The Impact of Improved Highways on Indian Firms

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Abstract

India's Golden Quadrilateral Program aimed at improving the quality and width of existing highways connecting the four largest cities in India. This affected the quality of highways available to firms in cities that lie along the routes of the four upgraded highways, while leaving the quality of highways available to firms in other cities unaffected. This feature allows for a difference-in-difference estimation strategy, implemented using data from the 2002 and 2005 rounds of the World Bank Enterprise Surveys for India. Firms in cities affected by the Golden Quadrilateral highway project reported decreased transportation obstacles to production, reduced average stock of input inventories (by about a week's worth of production), and a higher probability of having switched the supplier who provided them with their primary input. Firms in cities where road quality did not improve displayed no significant changes.

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1 Introduction and Motivation

This paper studies the response of firms in India to an ambitious program of highway improvements in order to measure the economic effects of infrastructure investments, an issue that has received widespread attention both in the context of developing countries such as India and more generally. It is motivated by, and contributes to, two strands in the literature.

The first is the literature on the role of the private sector in economic development, and particularly effects of government policies in enabling, constraining or retarding how the private sector performs (for example, Djankov et al. 2008, Knittel 2002). Within this literature, the Indian case has been the subject of a growing literature. Recent contributions to this literature have argued, for example, that excessively restrictive licensing policies were responsible for sub-optimal firm performance (see Chari 2007). This paper emphasizes the government's role as an enabler for private-sector development, since it finds positive efficiency effects of large-scale investments in infrastructure. In the specific case of India, this is a particularly compelling story, since many commentators have argued that the flipside of the Indian government's historical over-involvement with regulating and controlling private-sector activity was a tendency to neglect precisely those areas, such as infrastructure provision, where it may have had the greatest scope for impact.

More generally, this paper examines the economic effects of investments in infrastructure, in the spirit of papers such as Chandra and Thompson (2000). Highways are the quintessential example of such investments, are often posited as being essential for higher economic growth. Significant budgetary resources are allocated to highway construction in many countries based in part on a hypothesized causal link between infrastructure development and economic growth. Yet, empirical evidence on this issue is 'extremely controversial, and consists of studies that are divided on both the magnitude and direction of the net effect of infrastructure spending on economic growth' (Chandra and Thompson 2000).

Several issues complicate the estimation of the economic effects of infrastructure. First, while a variety of studies have found positive correlations between the level of infrastructure in an area and economic outcomes of interest, such as growth, endogeneous placement of new infrastructure makes it difficult to clearly quantify the causal effects on economic outcomes of interest. This issue can be summed up as follows: do areas with (more, better) infrastructure show better economic outcomes because of the infrastructure, or do better economic outcomes, or the potential for better economic outcomes, attract better infrastructure? Thus, we may see that better roads are linked to faster growth, but if we suspect that roads are likely to have been built or improved in areas that had the highest potential for economic growth, our estimates of the impact of roads on growth are biased upwards. Secondly, infrastructure can affect not only the quantum, but also the spatial distribution of economic activity, so that accounting for spillovers is important if we try to capture the overall net impact of infrastructure. Thirdly, there is little empirical evidence, apart from a small number of case studies (see, for example, Gulyani 2001), on the channels through which infrastructure affects economic outcomes. While studies of effects on growth or employment exist, there is little information on firm-level variables (such as inventories, input costs, capacity utilization, competition) that may respond to improvements in transport infrastructure, and through which the beneficial economic effects of highway construction are channeled.

While truly random placement of a major infrastructure project is hard to conceive of, a series of recent papers cognizant of the endogeneity issue have attempted to deal with it in different ways. For example, Duflo and Pande (2004) use gradient to instrument for the placement of hydroelectric projects in India, so as to obtain plausibly causal estimates of the economic effects of large hydroelectric projects. In the case of highway construction, both Chandra and Thompson (2000) and Michaels (2007) use a feature of the US Interstate Highway construction program that allows them to treat it as a natural experiment for counties through which the new interstate highways (did not) pass. The idea derives from the nature of the highway-building exercise: when a highway is built to connect cities A and B, it must pass through areas that lie in between the two, thus contributing to improved infrastructure in places that happen to lie in between the (possibly endogenously chosen) points that the highway is built to connect. If there is reason to believe that the precise route of the highway was not manipulated to include some intermediate areas (counties, districts, cities) and exclude others based on factors correlated with the outcomes of interest, then the highway construction can be treated as exogenous to the areas that the highway runs through.

In this paper, I use an identification strategy similar in spirit to that in Chandra and Thompson (2000) to address the endogeneity issue. I argue that India's Golden Quadrilateral Program, which seeks to improve the quality and width of existing highways connecting the four largest cities in India (Delhi, Mumbai, Kolkata, and Chennai), affected the quality of highway transportation available to firms in cities that happened to lie along the routes of the four National Highways it upgraded, while leaving the quality of highways available to firms in cities that lay along other national highways unaffected. This allows for a difference-in-difference estimation strategy, where changes in relevant outcomes for affected firms are compared to the corresponding outcomes for firms whose location precluded their directly benefiting from the highway program.

The structure and content of the data used here, which are from two rounds of the World Bank's Enterprise Surveys for India, are particularly well-suited for tackling the questions discussed above. The panel structure of the data allows me to compare the changes in the responses of a representative sample of 1,091 firms in 37 cities - of which 19 were directly affected by the highway upgradation program and the remaining 18 unaffected by it – between the year 2002, when the project had just begun, to the responses of the same firms in the year 2005, when it was approximately two-thirds complete. Further, the Enterprise Survey data contain firms' responses to questions which allow me to directly measure how the choices that firms make about inventories and input suppliers – which the theory suggests should respond to better transport infrastructure (see for example Shirley and Winston 2001) – are affected by the quality of highway infrastructure. The surveys also provide direct evidence about firms' perceptions of the degree to which transportation constitutes an obstacle to their productive activities. While these data are difficult to interpret in a cross-sectional setting, I utilize the panel structure of the data to see how firm's responses to this question reflected the change in road quality due to the Golden Quadrilateral project.

The key findings of the paper are as follows. First, I find that firms in cities affected by the highway project became 7.6 percentage points, or about 60 per cent, less likely to report that transportation constituted a 'major' or 'severe' obstacle to production, while there was no significant change in the responses of firms in off-Golden Quadrilateral cities. Secondly, the differences-in-differences estimate of the effect of the highway construction on the average stock of input inventories held by a firm is significantly negative and large in magnitude. Firms on the Golden Quadrilateral highways reduced their average input inventory (measured in terms of the number of days of production the inventory was sufficient for) by 7 days more than corresponding firms which lay on other highways. Thus, inventory management became siginificantly leaner for treatment firms relative to control firms after the improved highways were put into place. Finally, I find that firms in cities that gained better highway access were much more likely to have switched the supplier who provided them with their primary input than firms in cities where road quality did not improve. These latter two effects can, I argue, be interpreted as showing that firms that gain access to higher-quality highways are able to produce more efficiently (as captured by their inventory management becoming leaner) than in the absence of the improved highways, and to exploit opportunities that may earlier have been unfeasible, which we argue are unambiguously economically beneficial to these firms. I find that the results are robust to the exclusion of firms in the 4 nodal metropolitan cities (Delhi, Mumbai, Kolkata and Chennai), whose status as 'on-Golden Quadrilateral' cities was a matter of design rather than fortuitousness. Viewed together, these results support the idea that the highway construction project eased the extent to, and channels through, which transportation infrastructure constrains firms.

However, I also find that although there was no initial difference in the fraction of firms who report that transportation was a major obstacle between on- and off-Golden Quadrilateral cities, the same is not true of inventory holdings: firms in Golden Quadrilateral cities held significantly higher input inventories before the highway project than firms in off-Golden Quadrilateral cities. While not directly contradicting the identifying assumption of common trends, this does suggest that the argument made for using non-Golden Quadrilateral cities as controls for cities directly affected by the project may be problematic: perhaps the highways that were included in the highway project were at that point the most congested or overburdened. I attempt to understand why inventory behavior was so different among firms in Golden Quadrilateral cities compared to unaffected firms by including controls for industrial composition and also by revisiting the perceptions data, but the results are somewhat contradictory. If anything, fewer firms in Golden Quadrilateral cities said that transportation was no obstacle or a minor obstacle than firms in non-Golden Quadrilateral cities before the highways were in place, which does not square well with their reported inventory holdings.

The plan of the rest of the paper is as follows. Section 2 provides background information on the specific context of this paper, the Indian highway network and the Golden Quadrilateral project. Section 3 explains the identification strategy used in the paper, which relies on using the Golden Quadrilateral Project as a shock to the quality of highway infrastructure to cities it passed through versus those it bypassed that is unrelated to (firms in) the cities' (potential) economic performance. Section 4 motivates the focus on inventory behavior and supplier relationships, and discusses the data and variables used in this paper. Section 5 presents the key results and their interpretation. Section 6 concludes.

2 Background

2.1 The Indian Highway System

India's road network, which carries 65 per cent of the country's freight (World Bank 2007) is dominated by its 66,000 kilometer-long network of 228 federally-built and maintained National Highways, which connect major cities in the country to one another, and which carry 40 per cent of the country's road traffic inspite of comprising only 2 per cent of its aggregate road length of 3.3 millon kilometers. The prominent role played by the National Highway system has motivated policymakers to pay considerable attention to their quality and carrying capacity, which is widely acknowledged to be inadequate to the needs of a rapidly-expanding economy, both in terms of lane capacity (the bulk of the National Highway network as of the year 2000 was of two lanes or less; 32 per cent was in fact single-laned; and virtually none of the network was of 4 or more lanes) and surface quality. In addition, even national highways in India are not access-controlled, so that highways often pass through busy towns and villages, with adverse consequences not only for traffic speed but also safety .

This has led to widespread congestion: the World Bank estimated that 'a quarter of all India's highways are congested, reducing truck and bus speeds to 30-40 kmph'. It is therefore no surprise that policy-makers argue that India's highway network acts as a constraint on highe economic growth: for example, the World Bank country strategy for India 'identifies highway bottlenecks as one of the major constraints to poverty reduction and private sector-led growth' (World Bank 2005).

2.2 The Golden Quadrilateral Project

In December 2000, the Government of India approved Phase I of the National Highway Development Program (NHDP), the most ambitious program of highway improvement since Independence in 1947. Phase I of the NHDP was dominated by the Golden Quadrilateral Program, under which the four national highways most directly linking the four largest metropolitan cities in the country: NH2 (Delhi-Calcutta), NH8 (Delhi-Mumbai), NH4 (Mumbai-Chennai), and NH5(Calcutta-Chennai) were to be upgraded to 'international-standard' access-controlled 4- or 6-lane dual-carriageway highways with grade separators, access roads, etc. Actual implementation of the Golden Quadrilateral Project began in 2002, by the end of which year contracts for most sections had been awarded, and was substantially, though not completely, accomplished by the target completion date of December 2004: by 2006, 70 per cent of the project had been completed[1].

The Golden Quadrilateral marked a distinct shift in India's road-building strategy. Prior to the approval of the NHDP, India had concentrated its road-building budget on expanding all-weather access rather than improving quality or capacity. Prior to the NHDP, virtually all of the 600,000 km that was added to India's road network in the 1990s consisted of 'very low-standard roads to reach more of the rural areas which had before been outside the reach of all-weather access. High standard arterial highways ... were largely neglected' (World Bank 2005:2). The highways upgraded under the Golden Quadrilateral project were therefore India's first set of international-quality arterial highways, and the Golden Quadrilateral project thus led to a sharp increase in highway quality for the areas it connected over and above any other road improvements that may have taken place (because of other government programs involving road resurfacing, new road construction, etc.).

3 Identification Stragegy

3.1 The Golden Quadrilateral Project as a Natural Experiment

As discussed above, the key issue that makes it difficult to estimate the causal effect of infrastructure such as highways is that their placement is non-random, so that places that receive more or better infrastructure are systematically different from areas that do not. However, as Chandra and Thompson (2000) have pointed out, the nature of many large highway network projects is such as to allow them to be used as an exogenous shock to areas that they pass through. The argument relies on the fact that when highways are built to connect two places, they pass through areas that lie between those two points. If the highway route is not determined to specifically pass through certain intermediate areas to the exclusion of other possible places it could have been routed through, then it may be argued that intermediate areas get better infrastructure not as a consequence of economic or other characteristics, but merely because of where they are located.

[1] Phase 1 of the NHDP also included 931 kilometers of the proposed North-South-East-West (NSWEW) Highways, but this part of the NHDP was eventually effectively pushed into Phase II: as of 2007, only (xx) per cent of the length of the NSEW Highways had been completed.

The argument for using the Golden Quadrilateral project in a natural experiment framework is similar to that in Chandra and Thompson (2000), who use the US Interstate Highway construction program as an exogenous shock to the connectedness of districts through which the highways built passed relative to those they bypassed. The Government's decision to pick the existing highways connecting the country's four largest cities as the ones that were to be widened and improved as part of the project meant different things for smaller cities in the country depending on which national highway a particular city lay on. All major cities in India lie on the route of at least one National Highway, so whether or not a city saw a sharp improvement in the quality of its highway links depended on which pre-existing National Highway passed through or near it. Cities were not included or excluded from benefiting from the highway improvements under the Golden Quadrilateral based on their existing or potential economic growth, as we might imagine would be the case if the route of the highways was not pre-determined. The highways included in the Golden Quadrilateral provided the most direct links between the country's four largest cities, and the highway routes were not realigned to exclude some cities and include others.

Thus, cities could not opt in or out of getting improved highway access, thus precluding a situation where the highway was routed through areas that 'needed it most' (for example, areas which were growing more rapidly than others, or which had particularly pressing infrastructure issues). A city that lay between Delhi and Calcutta but was not on NH2 (such as Lucknow, a city in the state of Uttar Pradesh) would not directly benefit from improved connectivity from the Golden Quadrilateral, but a city that did lie on NH2 (such as Kanpur, a similar-sized city in the state of Uttar Pradesh) would. This motivates the empirical strategy used in this paper, where the changes in outcomes of firms that lay in cities that lay along the upgraded highways ('treated' cities) are compared to the corresponding changes in outcomes for firms in cities that did not lie along the route of the Golden Quadrilateral highways ('control cities') in order to measure the effect of highway quality. Put differently, our estimate of the effect of the Golden Quadrilateral uses the changes in outcome variables for firms on non-Golden Quadrilateral highways as estimates of the counterfactual for treated firms.

A caveat is, however, in order. The validity of the identification strategy relies on the assumption that the firms on the Golden Quadrilateral highways and other firms in the sample have common trends in inventory and supplier behavior, which is what makes the change over time in the outcomes for the latter sets of firms a good control for the former set. It is not possible, given that there is only one pre-treatment period, to test this common trends assumption; however, I will explicitly control for pre-existing differences between firms in treatment and control cities in the regressions whose results are presented here. As will be discussed in Section 5.4, a potential confound comes from the fact that while cities could not self-select onto the routes of the highways that were upgraded, the choice of which highways to upgrade may have been related to their existing condition, congestion conditions, traffic requirements, etc. In that sense, it is possible that our difference-in-difference estimates of the impact of the Golden Quadrilateral Project are upward biased, because road conditions along what eventually became the Golden Quadrilateral were initially worse than road conditions for non-Golden Quadrilateral cities.

4 Data and Outcome Variables of Interest

4.1 Data Sources and Contents

The outcome data used in this paper are from two rounds of the World Bank Enterprise Surveys carried out worldwide in the years 2002 and 2005. A subset of Indian firms in 37 Indian cities were surveyed in both years, giving us a panel of firms whose responses can be compared across two years in order to measure how the improvements in road infrastructure carried out as part of the Golden Quadrilateral affected firms who were on the route of the Golden Quadrilateral relative to those that were not. Of the cities covered in both survey years, 19 cities lay along the four highways that are part of the Golden Quadrilateral: NH2 (connecting Delhi and Calcutta), NH8 (connecting Delhi and Mumbai), NH4 (connecting Mumbai and Chennai) and NH5 (connecting Chennai and Kolkata), while the remaining 18 lay on other National Highways. Data on the location of the cities in the sample relative to Golden Quadrilateral and other highways is from NHAI maps supplemented with satellite data from Google Maps, which allows me to pinpoint which highway(s) a particular city lay on, and thus to classify the cities in the sample into on-Golden Quadrilateral (treated) versus off-Golden Quadrilateral (control) cities.

4.2 Outcomes of Interest: Inventories, Supplier Relationships and Perceptions of Transportation Quality

If infrastructure constrains firms' choices, we should find evidence that removing an infrastructural constraint leads to behavior that is unambiguously 'better' for firms than the choices they were making before the constraint was relaxed. Here, I focus on aspects of firms' inventory and supplier behavior, which I argue below are plausibly constrained by inadequate highway infrastructure, and which would therefore reasonably be expected to respond to the relaxation of the transport constraint; these are also aspects of firm behavior that the data allow me to examine. I also examine responses to a question in the surveys that asked firms to rate how much of an obstacle transportation constituted for them as an added source of information, albeit perceptions-based, on how firms' perceptions of the adequacy of the available tranportation infrastructure responded to the better highways.

4.2.1 Inventories

The intuition behind a focus on input inventories is straightforward. Since firms hold input inventories in order to ensure a smooth production flow, a firm's target inventory level is increasing in its expectations of future sales. However, firms incur costs (capital, storage and depreciation costs, among others) from holding inventories, also increasing in the amount of inventory held. The balance between these considerations affect the firm's reorder point, the minimum sustainable level of inventory.

As Shirley and Winston (2001) point out, faster and more reliable highway transportation means that input orders will be received more quickly and with less uncertainty. This means that, conditional on its expectations about production and sales, the firm will need to keep lower input inventories at any given point in time. The intuition is clarified by thinking of the extreme case, where orders could be received instantaneously, in which case firms would not have to keep any inventory at all: firms could practice what is known as 'Just-in-Time' inventory management. Ceteris paribus, therefore, we should expect a negative relationship between the level of inventories and the availability and quality of transportation, of which highway connectivity is a component.

The data used here allow both this hypothesis to be tested, because both the 2002 and 2005 surveys asked the respondent about inventory stocks held by the firm. Firms were asked how many days of production's worth of their most important input they held inventories of at the time a new delivery of this input came in from their suppliers. The answer to this question is thus our measure of firms' inventory holdings. Using the location of the firm in order to classify it as a 'treatment' or 'control' firm, I seek to measure whether on-Golden Quadrilateral firms saw greater reductions in their reported input inventory holdings between 2002 and 2005 relative to off-Golden Quadrilateral firms.

4.2.2 Supplier Relationships

Another plausible way in which improved roads could impact firms' input use behavior is by increasing the feasible set of suppliers from whom they could purchase the inputs needed for production. A supplier who was earlier not a feasible choice due to a combination of distance and poor road quality could become feasible given better roads. However, there would be no such expansion in the choice set of firms who were unaffected by improvements in road quality. If it were the case that road quality was constraining firms from making their optimal supplier choices, then firms in cities impacted by the highway-upgrading program should be more likely to re-optimize their choice of input supplier than firms in control cities, whose choice set is unaffected. On the other hand, any supplier who was 'feasible' before the highway upgrade continues to be feasible after the highway project, so that if a firm does not change its supplier, this implies that the pre-existing choice continues to dominate its expanded choice set, so that road quality was not a binding constraint.

Firms were asked about the length of time they had been in business with their main input supplier, so that evidence of differential changes in supplier turnover come from differential changes in the length of the supplier relationship. Consider how the change in the length of the relationship reported in the two surveys would relate to supplier turnover. The greater the propensity of firms in any sample of firms to change suppliers, the lower would be the mean increase in the length of the supplier relationship between the two time periods. Thus, the magnitude of the increase in the supplier relationship length allows us to make inferences about the probability of supplier change between the two periods. Extending this idea to two comparable groups of firms, therefore, we would find that if more firms in Group A had changed suppliers than in Group B, then the mean difference in the length of the relationship between the survey years would be smaller in Group A than in Group B. The differences-in-differences estimate of the effect of the Golden Quadrilateral project on supplier relationship length then allows us to isolate the effect of the project on supplier turnover, with a negative coefficient implying that firms in the treatment group increased their supplier relationship length by less than firms in the control group, implying that treated firms were more likely to have acquired a new supplier in the period between the surveys than control firms.

4.2.3 Perceptions of Transportation as an Obstacle to Production

Finally, the data also provide us with information about surveyed firms' perceptions about how severe an obstacle transportation constituted for them. Firms were asked to choose whether transport constituted no obstacle, a minor obstacle, a moderate obstacle, a major obstacle, or a very severe obtacle to production. In the results presented here, I reclassify this five-point scale into three categories of how severe an obstacle transportation constituted to the firm in question: low (incorporating no obstacle or a minor obstacle, the bottom two categories); medium (which corresponds to the 'moderate obstacle' answer), and high (which incorporates the highest two degrees in the data, major and very severe obstacle). There are well known problems with perceptions data, which make it difficult to compare the responses of different firms to each other, but this is obviated to some degree by being able to look at changes in the same set of firms' perceptions over time, which is what the panel structure of the data allows me to do. This is the approach adopted here in order to provide a set of results which supplement those from the data on inventory stocks and supplier turnover.

5 Results

Table 1 presents the industrial composition of firms in the sample, broken up by the status (on or off the Golden Quadrilateral) of the city the firms were located in. The distribution of firms across industries in treatment and control firms is similar: of the 8 top industries in the sample for treatment cities, 7 are also the among the top 8 in control cities. Nonetheless, there are differences: auto components and drugs/pharmaceuticals are a greater proportion of firms in treatment cities, while electronics firms make up a larger share of the control sample. In some of the regression results that follow, therefore, I will control for industrial composition.

5.1 Input Inventories: Leaner Inventory Management

Table 2 presents the means and standard deviations of the inventory stock variable for on- and off-Golden Quadrilateral cities in 2002 (the pre-period) and 2005 (the post-period). A comparison between the 2002 and 2005 inventory holding figures reveal there is a large change in the amount of inventory held by firms in cities affected by the Golden Quadrilateral project between the two survey years, while there is no such change in the inventory holdings of firms in the other cities in the sample. Firms in cities that lay on the Golden Quadrilateral held approximately 7 days of production's worth less of input inventories in 2005 than they did in 2002, whereas firms off the Golden Quadrilateral report virtually no change.

Table 3 presents results from regressions with firms' inventory holdings as the dependent variable. The coefficient of interest is that on the post-treatment dummy (i.e. the interaction term between the post-period and being in an on-project city), which is the differences-in-differences estimate of the impact of the Golden Quadrilateral. The first column presents results from the baseline specification with no additional controls. The estimated coefficient on the interaction of the post-period dummy with the treatment dummy is significantly negative, implying that treatment firms saw a reduction in their reported inventory holdings of approximately 7.5 days worth of production over and above that seen in the case of control firms.

A possible complication is that the distribution of firms across industries may have differed between treatment and control cities. If some industries then saw improvements in inventory management technology or a reduction in input inventory requirements that were unrelated to transportation infrastructure, and if these industries were disproportionately represented in cities on the Golden Quadrilateral, then the interpretation above could be misleading. To check for this, Column II of Table 3 reports results from a specification with industry fixed effects, which does not change the results: the coefficient of interest is -7.4, and is significantly negative. Finally, Column III reports results from a specification with firm fixed effects. The coefficient of interest continues to be significantly negative, and its magnitude is only slightly smaller, at -6.

5.2 Differential Supplier Turnover: Evidence on the Length of Supplier Relationships

As Table 4 shows, firms in cities on the Golden Quadrilateral showed a significantly lower increase in the length of their relationship with their main input supplier, with the point estimate of the coefficient of interest varying between -0.21 and -0.24 in alternative specifications. As I argued in Section 4.2.3 above, if supplier turnover were similar across the two groups of firms, then the interaction of the post-period with the treatment dummy should not pick up a significant coefficient. The coefficient on this variable thus suggests that supplier turnover was greater for firms on the Golden Quadrilateral than for other firms in the sample: firms in cities on the Golden Quadrilateral increased the length of their relationship with their main input supplier by around 4 months less than did corresponding firms in non-Golden Quadrilateral cities, thus implying that more firms in Golden Quadrilateral cities switched suppliers between the survey years than did firms in control cities.

5.3 Transportation as an Obstacle to Production

The fraction of firms who said that transport constituted a 'major' or a very severe obstacle' to production, i.e. those that picked either the highest or second-highest ordinal value on a 5-point scale changed differentially between firms in the affected and unaffected cities, again confirming the picture of disproportionate reductions in transportation obstacles to firms in the former set of cities. This percentage went down by 66.3 per cent, from 12.09 per cent in 2002 to 4.27 per cent in 2005, but there was no corresponding change for firms in off-Golden Quadrilateral cities, where the 2002 and 2005 numbers were 10.27 and 11.09 per cent of firms, respectively. Table 5 presents the results of differences-in-differences estimates: the results confirm the results from the regressions using inventories as the dependent variable, with the coefficient of interest (that on the variable post-treatment) being significantly negative. As Columns II and III of Table 5 show, these results are robust to the inclusion of industry and firm fixed effects. The perceptions data thus back up the results from the figures on input inventory management and the length of the supplier relationship presented in the preceding sub-sections.

All these results are as expected in that the Golden Quadrilateral eased transportation constraints differentially for affected firms relative to other firms. But were these constraints equally severe for both sets of firms to begin with, as one would expect if assignment was, as argued, unrelated to the conditions of the cities in either subset? Here, the perceptions data and the inventories data no longer tell the same story.

5.4 Pre-Existing Differences between Cities On and Off the Golden Quadrilateral

The coefficients on the variable 'treatment', which is a dummy which takes the value 1 for cities on the Golden Quadrilateral and 0 otherwise, is significantly positive (see Table 3), suggesting that there were significant pre-existing differences in inventory holding patterns between firms in treatment and control cities. A comparison across the rows of Column I of Table 2 confirms that non-Golden Quadrilateral cities held many more days of inventory in

2002 than Golden Quadrilateral cities did, suggesting either that road conditions or firms' characteristics/needs for inventories, or both, were systematically different between the two kinds of cities prior to the project being initiated. In the absence of more pre-Golden Quadrilateral data, it is not possible to explicitly test the 'common trends' assumption underlying the differences-in-differences estimation strategy, which may still be valid, but the finding reported above is potentially problematic for the simple exogenous change in road quality story stressed here, as it implies that while it may be the case that individual cities did not have the option to opt in or out of the project, there may be some reason that the 4 highways included in the project were included: perhaps these were the most congested and overburdened highways in the country. This is potentially problematic for the interpretation of the magnitude of the differences-in-differences results presented thus far, since it suggests that using the change in the inventory holdings of firms in non-Golden Quadrilateral cities may not be a good control for the counterfactual change in inventory holdings in Golden Quadrilateral cities.

Is it then the case that while treatment cities saw an improvement in their transport conditions that control cities did not, but began from a much worse position? Some evidence that speaks to this question is available from firms' responses in 2002 (the pre-period) to the question about the degree to which transportation posed an obstacle to their production. The distribution of firms' responses are very similar in treatment and control cities: about three-quarters of firms in either set of cities say that transportation posed either no or a minor obstacle to their production; likewise, 12 per cent of firms in treatment cities and 10 per cent in control cities say that it was a major or very severe obstacle. If anything, as Table 6 shows, the fraction of firms in treatment cities who say that transportation poses no obstacle is larger, at 0.47, than the corresponding fraction (0.40) in control cities. This does not suggest that firms in treatment cities were significantly more disadvantaged when it came to transportation than firms in control cities; if anything, quite the opposite. However, it is worth keeping in mind that this relies on comparing perceptions data across different firms, an undertaking that is problematic to the extent that two firms may perceive the same quality of infrastructure very differently: indeed, it appears here that firms in cities which would later benefit from better highways rated the quality of their transportation infrastructure very similarly to other firms although they also seem to have been holding far many more days' production worth of input inventories, which suggests that perceptions may be quite clearly conditioned by what is expected or appears to be the norm. The fact remains, however, that cities on and off the upgraded highways reported holding very different amounts of inventories prior to the project, so that the magnitude of estimates of the project's impact should be interpreted with some caution; this is something that data limitations preclude a deeper investigation of at this point.

5.5 Robustness Check: Excluding Nodal Metropolitan Cities

The results presented so far have all used data for all cities in the sample. Four of these cities - Delhi, Mumbai, Chennai and Kolkata - are the metropolitan cities which form the nodes of the improved highway system, and which the highways that were upgraded were chosen to connect. One obvious worry therefore is that these cities did not receive upgraded highways by virtue of lying on highways that were chosen to be upgraded: that argument works, strictly speaking, only for other cities that lay on the upgraded highways. I therefore test for the robustness of my results to the exclusion of these metropolitan cities by running the regressions again with these cities excluded from the sample. The results of the regressions on this non-metropolitan sample are presented in Table 7 for the three key outcome variables used here - days of inventory held, supplier history, and the probability that the firm rated transport as a 'major' or 'very severe' obstacle to production. Reassuringly, the exclusion of the nodal metropolitan cities has no effect on either the significance, direction, and in particular the magnitudes, of the estimated effects of the highway program.

6 Conclusion

Firms in cities that lay along one of the four national highways connecting the four largest cities in India that the Indian government upgraded as part of its Golden Quadrilateral report holding about a week's worth of production less of input inventories in 2005, when much of the project had been implemented than in 2002, when work had just begun, while firms which lay in cities off the Golden Quadrilateral highways report no such change.These firms also became much less likely to report that transportation was a major or severe obstacle to obstacle to production in 2005 relative to their responses to the same question in 2002. Firms on the upgraded highways also show a greater propensity to change suppliers between the two years, suggesting that they found more suitable suppliers at a greater rate than firms in cities unaffected by the highway project. Seen together, these pieces of evidence substantiate the idea that improved highways facilitated productive choices which firms may have wanted to make even earlier, but were constrained from being able to make by the quality of highways available to them. There is a large literature (see for example Djankov et al. 2008, Knittel 2002) that explores the effect of policy variables, such as regulatory practices and taxation, on firms' productive choices and through these on firm efficiency. This paper contributes to this literature by arguing that infrastructure quality is another key factor that affects how efficiently firms are able to produce, and by identifying the channels through which the effects of improved roads are channeled. In the specific context of India, the findings of this paper, seen in conjunction with the findings of papers such as Chari (2007) contribute to an understanding of what the government should (not) try to do if the private sector in that country is to fulfil its potential as a driver of economic growth.

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Table 1: Distribution of Firms Across Treatment and Control Samples

	Non-GQ	GQ cities
No. of Firms	487	604
Industrial Distribution (Per Cent of Firms in Sample in Each Industry)		
Garments	12.94	9.77
Textiles	12.94	12.58
Drugs and pharma	7.39	13.41
Auto components	9.86	14.57
Electronics	3.7	7.12
Electrical appliances	8.21	8.77
Machine tools	6.57	6.62
Food processing	12.94	5.13
Leather	2.46	4.14
Metals	8.01	3.48
Plastics	5.13	4.3
Rubber	2.05	1.66
Paper	1.03	1.49
Paints	0.62	0.5
Cosmetics	0.41	0.17
Other chemicals	4.11	3.97
Marine food processing	0.82	0.33
Agro processing	0.41	0.99
Wood	0.41	0.17
Sugar	0	0.66
Mineral processing	0	0.17

Table 2: Days of Inventory Held

	2002	2005	Change, 2002-5
	Non-GQ cities		
Days of Inventory Held	22.87	22.82	-0.05
(S.E.)	(28.42)	(19.31)	
	GQ cities		
Days of Inventory Held	34.28	26.71	-7.57
(S.E.)	(47.66)	(28.15)	

Table 3: Effect of the Golden Quadrilateral on Days of Inventory Held

Dependent Variable: Number of Days of Inventory of Most Important Input

post_treatment	**-7.52*** **	**-7.49*** **	**-7.18*** **	**-6.01*** **
SE	(2.79)	2.79	2.83	2.43
t-ratio	-2.69	-2.68	-2.54	-2.48
post	-0.05	-.050	-0.12	0.094
SE	1.59	1.58	2.10	1.51
t-ratio	-0.03	-0.03	-0.06	0.06
treatment	**11.41*** **	**11.08*** **	--	--
SE	2.39	2.38	--	--
t-ratio	4.77	4.64	--	--
Industry dummies	No	Yes	Yes	Yes
City fixed effects	No	No	Yes	No
Firm Fixed Effects	No	No	No	Yes
N	2109	2109	2109	2109

Table 4: Effect of the Golden Quadrilateral on Length of Firms' Relationship with Supplier

Dependent Variable: No. of Years In Business With Main Input Supplier

	I	II	III	IV
post_treatment	**-0.238*****	**-.236*****	**-0.236*****	**-0.215*****
SE	0.089	.088	0.083	0.084
t-ratio	-2.68	-2.65	-2.85	-2.57
post	0.364	0.363	0.363	0.354
SE	0.078	0.077	0.071	0.073
t-ratio	4.660	4.700	5.120	4.880
treatment	**0.478*****	**0.461*****	--	--
SE	0.072	.0709709	--	--
t-ratio	6.630	6.480	--	--
Industry dummies	No	Yes	Yes	No
City fixed effects	No	No	Yes	No
Firm Fixed Effects	No	No	No	Yes
N	2182	2182	2182	2182

Table 5: Effect of the Golden Quadrilateral on Firms' Perceptions of Transport

Dependent Variable: Dummy for Firm Saying Transport 'Severe' or 'Major' Obstacle

	I	II	III	IV
post_treatment	**-0.084***	**-.084*****	**-0.084*****	**-0.084*****
SE	0.049	.025	0.025	0.024
t-ratio	-1.71	-3.34	-3.44	-3.48
post	0.008	0.008	0.008	0.008
SE	0.043	0.020	0.018	0.019
t-ratio	0.19	0.42	0.45	0.44
treatment	0.018	0.018	--	--
SE	0.035	.0193	--	--
t-ratio	0.52	0.94	--	--
Industry dummies	No	Yes	Yes	No
City fixed effects	No	No	Yes	No
Firm Fixed Effects	No	No	No	Yes
N	2182	2182	2182	2182

Table 6 : Percentage of Firms Reporting That Transport Was *No* Obstacle to Production

	2002	2005	Change, 2002-5
	Non-GQ cities		
% of Firms	40.22	60.29	20.07
	GQ cities		
% of Firms	47.23	67.89	20.66

Table 7: Effect of the Golden Quadrilateral Excluding 4 Nodal Cities

Dependent Variable: See Column Head

Sample: Firms in all cities except Delhi, Mumbai, Kolkata, and Chennai

	Inventory	Suppliers	Obstacle
post_treatment	**-7.791*** **	**-0.196** **	**-0.075*** **
SE	2.728	0.090	0.027
t-ratio	-2.86	-2.19	-2.82
post	0.094	**0.353*** **	0.008
SE	1.855	0.061	0.018
t-ratio	0.1	5.8	0.5
Firm Fixed Effects	Yes	Yes	Yes
N	1756	1814	1814