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Highways and Spatial Development

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This Economic Premise examines the link between highways and spatial development. The Golden Quadrilateral (GQ) highway project in India—5,846 km of highways linking four major urban hubs—improved the connectivity and market accessibility of districts close to the highway compared to those more removed. Non-nodal districts located within 0–10 km from the highway experienced substantial increases in entry of new enterprises. The highways facilitated a more natural sorting of industries that are land and building intensive, improved efficiency in the manufacturing industries, and encouraged decentralization of urban transformation by making intermediate cities more attractive. Understanding these patterns is important for policy makers, because well-targeted infrastructure projects can improve resource reallocation, accelerate spatial development, and also promote shared prosperity.

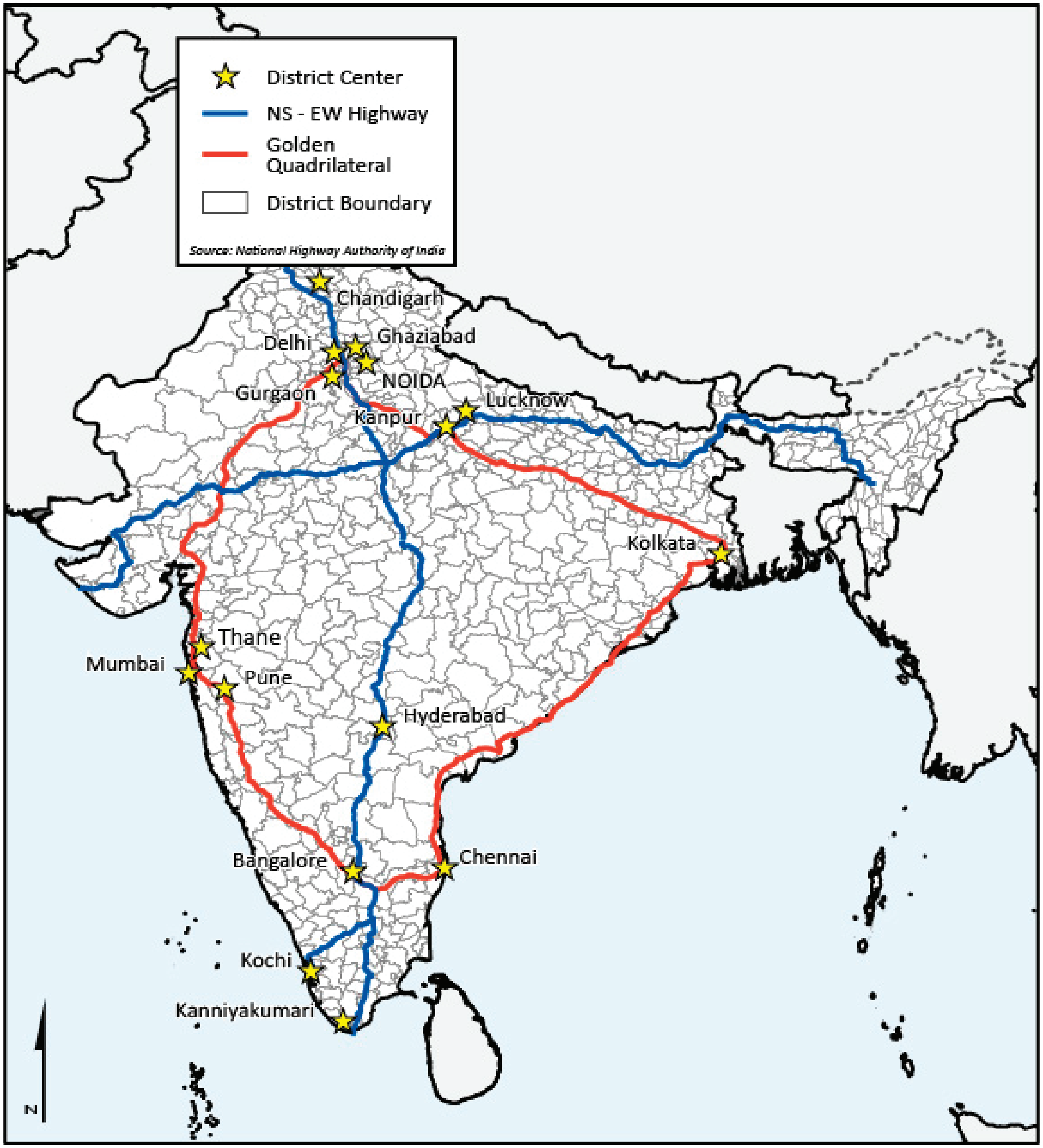
Adequate transportation infrastructure is an essential ingredient for economic development and growth. Beyond simply facilitating cheaper and more efficient movement of goods, people and ideas across places, transportation infrastructure impacts the distribution of economic activity and development across regions to the extent that agglomeration economies and efficient sorting can be realized, the levels of competition among industries and concomitant reallocation of inputs toward productive enterprises are achieved, and much more. Rapidly expanding countries like India and China often face severe constraints in terms of their transportation infrastructure. Many business leaders, policy makers, and academics report inadequate infrastructure as a critical obstacle to sustained growth that must be resolved with public funding—but to date, there is limited understanding of the economic impact of those infrastructure projects.

This note summarizes the main findings of the study conducted by Ghani, Goswami, and Kerr (2013) on the impact of the GQ project on organized manufacturing in India. The GQ project sought to improve the connection of four major cities in India: Delhi, Mumbai, Chennai, and Kolkata. The GQ system comprises 5,846 km (3,633 miles) of roads connecting many of the major industrial, agricultural, and cultural centers of India. Figure 1 maps the GQ network.

Ghani, Goswami, and Kerr (2013) studied how proximity to the GQ network in non-nodal districts affected the organization of formal manufacturing activity using establishment counts, employment, and output levels, especially among newly entering plants that chose their locations before or after the upgrades. This work on the organization of the manufacturing sector also considers industry-level sorting and the extent to which intermediate cities in India are becoming more attractive to manufacturing plants. The study examines the impact on the sector's performance through measures of average labor productivity as well as through total factor productivity (TFP).

Many researchers have shown that transport investments play an important role in spatial development, city competitiveness, and urbanization. Henderson (2010) finds that industrial decentralization in the Republic of Korea is attributable to massive transport and communications infrastructure investments. Baum-Snow et al. (2012) show that transport infrastructure aided the decentralization of industrial produc-

Figure 1. Map of GQ and NS-EW



tion and population in Chinese cities. Several other studies find positive economic effects in non-nodal locations due to transportation infrastructure in China (for example, Banerjee et al. [2012] and Roberts et al. [2012]), while Datta (2011) finds similar results for India. Duranton and Turner (2012) show that transportation investments increase city population in the United States. Desmet et al. (2012) have argued that manufacturing in India is slowly moving away from high-density districts to districts that are less congested, allowing industrial activity to spread more equally across space.

The Ghani, Goswami, and Kerr (2013) study provides important contributions to the literature. First, and perhaps most important, this study is the first to bring plant-level data to the analysis of highway projects. This is not feasible in the most-studied case of the United States, because the major highway projects mostly predate the United States' detailed census data. As a consequence, state-of-the-art work like Chandra and Thompson (2000) and Michaels (2008) use aggregate data and broad sectors. The later timing of the Indian reforms allows utilization of detailed plant data, providing more insight on many dimensions such as entry behavior and distributions of activity. An example of the resulting benefit is the improvement in allocative efficiency for industries initially positioned along the GQ network after the reforms. Second, existing work mostly identifies how the existence of transportation networks impacts activity, but Ghani, Goswami, and Kerr go a step deeper and also discuss the likely impacts from investments improving existing networks. The returns to this latter type of investment are very large and growing.

Data and Methodological Framework

The GQ project began in 2001, was two-thirds complete by 2005, and mostly finished in 2007. The study analyzed repeated cross-sectional surveys of organized manufacturing establishments carried out by the government of India at those points in time. Ghani, Goswami, and Kerr (2013) studied the organized sector surveys that were conducted in 1994–95 and covered several surveys from 1999–2000 to 2009–10. This coverage shows the performance of Indian manufacturing before the GQ upgrades began in 2001 as well as during and after the GQ upgrades. The work on the GQ was officially complete in 2005 (at the 90 percent mark) and 97 percent complete by 2007.

The core sample examines plant-level data from 311 districts. The key focus is on non-nodal districts very close to the GQ network and on comparing them to districts that were farther away. The study specifically compares non-nodal districts 0–10 km from the GQ network to districts 10–50 km away (and in some specifications, with additional concentric rings to 200 km away). Additional sources of variation come from the sequence in which districts were upgraded, differences in industry traits within the manufacturing sector, and differences in the traits of non-nodal districts 0–10 km from the GQ network.

Impacts of Highway Upgrades

Long-differenced estimations compare district activity in 2000, the year prior to the start of the GQ upgrades, with district activity in 2007 and 2009 (average across the years). About 95 percent of the GQ upgrades were completed by the end of 2006. The analysis uses two years after the conclusion of most of the GQ upgrades, rather than just the final data point of 2009, to be conservative. Most outcome variables are expressed in logs, with the exception of TFP, which is expressed in unit standard deviations. Estimations report robust standard errors, weight observations by log total district population in 2001, and have 311 observations representing the included districts.

Panel A of table 1 reports the base results. All estimations include the initial level of activity in the district for the appropriate outcome variable as a control to flexibly capture issues related to economic convergence across districts.[1] The columns of table 1 list dependent variables: columns 1–3 present measures of total activity in each district; columns 4–6 present measures of new entry specifically; columns 7 and 8 present the average productivity measures; and columns 9 and 10 present wage and labor cost metrics. The first row in the base results of panel A shows increases in nodal district activity for all metrics. The higher standard errors of these estimates, compared to the rows beneath them, reflect the fact that there are only nine nodal districts. These results are not emphasized, given that the upgrades were built around the connectivity of the nodal cities.[2]

The primary emphasis is on the highlighted row, which considers districts that are 0–10 km from the GQ network, but are not nodal districts. Columns 1–3 find increases in the aggregate activity of these districts. The coefficient on output is particularly strong and suggests a 0.4 log point increase in output levels for districts within 10 km of the GQ network in 2007–9 compared to 2000, relative to districts more than 50 km away from the GQ system. The estimates for establishment counts and output in districts 0–10 km from the GQ network exceed the employment responses. These employment effects fall short of being statistically significant at a 10 percent level, and this is not due to small sample size, as there are 76 districts within this range. Generally, the response around the GQ changes favored output over employment.

Columns 4–6 examine the entry margin by quantifying levels of young establishments and their activity. The study finds much sharper entry effects than the aggregate effects in columns 1–3, and these entry results are very precisely measured. The districts within 0–10 km of the GQ have a 0.8–1.1 log point increase in entry activity after the GQ upgrade compared to districts more than 50 km away. Columns 7 and 8 report results for the average labor productivity and TFP in the districts 0–10 km from the GQ network. These average values are weighted and thus primarily driven by the incumbent establishments of the districts. In general, analysis shows an increase in labor productivity for the district as a whole that is also evident in a comparison of columns 2 and 3. On the other hand, no TFP-level growth is apparent. Columns 9 and 10 show an increase in wages and average labor costs per employee in these districts.

For comparison, the third row of panel A provides the interactions for the districts that are 10–50 km from the GQ network. None of the effects on the allocation of economic activity that were seen in columns 1–6 for the 0–10 km districts are observed at this spatial band. This isolated spatial impact provides a first assurance that these effects can be

Table 1. Long-Differenced Estimations of the Impact of GQ Improvements, 2007–9 versus 2000

	Log levels of total activity			Log levels of young firm activity						
	Plants (1)	Employment (2)	Output (3)	Plants (4)	Employment (5)	Output (6)	Log labor productivity (7)	Total factor productivity (8)	Log average wage (9)	Log cost per employee (10)
DV: Change in manufacturing trait listed in column header Base spatial horizon measuring effects relative to districts 50+ km from the GQ network										
(0,1) Nodal district	1.467+++ (0.496)	1.255+++ (0.464)	1.413+++ (0.480)	1.640+++ (0.499)	2.004+++ (0.543)	2.468+++ (0.621)	0.138 (0.111)	1.971+++ (0.195)	0.382+++ (0.065)	0.393+++ (0.069)
(0,1) District 0-10 km from GQ	0.364+++ (0.128)	0.235 (0.144)	0.443+++ (0.163)	0.815+++ (0.161)	0.882+++ (0.198)	1.069+++ (0.277)	0.199+++ (0.074)	0.163 (0.195)	0.121++ (0.055)	0.130++ (0.056)
(0,1) District 10-50 km from GQ	-0.199 (0.185)	-0.325 (0.222)	-0.175 (0.293)	-0.238 (0.237)	-0.087 (0.314)	-0.281 (0.455)	0.157 (0.126)	0.286 (0.280)	0.098 (0.091)	0.095 (0.094)

Source: Authors' compilation.

Notes: Long-differenced estimations consider changes in the location and productivity of organized-sector manufacturing activity in 311 Indian districts from 2000 to 2007–9 from the Annual Survey of Industries (ASI). Explanatory variables are indicators for distance from the GQ network that was upgraded starting in 2001. Estimations consider the effects relative to districts more than 50 km from the GQ network. Column headers list dependent variables. Young plants are those less than four years old. Labor productivity is total output per employee in district, and TFP is weighted average of Sivadasan (2009) approach to Olley-Pakes estimations of establishment-level productivity with repeated cross-section data. Outcome variables are winsorized at their 1 percent and 99 percent levels, and entry variables are coded at the 1 percent level where no entry is observed to maintain a consistent sample. Estimations report standard errors, have 311 observations, control for the level of district activity in 2000, and weight observations by log total district population in 2001.

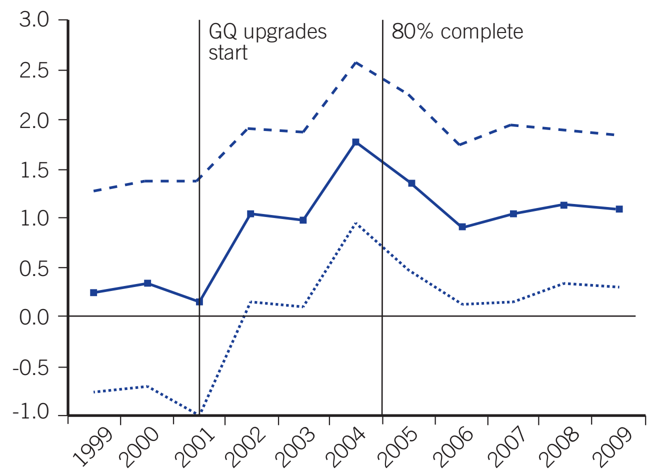
linked to the GQ upgrades rather than to other aspects, such as regional growth differences.

Ghani, Goswami, and Kerr (2013) test many variations on these themes. The first trial shows results after controlling for other district traits, including: national highway access, state highway access, broad-gauge railroad access, and district-level measures from the 2000 census of log total population, age profile, female-male sex ratio, population share in urban areas, population share in scheduled castes or tribes, literacy rates, and an index of within-district infrastructure. The inclusion of these controls in the long-differenced estimation is akin to including time trends interacted with these initial covariates in a standard panel regression analysis. The inclusion of these controls substantially reduces the coefficients for the nodal districts. More importantly, the increased activity for 0–10 km districts remains quite statistically and economically important. These patterns also hold when using alternative distance bands, including state fixed effects, and similar tests.

Also critical to the analysis is the placebo setting. Sections of the North–South and East–West (NS-EW) highway were scheduled to be upgraded at the same time as the GQ network, but the work was postponed. The study finds that the districts within 10 km of the NS-EW highway show no response. In addition, the results generally confirm the ordinary least square findings with straight-line instrument variable estimates that connect nodal cities, which helps with particular concerns about the endogenous weaving of the network toward certain districts with promising potential.

To better establish the timing of these reforms, the study team also constructed two dynamic specifications. First, they separately estimated effects for each calendar year to see whether the growth patterns appear to follow the GQ upgrades hypothesized to cause them. Effects are measured relative to the 1994 period and tend to confirm the right timing, as in figure 2, for the output levels of young firms. In an alternative dynamic specification, the study team identified the sections of highway that were completed earlier than others. Results show that the effects are largest in the district's where the work was completed by March 2003, followed by those finished by March 2006, and then the last sections to be built.

Figure 2. Dynamics of Log New Output Growth



Source: Authors' illustration.

The GQ upgrades also appear to have facilitated a more natural sorting of land- and building-intensive industries from the nodal districts into periphery locations. This general urban-rural or core-periphery pattern is evident in many countries and is associated with efficient sorting of industry placement. Moreover, this feature has particular importance in India because of government control over land and building rights, leading some observers to state that India has transitioned from its "license Raj" to a "rents Raj." Given India's distorted land markets, the heightened connectivity brought about by the GQ upgrades may be particularly important for efficient sorting of industry across spatial locations. These patterns suggest that the GQ upgrades may have helped with the efficient sorting of industries across locations. Ghani, Goswami, and Kerr (2012) find that infrastructure aids efficient sorting of industries and plants *within* districts, and these patterns show a greater efficiency *across* districts. Many studies have warned about the misallocation in the Indian economy (for example, Hsieh and Klenow [2009]), and these results suggest that better connectivity across cities/districts may reduce some of these distortions.

The upgrades also appear to encourage decentralization by making intermediate cities more attractive to manufacturing entrants. For instance, moderate-density districts—like Surat in Gujarat or Srikakulam in Andhra Pradesh—that border the GQ highway registered a more than 100 percent increase in new output and new establishment counts after the GQ upgrades. On the other hand, the GQ upgrades are not linked to heightened entry or performance in low-density areas. These results suggest that the improved connectivity enables manufacturing establishments to efficiently locate in intermediate cities, but that localization economies prevalent for the sector continue to preclude entry in low-density places.

Importantly, and the subject of ongoing research, the upgrades are also associated with better allocative efficiency in the organized sector. Allocative efficiency measures the extent to which the employment of an industry is contained in the industry's most productive plants. India generally compares very poorly to advanced economies, such as the United States, on this dimension. Industries that were initially positioned along the GQ show improved allocative efficiency compared to industries initially positioned on the NS-EW system. This is encouraging for the competitive dynamics induced by better infrastructure.

Conclusions

This note summarizes the Ghani, Goswami, and Kerr (2013) study on the impact of a large-scale highway project on economic activity in the Indian formal manufacturing sector using establishment-level survey data from 1994–2009. The GQ project in India upgraded the quality and width of 5,846 km of highways linking four major cities in India. In the process, this upgrade improved the connectivity and market accessibility of districts lying close to the highway compared to those more removed. Non-nodal districts located within 0–10 km from the GQ network experienced substantial increases in entry levels and ambiguous productivity consequences. Dynamic specifications and comparisons to the NS-EW highway system mostly confirm these conclusions. The GQ upgrades also appear to have facilitated a more natural sorting of industries that are land and building intensive from the nodal districts into periphery locations and have improved allocative efficiency in the manufacturing industries located along the GQ network. The upgrades also appear to be encouraging decentralization by making intermediate cities more attractive to manufacturing entrants.

The study by Ghani, Goswami, and Kerr (2013) contributes to the literature on the economic impacts of transportation networks in developing economies that is unfortunately quite small relative to its policy importance. Understanding the impacts of a large-scale infrastructure project on economic activity and the pattern of development is important for policy makers and regional analysis because these impacts identify how infrastructure investments shape the spatial growth of regions within India and the distribution of industrialization and income. This study provides quantitative estimates of the likely impact of other highway development projects in India, and the work on the relative impacts across districts by distance to the network offers insights into the distributional impacts of these infrastructure projects. This type of empirical analysis is an essential input for urban planning and economic policy, which govern the distribution of economic activity and industrial development of a country. The study's results on improved spatial sorting can also help guide policies for promoting stronger productivity growth and better allocation of scarce resources in India.

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Notes

1. In general, however, the estimates show very little sensitivity to the inclusion or exclusion of this control.
2. Because the coefficients are being measured for each band relative to districts more than 50 km away from the GQ network, the inclusion or exclusion of the nodal districts does not impact the core results regarding non-nodal districts.

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