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The impact of improved highways on Indian firms ☆

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ABSTRACT

India's Golden Quadrilateral Program, a major highway project, aimed at improving the quality and width of existing highways connecting the four largest cities in India. It affected the quality of highways available to firms in cities that lay along the routes of the four upgraded highways, while leaving the quality of highways available to firms in other cities unaffected. This feature of the project allows for a difference-in-difference estimation strategy, where status on and off the improved highways, and distance from them, are used as treatment variables. This strategy is 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 reduced their average stock of input inventories by between 6 and 12 days' worth of production. Firms in cities where road quality did not improve showed no significant changes. The reduction in stocks of input inventories also varied inversely with the distance between the city in which a firm was located and the nearest city on an improved highway. Firms on the Golden Quadrilateral were also more likely to have switched the supplier who provided them with their primary input, suggesting that they saw reason to re-optimize their choice of supplier after the arrival of better highways. Consistent with these findings, firms on the improved highways reported decreased transportation obstacles to production, while firms in control cities reported no such change.

1. Introduction and Motivation

This paper studies the effects of an ambitious program of highway improvements in India on firms in that country. It is motivated by – and contributes to – a large literature on the economic effects of investments in large-scale infrastructure, a key issue in development. Highways, the quintessential example of such infrastructure investments, are studied in papers such as Michaels (2008), Chandra and Thompson (2000) and Fernald (1998).

Such infrastructure investments are often posited as being essential for higher economic growth. Recently, for example, the World Bank has argued that Africa suffers from an "extensive infrastructure deficit" (Foster and Briceño-Garmendia 2009). Its simulations suggest that bridging this gap could have large growth dividends. For example, if "all African countries were to catch up with Mauritius in infrastructure, per capita economic growth in the region could increase by 2.2 percentage points" (ibid).

Significant budgetary resources are allocated to (or sought for) highway construction in many countries, based in part on such 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).

This is because estimating the economic effects of infrastructure must contend with several issues that complicate the analysis. In what follows, I briefly lay out the nature of these problems, before discussing how I attempt to deal with them in this paper through a combination of the identification strategy, data, and outcome variables used.

The first key issue that arises in trying to estimate the economic effects of infrastructure is that of the endogenous placement of new infrastructure, which makes it difficult to clearly quantify causal effects. This problem can be summed up as follows: do areas with (more, better) infrastructure show better economic outcomes *because of* the infrastructure, or is better infrastructure *attracted by* (the potential for) better economic outcomes? For example, we may observe that areas with better roads grow faster. However, if we suspect that roads are likely to have been built or improved in areas that had the highest potential for economic growth, simple correlations between road quality and growth are likely to overstate the impact of roads on growth (see, for example, the discussion in Qian et al., 2009).

Only truly random placement of a major infrastructure project can hope to deal with the endogenous placement of infrastructure in a completely satisfactory fashion. Particularly in the case of large-scale projects like inter-state highways or big dams, such random

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placement is difficult to conceive of. But in its absence, a series of recent papers cognizant of the endogeneity issue have attempted to tackle it creatively by using plausible instruments or a natural experiment to aid identification. For example, Duflo and Pande (2007) use gradient to instrument for the placement of hydroelectric projects in India 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 (2008) use a feature of the US Interstate Highway construction program that allows them to treat it as a natural experiment that affected counties through which the new interstate highways passed differently from those it bypassed. 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 the precise route of the highway was not manipulated to include some intermediate areas –whether counties, districts, or 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.

This paper approaches the issue of endogeneity using an identification strategy similar in spirit to that used by Chandra and Thompson (2000) and developed further in Michaels (2008). The nature of the project studied (India's Golden Quadrilateral, or "GQ" highway scheme) and panel data on a sample of firms representative of the country's entire non-agricultural private economy enable me to tease out plausibly causal estimates of the impact of improved highways on firms in India. I do so using a differences-in-differences approach, where changes in relevant outcomes for firms affected by the Golden Quadrilateral are compared to changes in outcomes for other firms.

The Golden Quadrilateral program sought to improve the quality and width of 5,846 km of existing highways connecting the four largest cities in India (Delhi, Mumbai, Kolkata, and Chennai). This dramatically improved the quality of highway transportation available to firms in cities that happened to lie along the routes of the four existing highways that were upgraded. However, firms in cities not on these highways did not directly benefit from comparable increases in the quality of highways available to them (see Fig. 1 for a depiction of the location of cities in the data relative to the upgraded highways). The position of the city where a firm is located relative to the highways that were upgraded thus created variation in the extent to which a firm should have seen the quality of the highways available to it improve as a result of the Golden Quadrilateral project.

I use data from two waves of the World Bank's Enterprise Surveys for India, which collected information about a random sample of firms in the formal sector, stratified by sector of activity, firm size, and geographical location so as to generate a sample[1] of firms "representative of the whole non-agricultural private economy". The panel structure of the data allows me to compare the responses of a representative sample of 1,091 firms in 37 Indian cities in 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, providing plausibly causal estimates of the effects of the project. Table 1a and b summarize relevant features of the cities, industries, and firms in the panel.

This paper's second contribution is an attempt to empirically document some of the microeconomic channels through which infrastructure affects economic outcomes. Theory suggests that firm-level variables (such as inventories, input costs, or capacity utilization) may respond to improvements in transport infrastructure (see, for example, Shirley and Clifford, 2004). But while a number of papers identify macroeconomic effects of infrastructure on growth, employment, or price convergence (see, for example, Demurger 2001, Chandra and Thompson 2000, and Donaldson, 2010), the microeconomic channels identified by the theoretical literature have received relatively little empirical attention beyond a small number of instructive case studies (see, for example, Gulyani 2001 and Holl 2004) and a recent paper by Duranton et al. (2011) which explores the effect of highways on the volume, value and composition of trade. However, the Enterprise Survey data contain firms' responses to questions that allow me to directly measure how the choices that firms make about inventories and input suppliers are affected by the quality of highway infrastructure.

I use two "treatment variables" to capture the degree to which a given firm is affected by the highway program. The first is a binary variable, which takes the value 1 if the firm is located in one of the 19 cities in the data on an upgraded highway and 0 if it is located in one of the other 18 cities. However, firms in "off-project" cities, whose cargo could also use the improved highways for at least part of their journey, were also affected by the project, albeit indirectly and to a smaller extent. This motivates a second, continuous, treatment variable: the driving distance of the city a firm is located in from the nearest city on the Golden Quadrilateral.

I also use two samples. The first (the "full sample") includes all the cities in the sample, while for the other I exclude the four metropolitan cities (Delhi, Mumbai, Kolkata, and Chennai) and their contiguous suburbs (Gurgaon, Faridabad, Ghaziabad and NOIDA in the case of Delhi, and Thane in the case of Mumbai). This "restricted sample" thus includes firms off the Golden Quadrilateral and those in non-nodal Golden Quadrilateral cities. The rationale for excluding the nodal cities from the analysis is that their status as 'on-Golden Quadrilateral' cities was a matter of design rather than fortuitousness, since these cities formed the nodes of the new system of highways. The choice of sample makes no difference to the sign and significance of the results I find, though the magnitudes of the effects naturally vary by sample. In the discussion, I emphasize the restricted sample because the identification is cleanest in this case. Further, as is clear for instance from Table 2a, the effects found are driven almost entirely by the cities in the restricted sample.

The key findings relate to firms' holdings of inventories of their principal input, and are as follows. A comparison of means shows that non-nodal firms on the Golden Quadrilateral highways reduced their average input inventory (measured in terms of the number of days of production the inventory held was sufficient for) by 10.5 days more than firms situated on other highways. In the full sample, the corresponding effect was 7 days' worth of production. The regression estimates are both statistically and economically significant, and suggest that being on the Golden Quadrilateral reduces inventory holdings by the equivalent of at least 6 days' worth of production (with the highest estimate from the restricted sample showing an effect just under twice as large). The effects are most pronounced for industries such as pharmaceuticals, food processing and electronics (see Table 2c). Being an additional kilometer further from the Golden Quadrilateral causes a firm to hold between 0.13 and 0.22 days' more worth of inventories. Thus, inventory management became significantly leaner for treatment firms relative to control firms after the improved highways were put into place.

I also find that firms in cities that gained better highway access were more likely to have switched the supplier who provided them with their primary input than firms in cities where road quality did not undergo a comparable improvement. Since any supplier available to a firm before the change continues to be available after the change, the fact that more firms on the improved highways change their primary input supplier suggests that a better supplier becomes feasible after the highway construction. This is a revealed preference argument: if highway quality was not constraining firms' input supplier

[1] More details about the sampling methodology adopted by the Enterprise Surveys is available at http://www.enterprisesurveys.org/Documents/Sampling_Note.pdf.