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The Impact of the Golden Quadrilateral Project for the Location and Performance of Indian Manufacturing

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Abstract :- **Reviewinvestigate the impact of the Golden Quadrilateral (GQ) highway project on the Indianorganized manufacturing sector using enterprise data. The GQ project upgraded the quality and width of5,846 km of roads in India. Use a difference-in-difference estimation strategy to compare non-nodaldistricts based upon their distance from the highway system. here find several positive effects for non-nodal districts located 0-10 km from GQ that are not present in districts 10-50 km away, most notablyhigher entry rates and increases in plant productivity. These results are not present for districts located onanother major highway system, the North-South East-West corridor (NS-EW). Improvements for portionsof the NS-EW system were planned to occur at the same time as GQ but were subsequently delayed.Additional tests show that the GQ project's effect operates in part through a stronger sorting of land-intensive industries from nodal districts to non-nodal districts located on the GQ network. The GQupgrades further helped spread economic activity to moderate-density districts and intermediate cities.**

Keywords: - **Highways, roads, infrastructure, India, development, manufacturing, density, rent.**

I. INTRODUCTION

Adequate transportation infrastructure is an essential ingredient for economic development and growth. Beyond simply facilitating cheaper and more efficient movements of goods, people, and ideas across places, transportation infrastructure

Impacts the distribution of economic activity and development across regions, the extent to which agglomeration economies and efficient sorting can be realized, the levels of competition among industries and reallocation of inputs towards productive enterprises, and much more. Rapidly expanding countries like India often face severe constraints on their transportation infrastructure. Many business leaders, policy makers, and academics describe infrastructure as a critical hurdle for sustained growth that must be met with public funding, but to date we have a very limited understanding of the economic impact of those projects.

This paper studies the impact of the Golden Quadrilateral (GQ) project, a large-scale highway construction and improvement project 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 mi) of road connecting many of the major industrial, agricultural, and cultural centers of India. It is the fifth-longest highway in the world. The massive project began in 2001, was two-thirds complete by 2005, and mostly finished in 2007. Datta (2011), a study that we describe in greater detail below, finds that GQ upgrades quickly improved the inventory management and sourcing choices of manufacturing plants located in non-nodal districts along the GQ network by 2005.

II. INDIAN HIGHWAYS AND GOLDEN QUADRILATERAL PROJECTS

Road transport is the principal mode of movement of goods and people in India, accounting for 65% of freight movement and 80% of passenger traffic. The road network in India has three categories: (i) national highways that serve interstate long-distance traffic; (ii) state highways and major district roads that carry mainly intrastate traffic; and (iii) district and rural roads that carry mainly intra-district traffic. As of January 2012, India possessed 71,972 km of national highways and expressways and 3.25 millionkm of secondary and tertiary roads. While national highways constitute about 1.7% of the road network, they carry more than 40% of the total traffic volume.4

To meet its transportation needs, India launched its National Highways Development Project (NHDP) in 2001. This project, the largest highway

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project ever undertaken by India, aimed at improving the Golden Quadrilateral (GQ) network, the North-South and East-West (NS-EW) Corridors, Port Connectivity, and other projects in several phases. The total length of national highways planned to be upgraded (i.e., strengthened and expanded to four lanes) under the NHDP was 13,494 km; the NHDP also sought to build 1,500 km of new expressways with six or more lanes and 1,000 km of other new national highways, including road connectivity to the major ports in the country. Thus, in a majority of cases, the NHDP sought to upgrade a basic infrastructure that existed, rather than build infrastructure where none previously existed.

The NHDP has evolved to include seven different phases, and our paper focuses on the first two stages. NHDP Phase I was approved in December 2000 at an estimated cost of Rs 30,300 crore (1999 prices). Phase I planned to improve 5,846 km of the GQ network, 981 km of NS-EW, 356 km of Port Connectivity, and 315 km of other national highways, for a total improvement of 7,498 km. Phase II was approved in December 2003 at an estimated cost of Rs 34,339 crore (2002 prices). This phase planned to improve 6,161 km of NS-EW and 486 km of other national highways, for a total improvement of 6,647 km. About 442 km length of highway is common between GQ and NS-EW.

The GQ network, totaling a length of 5,846 km, connects the four major cities of Delhi, Mumbai, Chennai, and Kolkata. Figure 1 provides a map of the GQ network. Beyond the four major cities that the GQ network connects, the highway touches many smaller cities like Dhanbad in Bihar, Chittaurgarh in Rajasthan, and Guntur in Andhra Pradesh. The GQ upgrades began in 2001, with a target completion date. of 2004. To complete the GQ upgrades, 128 separate contracts were awarded. In total, 23% of the work was completed by the end of 2002, 80% by the end of 2004, 95% by the end of 2006, and 98% by the end of 2010. Differences in completion points were due to initial delays in awarding contracts, land acquisition and zoning challenges, funding delays,6 and related contractual problems. Some have also observed that India's construction sector was not fully prepared for a project of this scope. As of August 2011, the cost of the GQ upgrades was about US$6 billion (1999 prices), about half of the initial estimates.

The NS-EW network, with an aggregate span of 7,300 km, is also shown in Figure 1. This network connects Srinagar in the north to Kanyakumari in the south, and Silchar in the east to Porbandar in the west. The NS-EW upgrades were initially planned to begin in Phase I of NHDP along with the GQ upgrades. The scope of the first phase of upgrades was smaller at 981 km, or 13% of the total network, with the remainder originally planned to be completed by 2007. However, work on the NS-EW corridor was pushed into Phase II and later, due to issues with land acquisition, zoning permits, and similar. In total, 2% of the work was completed by the end of 2002, 4% by the end of 2004, and 10% by the end of 2006. These figures include the overlapping portions with the GQ network that represent about 40% of the NS-EW progress by 2006. Since then, the planned upgrades for the NS-EW have expanded substantially. As of January 2012, 5,945 of the 7,300 kilometers in the project have been completed, at an estimated cost of US$12 billion.

III. EMPIRICAL ANALYSIS OF THE IMPACT OF HIGHWAYS ON ECONOMIC ACTIVITY

This section analyzes the impact of highway construction on manufacturing activity across districts. We use simple linear models with outcome variables expressed in logs, with the exception of TFP, which is expressed in unit standard deviations. Estimations include district and year fixed effects. These district fixed effects absorb long-run levels in manufacturing activity by district (along with any other fixed trait), while the year fixed effects absorb aggregate changes in the Indian manufacturing sector.

Estimations report standard errors clustered by district, weight observations by log total district population in 2001, and have 1,248 observations as the cross of four surveys and 312 districts.

Base Pre-Post Estimations of GQ Upgrades

Table 2a shows the simplest panel estimations where explanatory variables in Panel A are interactions of two indicator variables for how far a district is from the GQ highway network with an indicator variable for the post-GQ upgrades (equal to one in 2005 and 2007). The district fixed effects control for the main effects of distance, and the year fixed effects control for the main effects of the post-GQ upgrades period. Thus, the interactions quantify differences in outcomes after the GQ upgrades by spatial band compared to the excluded group that comprises districts located more than 50 km from the GQ network.

Column headers provide the outcome variables studied. Columns 1-3 present measures of total activity in each district, Columns 4-6 present measures of new entry specifically, and Columns 7 and 8 present our average productivity measures. The first row shows increases in nodal district activity for Columns 1-6. As we have noted, we do not emphasize these results much given that the upgrades were built around the connectivity of the nodal cities. The imprecision in these estimates is mostly due to the fact that there are only nine nodal districts. As effects are being measured for each band relative to districts more than 50 km from the GQ network, the inclusion or exclusion of the nodal districts does not impact our core results regarding non-nodal districts.

This paper primary emphasis is on the highlighted row where we consider districts that are 0-10 km from the GQ network but are not nodal districts. To some degree, the upgrades of the GQ network can be taken as exogenous for these districts. Columns 1-3 find limited effects for the total activity contained in these districts. As foreshadowed in Table 1b, we find positive point estimates for higher establishment counts and output in districts 0-10 km from the GQ network after the upgrades, but small declines in employment. These effects are not statistically significant, and this is not due to small sample size as we have 76 districts within this range. Columns 4-6 examine instead the entry margin by quantifying levels of young establishments and their activity. We find much sharper entry effects than the aggregate effects in Columns 1-3, and these entry results are precisely measured. The districts within 0-10 km of GQ have a 0.4-0.9 log point increase in entry activity after the GQ upgrade compared to districts more than 50 km away. We further discuss these differences between total levels and entry rates when reviewing Table 2b.

Columns 7 and 8 show an increase in the average labor productivity and TFP in the districts 0-10 km from the GQ network. These increases are primarily driven by the incumbent establishments of the districts. We do not separately quantify the labor productivity and TFP changes of new entrants similar to Columns 4-6, as much of the impact of new entrants comes from the extensive margin and these plant-level traits are not defined in these cases. The labor productivity result is also evident in a comparison of Columns 2 and 3, with the difference being that Column 7's measure is calculated at the plant level. We return to the interpretation of these productivity results after viewing the dynamic specifications.

For comparison, the third row of Panel A provides the interaction for the districts that are 10-50 km from the GQ network. None of the effects that we measure for the 0-10 km districts are observed at this spatial band, which provides a first assurance that these effects can be linked to the GQ upgrades rather than other features like regional growth differences.

Panel B extends the spatial horizons studies in Panel A to include two additional distance bands for districts 50-125 km and 125-200 km from the GQ network. These two bands have 48 and 51 districts, respectively. In this extended framework, we measure effects relative to the 97 districts that are more than 200 km from the GQ network in our sample. Three observations can be made. First, the results for districts 0-10 km are very similar when using the new baseline. Second, the null results generally found for districts 10-50 km from the GQ network mostly extend to districts 50-200 km from the GQ network. Even from a simple association perspective, the manufacturing growth in the period surrounding the GQ upgrades is localized in districts along the GQ network.

As a final and more speculative point, the negative point estimates in Columns 4-6 have a pattern that might suggest a ―hollowing-out‖ of new entry towards districts more proximate to the GQ system after the upgrades. This pattern is similar to Chandra and Thompson's (2000) finding that U.S. counties that were next to counties through which U.S. highways were constructed were adversely affected. Chandra and Thompson (2000) described their results within a theoretical model of spatial competition whereby regional highway investments aid the nationally-oriented manufacturing industry and lead to the reallocation of economic activity in more regionally-oriented industries. The point estimates suggest a similar force might be occurring within Indian manufacturing as well, but the lack of statistical precision prevents strong conclusions in this regard

Returning to the differences between Columns 1-3 and 4-6, we suspect that three factors are behind the weaker response on total activity compared to entry. First, our post-upgrades data come from 2005 and 2007, which is just at the end of the GQ upgrades that began in 2001. It takes time for activity to shift spatially, especially if there are agglomeration forces or similar with existing industry bases, and we are likely under-estimating the ultimate changes that may occur in the spatial distribution of Indian manufacturing as a consequence. By contrast, the entry margin—where location choices are being made at present—adjust much faster to the changing attractiveness of regions, and thus register sharper effects in the short- to medium-run. A second reason why total shifts in activity may be dampened in districts on the GQ network is that entrants may be displacing incumbent establishments from the districts. In fact, this competition is a key reason cited by proponents for infrastructure investments. Unfortunately, this paper data do not allow us to study the exit margin with sufficient detail to make accurate assessments.

Table 2b presents evidence on a third rationale that partly overlaps with the other two. Prior to the GQ project, there existed some infrastructure linking these cities. In a minority of cases, the existing roads did not even comprise the beginning of a highway network, and so the GQ project built highways where none existed before. In other cases, however, a basic highway existed that could be upgraded. Of the 70 districts lying near the GQ network, new highway stretches comprised some or all of the construction for 33 districts, while 37 districts experienced purely upgrade work.

In Table 2b, we split the 0-10 km interaction variable for these two types of interventions. The results are very interesting. Columns 4-8 show mostly similar entry and productivity consequences regardless of the initial roadwork's condition. Columns 1-3, however, show distinct effects regarding total activity. Places that completely lacked a highway before GQ exhibit increases in aggregate activity. In these cases, the entry has enough aggregate consequences to register during the time period of our study. On the other hand, upgrades of existing facilities display null effects. Because of the earlier two limitations noted, it could be that upgraded portions will also demonstrate increases in aggregate activity in the long-run.

Dynamic Specifications

Table 3a presents a dynamic version of the pre-post estimations using the shorter spatial horizon that measures effects relative to districts 50+ km from the GQ network. In this specification, we interact the indicator variables for district distance bands with indicator variables for the years 2000, 2005, and 2007. By separately estimating effects for each year, we can observe whether the growth patterns appear to follow the GQ upgrades hypothesized to cause them. Effects are measured relative to the 1994 period. We include but do not report interactions for nodal districts and each year, as well.

The patterns in Columns 4-6 are comforting for the entry results. We do not observe a substantial uptick in 2000 that would suggest a pre-trend to the GQ upgrades. This lack of pre-trend also extends to the total activity measures in Columns 1-3, although we did not observe a substantial pre-post effect for these results anyway with the full sample. Likewise, we do not observe any worrisome patterns for the districts 10-50 km apart from the GQ network. In fact, the latter provide additional support in that the coefficients for the 2000 interaction in the 0-10 km (top row) are similar to those for 10-50 km (fourth row), while the subsequent differences in entry rates in 2005 and 2007 are quite stark.

By contrast, the dynamic specifications suggest that some caution is warranted in interpreting the observed growth in labor productivity and TFP for districts 0-10 km from the GQ network. The first row in Columns 7 and 8 show non-trivial performance declines in 2000 compared to 1994 for these districts; they also highlight that much of the performance gain we observe in Table 2a is through a comparison of outcomes in 2005 and 2007 against outcomes in 2000, rather than compared to 1994.

There are two potential interpretations that could follow. The first, less-positive interpretation is that the performance gain we observe in Table 2a is a recovery from some short-term decline in productivity that is spuriously timed with the GQ upgrades. Some evidence in support of this story is registered in the fact that TFP growth reverts back to almost 1994 levels in Column 8. However, a second, more-positive interpretation is that the GQ upgrades managed to stop and reverse some adverse decline in productivity that these districts were experiencing. Some evidence in support of this story is evident in the fact that districts 10-50 km from the GQ network also experienced lower productivity in 2000 that did not subsequently recover. In the end, our analysis provides equal support to both interpretations.

In summary, the dynamic specifications of Table 3a provide support for a causal link in that the observed increases in entry rates from the simple pre-post estimations have a timing that appears well aligned with the GQ upgrades. On the other hand, the productivity results are more difficult to interpret and may suggest that our productivity findings in Table 2a are upwardly biased due to a rebound effect from spuriously lower productivity levels in 2000.

Table 3b takes a second dynamic approach. Due to the size of the GQ project, some sections were completed earlier than other sections. Using our framework from Table 2a, we further interact our indicator variable for being 0-10 km from the GQ network with indicator variables for whether the district's work was completed by March 2003, March 2006, or later. Of the 70 districts, 27 districts were completed prior to March 2003, 27 districts between March 2003 and March 2006, and 16 districts afterwards. In almost every case in Table 3b, the relative sizes of the effects by implementation date are consistent with the project's completion taking hold and influencing economic activity. Given that our final data survey comes from 2007, it is not surprising that we do not yet see substantial activity in the districts completed after March 2006. On the other hand, expansions in activity are generally strongest for districts that were completed by March 2003. Again, the timing of the GQ upgrades is consistent with the results we observe.

Comparison of GQ Upgrades to NS-EW Highway

Table 4 compares districts proximate to the GQ network to districts proximate to the NS-EW highway network that was not upgraded. The idea behind this comparison is that districts that are at some distance from the GQ network may not be a good control group if they have patterns of evolution that do not mirror what districts immediately on the GQ system would have experienced had the GQ upgrades not occurred. This comparison to the NS-EW corridor provides perhaps a stronger foundation in this regard, especially as its upgrades were planned to start close to those of the GQ network before being delayed.

The upgrades scheduled for the NS-EW project were to start contemporaneous to and after the GQ project. To ensure that we are comparing apples to apples, we identified the segments of the NS-EW project that were to begin with GQ and those that were to follow in the next phase. We use separate indicator variables for these two groups so that we can compare against both. Of the 76 districts lying with 0-10 km of NS-EW, 40 districts were to be covered in the 48 NS-EW projects identified for Phase I. The empirical appendix provides greater detail on this division.

The powerful result from Table 4 is that none of the outcomes we measure for the GQ system in the post-upgrade period are observed for districts along the NS-EW corridor. The placebo-like coefficients from the interactions of post-GQ upgrades with districts lying between 0-10 km from the NS-EW highway are mostly negative and never statistically significant. The lack of precision is not due to too few districts along the NS-EW system, as the district counts are comparable and the standard errors are of very similar magnitude. In Appendix Table 1, we show that null results continue to hold when we combine the NS-EW indicator variables and that the coefficients are well estimated. Said differently, with the precision that we estimate the positive responses along the GQ network; we estimate a lack of a change along the NS-EW corridor. Along with the dynamic results in Tables 3a and 3b, these patterns speak to the likely link of the economic changes to the GQ upgrades.

Industry Heterogeneity in Entry Patterns

This paper last two analyses change the focus from estimating aggregate effects from the GQ upgrades to identifying in greater detail the heterogeneity in the effects observed by important industry or district traits. These exercises provide additional confidence around the patterns developed and, as highlighted below, have special policy relevance in India.

Table 5 describes a key feature of the industry heterogeneity in entry that occurred after the GQ upgrades. We focus specifically on the land and building intensity of industries. We select this intensity due to the intuitive inter-relationship that non-nodal districts may have with nodal cities along the GQ network due to the general greater availability of land outside of urban centers and its cheaper prices. 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 due to government control over land and building rights, leading some observers to state that India has transitioned from its ―license Raj‖ to a ―rents Raj‖ (e.g., Subramanian, 2012a,b). 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.

This paper measure land and building intensity at the national level in the year 2000 through the industry's closing net value of the land and building per unit of output. Appendix Table 2 provides specific values, and we find similar results when only using land intensity. In Table 5, we repeat our entry specifications isolating district activity observed for industries in three bins: those with low land intensity (the bottom quartile of intensity), medium intensity (the middle two quartiles), and high intensity (the top quartile).

The patterns in Table 5 are striking. The districts 0-10 km from the GQ network show a pronounced growth in entry by industries that are land and building intensive. With all three outcome measures of establishments, employment, and output, there are no adjustments in entry for the least-intensive industries. This entry effect only becomes statistically and economically important at moderate land and building intensities, and the effect is largest for industries with the highest intensities. As remarkable, the opposite pattern is generally observed in the top row for nodal districts—where nodal districts areexperiencing heightened entry of industries that are less land and building intensive after the GQ upgrades—and no consistent patterns are observed for districts 10-50 km from the GQ network.

These patterns suggest that the GQ upgrades may have helped with the efficient sorting of industries across locations. Ghani et al. (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 (e.g., Hsieh and Klenow 2009), and these results suggest better connectivity across districts may be able to reduce some of these distortions. More speculatively, these results also suggest that infrastructure may improve upon land market distortions caused by the ―rent Raj and similar.

Highways and Spatial De-Concentration

The development and growth of Indian economy in the last two decades has been accompanied by widening spatial disparities. Cities like Gurgaon in Haryana and Bangalore in Karnataka have experienced high growth in economic activity and real estate developments, while many other places remain mired in poverty and stagnation. These differentials are common to many developing economies (e.g., World Development Report 2009), as well as advanced economies. For instance, China's growth is attributable mainly to coastal provinces. However, unlike China, growth in India's moderate-sized cities is relatively lower. Desmet et al. (2012) argue 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.

In this section, we examine whether investment in infrastructure such as highways can play a role in facilitating the shift of manufacturing activity to intermediate-sized districts. We group districts into three bins based on their population density: low-density districts are below the median density for India (up to 353 persons per square km); moderate-density districts are those in the middle two quartiles (353-693 persons per square km), and high-density districts are those in the top quartile (over 693 persons per square km).

Table 6 presents the results of interacting the three repressors from paper study typical approach with indicator variables for the various density bins. The one exception is that all of the nodal districts are above the median density for India, and so we do not have a low-density nodal-district effect. Effects continue to be measured against districts farther than 50 km from the GQ network.

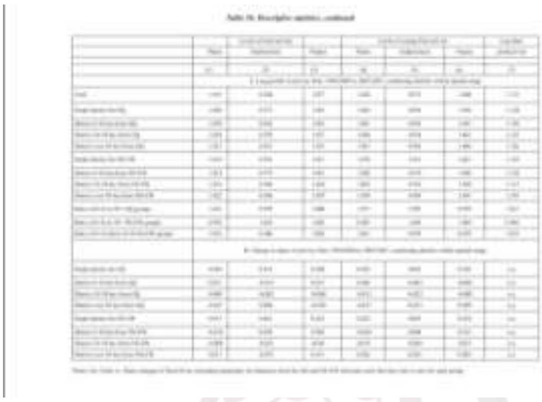
The results in Table 6 suggest that the GQ upgrades have increased new entry the most in high- and medium-density districts that lie 0-10 km from the GQ network. For instance, moderate-density districts, like Surat in Gujarat or Srikakulam in Andhra Pradesh, that lie on the GQ highway registered more than 100% increase in new output and new establishment counts after GQ upgrades. On the other hand, the GQ upgrades are not linked to heightened entry or performance in low-density areas. One interpretation of these results is 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.[12]

The findings are similar to Baum-Snow et al. (2012) who identify how infrastructure aided the decentralization of industrial production and population in Chinese cities from 1990-2010. Henderson et al. (2001) similarly find that industrial decentralization in Korea is attributable to massive transport and communications infrastructure investments in the early 1980s. These and similar studies form the foundation for development recommendations with respect to infrastructure found in the World Bank's (2012) Urbanization Review Flagship Report and comparable policy reports.

IV. CONCLUSIONS

This paper evaluates the impact of a large-scale highway project on economic activity in the Indian manufacturing sector using establishment-level survey data from 1994-2007. The Golden Quadrilateral highway project of India upgraded the quality and width of 5,846 km of highways linking four major hubs 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 higher productivity. Dynamic specifications and comparisons to the NS-EW highway system mostly confirm these conclusions, with the most substantial caveat being that the productivity gains may be upwardly biased by a pre-period dip. 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 the periphery locations; the upgrades also appear to be encouraging decentralization by making intermediate cities more attractive for manufacturing entrants.

There are several points of future research that we hope to undertake. First, we are continuing to examine the extent to which the GQ project improved the allocative efficiency of the manufacturing sector in India. Given the high levels of misallocation with which India is starting, improvements in allocation are most important. Second, we intend to study next the impact of the GQ upgrades on the unorganized sector. Ghani et al. (2012) highlight the extent to which the organized and unorganized sectors are moving in different directions within India, with the unorganized sector becoming more urbanized, and we need to better understand the role that infrastructure connections across districts play in this process. This work will also examine issues like the gender of business owners to understand how improved highways affect sub-groups of the population differently. Finally, looking beyond the manufacturing sector, it will be very interesting to use satellite-based data to examine the aggregate economic outcome associated with these upgrades.



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