiple regions with internal trade costs and multiple sectors ($\gamma < 1$), the expression changes.

B. Data: Sources and cleaning

Annual Survey of Industries (ASI)

Under the Indian Factory Act of 1948, all establishments without power and employing more than 20 workers or those with power and employing more than 10 workers are required to be registered with the Chief Inspector of Factories in each state. This register is used as the sampling frame for the ASI. The ASI extends to the entire country, except the states of Arunachal Pradesh, Mizoram and Sikkim and the Union Territory (UT) of Lakshadweep. The ASI provides statistical information to assess changes in the growth, composition, and structure of the organized manufacturing sector, comprising activities related to manufacturing processes, repair services, gas and water supply, and cold storage. Following data cleaning in prior research, certain states such as the seven North-Eastern states and the erstwhile state of Jammu and Kashmir are also excluded from the analysis. At the same time, districts whose total plant count was less than 50 were dropped.

Creating consistent districts

One challenge with using district identifiers is that the set of districts evolved quite significantly over the period of study (1989-2009). Accordingly, we create consistent district boundaries for the entire period. Our source of GIS data for district-boundaries is DataMeet (datameet.org).

The number of districts in India increased from 466 in the 1991 Census to 640 in the 2011 Census. Given that the total area of the country did not change, the new districts were carved out of existing districts. Over this period, new districts were created in two different ways. To understand the different types of re-districting that happened, we introduce some terms: if district 1 has been formed using some area belonging to district 2, then district 2 is the "parent" while district 1 is the "child" (Kumar and Somanathan, 2009).

The first type of re-districting occurs when an existing district is split into two or more districts. Using the terminologies introduced above, this would be multiple children having a single parent. For example, Bijapur district in the state of Karnataka was split into Bagalkot and Bijapur in 1997. We deal with this type of re-districting by simply merging the newly formed districts, Bagalkot and Bijapur after 1997, to create the pre-1997 Bijapur district. Accordingly, variables such as output, employment, etc. of the two child districts are aggregated and assigned to the parent district.

The second type occurs when a new district(s) is carved out of multiple old districts. This would be a single child having multiple parents. For example, Moga district in the state of Punjab was formed from parts of Faridkot and Firozpur in 1995. This type of re-districting is much harder to deal with because, apart from needing the map of the re-drawn districts, we also need the ASI data at a more dis-aggregate level, something that we do not have. In this situation, we combine Faridkot and Firozpur before 1995 to create an artificial district which then becomes the single parent of the newly drawn districts of Faridkot, Firozpur and Moga after 1995. We then apply the same methodology as above.

C. Descriptive: Additional charts

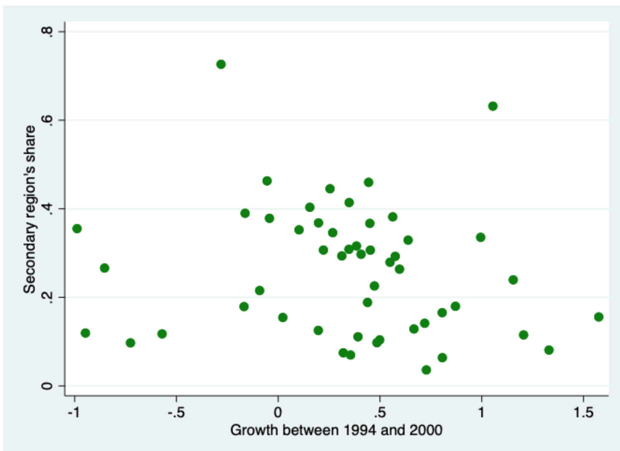

Figure 5: Spatial distribution of industries

The figure shows the relation between an industry's growth rate over the period 1994-00 and its share of output produced in the secondary region in 1994.
Source: Annual Survey of Industries and author's calculation

D. Empirics: Additional tables

Table 4: Port access and economic activity

	ΔVA	ΔMaterials	ΔBuilding	ΔLand	ΔLab. Cost
	(1)	(2)	(3)	(4)	(5)
Secondary	0.02	-0.04	-0.18	0.13	-0.16
	(0.28)	(0.23)	(0.24)	(0.34)	(0.26)
Interior	-0.08	-0.17	-0.22	0.03	0.06
	(0.50)	(0.48)	(0.46)	(0.58)	(0.47)
1994-00 × Secondary	0.62	0.66*	0.90**	0.61	0.79**
	(0.45)	(0.35)	(0.42)	(0.57)	(0.40)
1994-00 × Interior	0.34	0.50	0.83	0.45	0.01
	(0.67)	(0.63)	(0.69)	(0.89)	(0.64)
2000-09 × Secondary	-0.78**	-0.68**	-0.67**	-0.82*	-0.58*
	(0.35)	(0.31)	(0.34)	(0.43)	(0.34)
2000-09 × Interior	-0.67	-0.77	-0.95	-0.71	-0.71
	(0.59)	(0.56)	(0.58)	(0.75)	(0.55)
Observations	930	930	927	909	929
R^2	0.09	0.07	0.09	0.06	0.06

The dependent variable is cumulative growth rate of value-added, materials, buildings, land and labor cost at the district level, weighted by district-level population in 1991. The omitted category is the primary region during the period 1989-94. *, ** and *** correspond to significance level at 10, 5 and 1 percent respectively. Standard errors are clustered at the district-level.

Table 5: Port access, effective rate of protection and economic activity

	ΔOutput		ΔEmployment		ΔPlant	
Change in ERP	Large	Small	Large	Small	Large	Small
	(1)	(2)	(3)	(4)	(5)	(6)
Secondary	-0.32	-0.08	-0.28	-0.10	-0.18	-0.18
	(0.27)	(0.31)	(0.23)	(0.23)	(0.19)	(0.19)
Interior	-0.18	0.09	-0.08	-0.04	-0.25	-0.28
	(0.50)	(0.46)	(0.38)	(0.38)	(0.32)	(0.29)
1994-00 × Secondary	1.26**	0.31	1.04**	0.36	0.87**	0.63**
	(0.50)	(0.48)	(0.40)	(0.35)	(0.40)	(0.30)
1994-00 × Interior	0.55	-0.03	0.46	0.08	0.85	0.55
	(0.78)	(0.69)	(0.61)	(0.51)	(0.55)	(0.41)
2000-09 × Secondary	-0.34	-0.45	-0.29	-0.42	-0.38	-0.28
	(0.38)	(0.38)	(0.31)	(0.32)	(0.28)	(0.26)
2000-09 × Interior	-0.47	-0.76	-0.59	-0.45	-0.35	0.01
	(0.64)	(0.57)	(0.46)	(0.51)	(0.43)	(0.42)
Observations	879	892	879	892	879	892
R^2	0.09	0.06	0.11	0.07	0.08	0.09

The dependent variable is cumulative growth rate of output, employment and plants at the district level, weighted by district-level population in 1991. The omitted category is the primary region in the period 1989-94. Industries are grouped into Large (larger than median change in effective rate of protection between 1993 and 1997) and Small. *, ** and *** correspond to significance level at 10, 5 and 1 percent respectively. All regressions include state-period fixed effects. Standard errors are clustered at the district-level.

Table 6: Port access and economic activity (Split 2000-09)

	ΔOutput		ΔEmployment		ΔPlant	
	(1)	(2)	(3)	(4)	(5)	(6)
Secondary	-0.10	-0.01	-0.19	-0.10	-0.21	-0.13
	(0.24)	(0.23)	(0.19)	(0.20)	(0.18)	(0.18)
Interior	-0.00	-0.07	-0.13	-0.08	-0.34*	-0.36
	(0.31)	(0.46)	(0.22)	(0.37)	(0.18)	(0.30)
1994-00 × Secondary	0.59*	0.63*	0.62**	0.60**	0.72***	0.74**
	(0.33)	(0.37)	(0.26)	(0.30)	(0.26)	(0.31)
1994-00 × Interior	0.01	0.37	0.10	0.20	0.50*	0.67
	(0.40)	(0.62)	(0.29)	(0.47)	(0.26)	(0.45)
2000-05 × Secondary	-0.47*	-0.66**	-0.21	-0.43	-0.15	-0.32
	(0.27)	(0.30)	(0.24)	(0.28)	(0.22)	(0.24)
2000-05 × Interior	-0.52	-0.57	-0.17	-0.39	0.21	0.17
	(0.37)	(0.52)	(0.28)	(0.43)	(0.26)	(0.42)
2005-09 × Secondary	0.13	-0.05	0.14	0.00	0.18	0.06
	(0.26)	(0.26)	(0.23)	(0.21)	(0.20)	(0.19)
2005-09 × Interior	-0.15	-0.20	-0.08	-0.11	0.23	0.18
	(0.36)	(0.50)	(0.27)	(0.40)	(0.20)	(0.32)
State-period FE	No	Yes	No	Yes	No	Yes
Observations	1240	1240	1240	1240	1240	1240
R^2	0.03	0.06	0.06	0.08	0.06	0.08

The dependent variable is cumulative growth rate of output, employment and plants at the district level, weighted by district-level population in 1991. The omitted category is the primary region during the period 1989-94. *, ** and *** correspond to significance level at 10, 5 and 1 percent respectively. Standard errors are clustered at the district-level.

Table 7: Port access and economic activity (Unweighted observations)

	ΔOutput		ΔEmployment		ΔPlant	
	(1)	(2)	(3)	(4)	(5)	(6)
Secondary	-0.13	-0.06	-0.14	-0.06	-0.09	-0.02
	(0.23)	(0.24)	(0.20)	(0.21)	(0.17)	(0.18)
Interior	0.13	0.17	0.03	0.17	-0.13	-0.07
	(0.28)	(0.46)	(0.20)	(0.36)	(0.16)	(0.28)
1994-00 × Secondary	0.71**	0.88**	0.58**	0.65**	0.56**	0.65**
	(0.35)	(0.39)	(0.28)	(0.31)	(0.23)	(0.30)
1994-00 × Interior	-0.21	0.04	-0.09	-0.06	0.27	0.32
	(0.36)	(0.64)	(0.27)	(0.49)	(0.23)	(0.44)
2000-09 × Secondary	-0.32	-0.73**	-0.28	-0.58**	-0.25	-0.53**
	(0.28)	(0.31)	(0.25)	(0.28)	(0.23)	(0.25)
2000-09 × Interior	-0.70*	-0.93*	-0.54**	-0.76*	-0.12	-0.25
	(0.37)	(0.53)	(0.27)	(0.44)	(0.23)	(0.37)
Observations	930	930	930	930	930	930
R^2	0.03	0.07	0.04	0.08	0.03	0.07

The dependent variable is cumulative growth rate of output, employment and plants at the district level, weighted by district-level population in 1991. The omitted category is the primary region during the period 1989-94. *, ** and *** correspond to significance level at 10, 5 and 1 percent respectively. Standard errors are clustered at the district-level.

Table 8: Port access and economic activity (Unbalanced panel)

	ΔOutput		ΔEmployment		ΔPlant	
	(1)	(2)	(3)	(4)	(5)	(6)
Secondary	-0.17	-0.04	-0.22	-0.10	-0.24	-0.13
	(0.23)	(0.22)	(0.19)	(0.19)	(0.17)	(0.17)
Interior	-0.05	0.05	-0.17	-0.03	-0.28	-0.20
	(0.27)	(0.40)	(0.20)	(0.32)	(0.17)	(0.27)
1994-00 × Secondary	0.69**	0.69*	0.67***	0.61**	0.76***	0.75**
	(0.33)	(0.36)	(0.26)	(0.29)	(0.25)	(0.30)
1994-00 × Interior	0.09	0.21	0.15	0.15	0.43*	0.49
	(0.36)	(0.57)	(0.27)	(0.43)	(0.26)	(0.43)
2000-09 × Secondary	-0.40	-0.66**	-0.25	-0.53*	-0.15	-0.38
	(0.28)	(0.30)	(0.26)	(0.28)	(0.23)	(0.24)
2000-09 × Interior	-0.70*	-0.92*	-0.42	-0.65	-0.02	-0.21
	(0.36)	(0.47)	(0.29)	(0.41)	(0.25)	(0.37)
State-period FE	No	Yes	No	Yes	No	Yes
Observations	1018	1018	1018	1018	1018	1018
R^2	0.04	0.06	0.06	0.08	0.06	0.08

The dependent variable is cumulative growth rate of output, employment and plants at the district level, weighted by district-level population in 1991. The omitted category is the primary region during the period 1989-94. *, ** and *** correspond to significance level at 10, 5 and 1 percent respectively. Standard errors are clustered at the district-level.

Table 9: Port access and economic activity (Alternative classification of regions)

	ΔOutput		ΔEmployment		ΔPlant	
	(1)	(2)	(3)	(4)	(5)	(6)
Secondary	-0.02	0.03	-0.14	-0.07	-0.27	-0.22
	(0.23)	(0.23)	(0.19)	(0.20)	(0.18)	(0.18)
Interior	-0.14	-0.31	-0.28	-0.33	-0.44^{**}	-0.51^{*}
	(0.29)	(0.43)	(0.22)	(0.35)	(0.18)	(0.30)
1994-00 × Secondary	0.54	0.55	0.55^{**}	0.53^{*}	0.77^{***}	0.79^{**}
	(0.33)	(0.35)	(0.26)	(0.29)	(0.28)	(0.31)
1994-00 × Interior	0.24	0.66	0.37	0.57	0.72^{**}	0.93^{**}
	(0.40)	(0.58)	(0.29)	(0.44)	(0.28)	(0.45)
2000-09 × Secondary	-0.64^{**}	-0.83^{***}	-0.34	-0.54^{*}	-0.16	-0.32
	(0.31)	(0.31)	(0.30)	(0.30)	(0.25)	(0.26)
2000-09 × Interior	-0.64	-0.70	-0.33	-0.46	0.08	-0.03
	(0.39)	(0.52)	(0.33)	(0.45)	(0.27)	(0.41)
State-period FE	No	Yes	No	Yes	No	Yes
Observations	930	930	930	930	930	930
R^2	0.05	0.08	0.07	0.09	0.07	0.09

The dependent variable is cumulative growth rate of output, employment and plants at the district level, weighted by district-level population in 1991. Primary, secondary and interior regions correspond to districts within 150 km, between 150 and 350 km, and more than 350 km from nearest ports respectively. The omitted category is the primary region during the period 1989-94. *, ** and *** correspond to significance level at 10, 5 and 1 percent respectively. Standard errors are clustered at the district-level.

Table 10: Port access and economic activity (Alternative classification of regions)

	ΔOutput		ΔEmployment		ΔPlant	
	(1)	(2)	(3)	(4)	(5)	(6)
Secondary	-0.13	-0.10	-0.11	-0.06	-0.17	-0.18
	(0.26)	(0.29)	(0.20)	(0.24)	(0.17)	(0.24)
Interior	0.08	-0.00	-0.12	-0.08	-0.36*	-0.41
	(0.36)	(0.53)	(0.25)	(0.41)	(0.19)	(0.36)
1994-00 × Secondary	0.64*	0.81*	0.55**	0.62*	0.68***	0.76**
	(0.36)	(0.42)	(0.27)	(0.33)	(0.25)	(0.35)
1994-00 × Interior	-0.26	0.11	-0.04	0.12	0.30	0.43
	(0.44)	(0.71)	(0.33)	(0.55)	(0.28)	(0.51)
2000-09 × Secondary	-0.39	-0.68*	-0.37	-0.62*	-0.27	-0.42
	(0.31)	(0.37)	(0.25)	(0.33)	(0.22)	(0.31)
2000-09 × Interior	-0.81*	-0.98	-0.40	-0.58	0.27	0.24
	(0.47)	(0.64)	(0.35)	(0.53)	(0.31)	(0.52)
State-period FE	No	Yes	No	Yes	No	Yes
Observations	930	930	930	930	930	930
R^2	0.05	0.08	0.06	0.09	0.06	0.09

The dependent variable is cumulative growth rate of output, employment and plants at the district level, weighted by district-level population in 1991. Primary, secondary and interior regions correspond to districts within 250 km, between 250 and 450 km, and more than 450 km from nearest ports respectively. The omitted category is the primary region during the period 1989-94. *, ** and *** correspond to significance level at 10, 5 and 1 percent respectively. Standard errors are clustered at the district-level.

Table 11: Port access, tariff cuts and economic activity (Alternative industry classification)

	ΔOutput		ΔEmployment		ΔPlant	
Change in Tariff	Large	Small	Large	Small	Large	Small
	(1)	(2)	(3)	(4)	(5)	(6)
Secondary	-0.16	-0.08	-0.30	-0.03	-0.19	-0.18
	(0.31)	(0.25)	(0.25)	(0.21)	(0.21)	(0.17)
Interior	0.06	-0.26	-0.04	-0.24	-0.31	-0.30
	(0.61)	(0.38)	(0.47)	(0.31)	(0.34)	(0.27)
1994-00 × Secondary	1.01*	0.71*	1.00**	0.47	0.86**	0.71**
	(0.51)	(0.37)	(0.40)	(0.31)	(0.37)	(0.29)
1994-00 × Interior	0.72	0.54	0.59	0.30	0.77	0.59
	(0.84)	(0.57)	(0.64)	(0.44)	(0.52)	(0.42)
2000-09 × Secondary	-0.61	-0.77**	-0.32	-0.65**	-0.30	-0.37
	(0.47)	(0.32)	(0.36)	(0.30)	(0.30)	(0.25)
2000-09 × Interior	-1.18	-0.37	-0.57	-0.20	0.00	-0.10
	(0.84)	(0.52)	(0.59)	(0.47)	(0.42)	(0.43)
Observations	877	892	877	892	877	892
R^2	0.07	0.08	0.08	0.09	0.07	0.09

The dependent variable is cumulative growth rate of output, employment and plants at the district level, weighted by district-level population in 1991. The omitted category is the primary region in the period 1989-94. Industries are grouped into Large (larger than median absolute change in output tariff between 1993 and 1997) and Small. *, ** and *** correspond to significance level at 10, 5 and 1 percent respectively. All regressions include state-period fixed effects. Standard errors are clustered at the district-level.

Table 12: Districts by region and GQ status

	Off GQ	On GQ	Total
Primary	82	38	120
Secondary	80	20	100
Interior	55	10	65
Total	217	68	285

Districts in the balanced panel. The district count includes the nodal districts. If we exclude the nodal districts (Delhi, Mumbai, Kolkata, Chennai, Gurgaon, Faridabad, Ghaziabad and Thane), the number of primary districts on the GQ drop to 30. All the other figures remain unchanged.

Table 13: Port access, highways and economic activity (Straight-line IV)

	Δ Output	Δ Employment	Δ Plant
	(1)	(2)	(3)
Secondary	0.18	0.14	0.22
	(0.28)	(0.23)	(0.20)
Interior	0.07	0.16	-0.20
	(0.48)	(0.37)	(0.30)
1994-00 × Secondary	0.38	0.43	0.28
	(0.43)	(0.35)	(0.33)
1994-00 × Interior	0.29	0.09	0.45
	(0.63)	(0.48)	(0.44)
2000-09 × Secondary	-0.78**	-0.89***	-0.74**
	(0.38)	(0.34)	(0.30)
2000-09 × Interior	-1.07*	-1.09**	-0.27
	(0.59)	(0.46)	(0.46)
1994-00 × Secondary × On GQ	0.51	0.48	1.34**
	(0.75)	(0.67)	(0.62)
1994-00 × Interior × On GQ	-0.30	0.27	0.29
	(1.08)	(0.84)	(0.65)
2000-09 × Secondary × On GQ	-0.07	0.77	0.87*
	(0.70)	(0.63)	(0.51)
2000-09 × Interior × On GQ	0.80	1.58*	0.54
	(0.94)	(0.82)	(0.66)
Observations	930	930	930
R^2	0.08	0.10	0.10

The dependent variable is cumulative growth rate of output, employment and plants at the district level, weighted by district-level population in 1991. The omitted category is the primary region not on GQ in the period 1989-94. "On GQ" is an indicator variable that takes a value of 1 if a district lies within 10 km of GQ. For brevity, we do not report coefficients for double interaction terms of the form Period × GQ indicator and Region × GQ indicator. *, ** and *** correspond to significance level at 10, 5 and 1 percent respectively. All regressions include state-period fixed effects. Standard errors are clustered at the district-level.

Table 14: Port access, highways and economic activity (staggered building)

	Δ Output	Δ Employment	Δ Plant
	(1)	(2)	(3)
1994-00 × Secondary × Early GQ	-0.65	-0.41	-0.11
	(0.94)	(0.81)	(0.66)
1994-00 × Secondary × Late GQ	-0.19	-0.13	0.37
	(1.10)	(0.92)	(0.72)
1994-00 × Interior × Late GQ	-1.73	-0.91	-0.17
	(1.07)	(0.88)	(0.73)
2000-05 × Secondary × Early GQ	1.01	1.49*	1.15*
	(0.86)	(0.80)	(0.64)
2000-05 × Secondary × Late GQ	-0.23	0.71	0.63
	(0.80)	(0.68)	(0.51)
2000-05 × Interior × Late GQ	-0.19	0.27	0.31
	(1.10)	(0.90)	(0.72)
Observations	930	930	930
R^2	0.08	0.10	0.10

The dependent variable is cumulative growth rate of output, employment and plants at the district level, weighted by district-level population in 1991. The omitted category is the primary region not on GQ in the period 1989-94. "On GQ" is an indicator variable that takes a value of 1 if a district lies within 10 km of GQ. For brevity, we only report coefficients on the triple iteraction terms. *, ** and *** correspond to significance level at 10, 5 and 1 percent respectively. All regressions include state-period fixed effects. Standard errors are clustered at the district-level.