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Transport Infrastructure and Firm Performance

Evidence from Southern Africa

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Abstract

This paper investigates the impact of investments in transport infrastructure on firm performance. Using an original survey of approximately 900 firms in Southern Africa, I estimate the impact of access to a railway on firm sales. Exposure to railway infrastructure is instrumented by geographic proximity to the historical layout of a railway line destroyed by a civil war in the 1980s and rebuilt in 2008. To further account for historical advantages of regions served by the original railway I adopt a differences-in-differences approach that compares the performance of firms in the catchment area of the new railroad to that of firms in other historical transport corridors that planned to rebuild their railroads, but have not yet executed them. Overall, I find limited firm-level gains from access to the railway. I provide suggestive evidence on how the absence of impact may be driven by monopolistic practices of railway parastatals managing access to rail services. These findings highlight important policy complementarities between investments in "hard" and "soft" railway infrastructure.

Keywords: Transport Infrastructure; Firm Behavior; Transport; Trade Costs
JEL Classification Numbers: O18, O22, R42, R48.

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1 Introduction

An extensive literature suggests that reducing transport costs can promote trade, substantially increase income and improve welfare, particularly in the developing world (Amjadi and Yeats 1995; Frankel and Romer 1999; Hummels 1999; Limao and Venables 2001; Obstfeld and Rogoff 2001; Atkin and Donaldson 2012).[1] As a result, recent decades have witnessed large scale aid efforts to reduce transport costs, mostly through investments in the hard infrastructure of transport networks such as ports, railways and roads.[2] While the transport agenda has been at the forefront of the development discourse and policy in recent years, there is still limited empirical evidence on the micro-level mechanisms through which certain types of transport investments affect economic activity. Understanding these micro-links is however key to guide governments and donors in prioritizing investments across transport modes, in forecasting demand for transport services and in identifying optimal financing models that can ensure sustained improvements in transport services.

In this paper, I exploit a "quasi-experiment" provided by the rebuilding of a railway corridor in Southern Africa, to examine the direct and indirect effects of investments in railways on firm performance.

Decades of under-investment in transport infrastructure, and large distances between centers of production or consumption and trading gateways such as ports, mean that transport bottlenecks have been particularly taxing in Sub-Saharan Africa (SSA). Investments in transport infrastructure in recent decades have targeted all transport modes, but some of the most costly and challenging projects undertaken to date involved building railroad networks. While rail is often perceived to be the most cost-effective, safe and reliable mode of transport over long distances, the relationship

[1]Hummels (1999) argues that transport costs are comparable in magnitude and in variability to tariff barriers across countries, commodities and time; while Hummels (2008) and Amjadi and Yeats (1995) suggest that high transport costs impose a higher effective rate of protection than tariffs in most of the developing world. Limao and Venables (2001) in turn predict that a 10 percent decline in transport costs would increase trade by 25 percent for most developing countries.

[2]In 2011, expenditures on infrastructure in Sub-Saharan Africa were in the order of 11 billion dollars. Over the past decade, the World Bank alone (including the IFC and MIGA) have committed over 50 billion USD for operations or guarantees in the transport sector, amounting to approximately 12% of its total expenditure.

between railway investments and economic activity is however still heavily debated in the literature. Fogel (1964) first challenged the importance of the railways in triggering economic activity by applying the social savings methodology to compare the value added of the railways in 19th century US to an alternative transport network reliant on improved roads and canals. Fishlow (1968) countered these conclusions arguing that the social savings approach biased these estimates downwards by relying on hypothetical (instead of actual) transport networks available at the time.[3] Both authors however converged on the fact that the American experience was very context-specific, and that investments in railroads throughout the developing world were unlikely to yield similar results. More recently, Banerjee, Duflo and Qian (2012) find limited growth effects of the Chinese historical railroads. In contrast, Donaldson (2010) provides evidence that the railroads built in colonial India significantly reduced trade costs and stimulated inter-state trade; a result confirmed in Jedwab and Moradi (2011) in colonial Ghana.

While research on the impact of the most recent wave of investments in railway infrastructure in post-colonial SSA remains rare due to data and identification constraints (Wolpin and Rosenzweig 2000), a recent technical report by the World Bank provided a dire (qualitative) assessment of 20 years of the organization's support for railways in post-colonial Africa: out of 15 railway projects supported, none appears to have had a sustained impact on economic development (IEG World Bank 2013).

To investigate whether the relationship between investments in the railway and firm performance is causal, I rely on a quasi-experiment generated by the rebuilding of a railway connecting the industrial and agricultural heartland of South Africa to the Port of Maputo in Mozambique (see Figure 1). The layout of this transnational railway was determined in the 19th century, primarily to provide the South African mining industry with a fast connection to the sea. The line was severely damaged in the 1980s due to civil war in Mozambique. In the early 2000s, the Mozambi-

[3] Others have pointed out further methodological shortcomings of the social savings approach namely its vulnerability to positive bias due to an assumption of an elastic transport demand and a negative bias due to a neglect of increasing returns to scale in a given transport mode (David 1969).

can government resorted to concessional lending to rebuild its transport infrastructure. Despite a stated preference for a new railway line to connect the domestic market, the international financial institutions supporting the project pressured for the rebuilding of the historic transport corridor connecting South Africa to Southern Mozambique, as a guarantor of political integration and stability in the region. The high capital requirements associated with building a new railroad constrained the government into rehabilitating the old one.

In South Africa, since the destruction of the original line, the depletion of former mineral reserves has since changed the spatial location of several mining companies and containerization has vastly expanded the range of products that can be shipped by rail. As a result, the new railway, following the historical layout, serves a very different set of industries and firms than it was originally designed to. The layout of the railroad is therefore plausibly exogenous to the current geographic location of firms operating in the region. To estimate the impact of access to rail on firm performance I instrument rail usage with the distance between each firm and the closest station of the railroad. To control for observable and unobservable industry-level transport technology and time-invariant province-level characteristics that may be associated with railroad placement and firm performance I include industry and province level fixed effects. To further mitigate the possibility of selection bias in the location of firms, I show that the main results are robust to restricting the analysis to firms that were established at least eight years before the railroad was rebuilt.

To evaluate the impact of the railway on Mozambican firms, I exploit the fact that there are two additional "control" corridors in the country, for which the rebuilding of their respective railroads was planned but not executed due to contractual disagreements between the private partners overseeing the works. Contamination of these control groups is unlikely given the geography of the transport network and the significant distance between the Southern Corridor and the alternative transport corridors in the country -the Beira and Nacala corridors are 2700 and 1200 kms North of Maputo respectively-. This allows me to apply a straightforward differences-in-differences approach to isolate the impact of a firm being in a treated corridor (Maputo), and a triple-differences estimator, by interacting an indicator for a treated corridor with the distance between the firm and the closest historical railway station. This strategy allows me to mitigate concerns with any historical advantages of firms located closer to the railway and to directly control for overall trends in firm performance in the country.

First, I show that the railway had a negligible impact on firms' transportation costs. Second, I find no reduced-form evidence of firm-level output gains associated with proximity to a working station of the railroad. These results hold across both South African and Mozambican firms, and for firms of different sizes. Third, I provide (only) suggestive evidence on how monopolistic practices in railway management could explain the limited impact of railways on business, in the form of distorted pricing practices and restrictive access to rail slots.

This paper contributes to a longstanding literature attempting to measure the impact of railway infrastructure on economic activity (Fogel 1964, Fishlow 1965; Auschauer 1989; Attack and Margo 2009; Banerjee et al. 2012; Donaldson 2010; Atack, Bateman, Haines, and Margo 2010) and transport infrastructure more broadly on economic growth (Limao and Venables 2001; Clark, Dollar, and Micco 2004; Michaels 2008; Duranton and Turner 2012). It also adds to a growing literature highlighting the complementarity between the quality of governance and economic returns to infrastructure (Jones and Romer 2009, Robinson and Tvorcik 2005) and to studies stressing the role of the soft side of transport infrastructure in constraining the functioning of transport markets (Raballand and Maacchi 2010; Sequeira and Djankov 2011).

While I build on this research, there are two main advantages to the approach I take in this paper. First, placing the firm as the main unit of analysis can provide a clearer picture of the potential distributional impact of railways across regions and across firm types. Second, I rely on original survey data to measure firm performance, to identify the exact location of firms and to identify prices for alternative transport modes available to firms. Second, I observe the impact of investments in railroads in a contemporary setting, mitigating the potential policy confounds associated with historical studies and longer time horizons. The trade off to bear in mind is that the results speak mostly to the short-run impact of railways on firm performance.

The paper proceeds as follows. Section 2 discusses the main conceptual framework, Section 3 describes the empirical setting and the data collected for this study; Section 4 presents the main empirical results, Section 5 discusses robustness checks, Section 6 discusses qualitative findings on the importance of soft infrastructure and Section 7 concludes.

2 Conceptual Framework

An extensive literature, mostly empirical, has long debated the role of the railways in stimulating economic growth. The earlier literature contended that the railways were a critical pre-condition for economic take off in nineteenth century US (Schumpeter 1942; Rostow 1960) due to its substantial linkages to the development of the industrial complex (Hirschman 1967). Fogel (1964) however famously placed the contribution of the railroads into historical perspective, by interpreting the American experience with rail against the backdrop of an already changing economy. Introducing the social savings methodology, Fogel estimated the cost savings introduced by the railroads relative to its best hypothetical alternative: freight transportation by an expanded (and improved) network of rivers, canals and roads. The author concludes that the value added attributable to railroads was relatively small (2.7% of GNP). Fishlow (1965) estimated higher social savings by using as counterfactual the actual transport routes that existed at the time, instead of the hypothetically expanded and improved transport network. Both authors however converged on two main issues: the heterogeneous effects of rail across regions (eg: despite substantial railroad mileage in the South, there was a general consensus that it did not lead to industrialization or to the diversification of its economy); and the exceptional nature of the American experience. Developing countries with unproductive agricultural and manufacturing sectors, wasteful government institutions, poor governance and limited entrepreneurial capital should not expect the railroads to succeed in stimulating economic growth (Fishlow 1964).

Recent empirical studies testing this hypothesis continued to reach mixed results. Jedwab and Moradi (2012) provided evidence on how districts in colonial Ghana connected to the railway system were more urbanized, had better infrastructure and larger manufacturing and service sectors, despite thirty years of marked decline in rail transportation. Donaldson (2013) finds similar results, revealing that railroad investments in colonial India were associated with significant reductions in trade costs, price convergence and gains from trade. A second set of studies found more limited growth effects of rail in colonial Ghana (Chaves, Engerman and Robinson 2010) and China (Banerjee, Duflo and Qian 2012). What has remained relatively unexplored in this debate is the impact of railroads on firm performance, as an important micro-foundation of economic activity.

In theory, investments in railways can affect firm performance through various channels. By lowering transportation costs, investments in railways can stimulate product market competition, enlarge markets, reduce costs through economies of scale and facilitate market interactions both among firms and between firms and customers (Murphy, Shleifer and Vishny 1989; Lall et al 2004; Graham 2007; Holl 2006 and 2011). If railways affect labor mobility they can further increase access to specialized labor and generate important economies of agglomeration. Finally, investments in transport infrastructure can affect firm productivity by reducing reliance on costly inventory keeping (Holl, 2006; Datta, 2011; Kremer et al 2013).

Motivated by this literature, I investigate empirically how investments in rail infrastructure affect firm-level transport costs and firm performance. Focusing on the firm as the main unit of analysis further allows me to detect potential distributional effects of investments in rail across firm size, sector and region.

3 Empirical Setting

3.1 The Maputo Transport Corridor

In the mid 2000s Mozambique began rebuilding its transport networks with the primary goal of connecting a fragmented domestic market following decades of civil conflict, natural disasters and economic instability. Given the high capital requirements of railway systems, resorting to concessional lending by international financial institutions (IFIs) was the only viable policy option. This financial support conditioned the type of investments made. While Government's stated preference went towards investments in domestic transport corridors, the IFIs' support was directed towards investments in international transport links that would promote regional peace and stability through economic integration. For Mozambique, this meant targeting three international corridors that had historically connected the country to South Africa (Maputo corridor), Zimbabwe (Central corridor) and Malawi (Northern corridor).

Each of these corridors consisted of a main railway line, a port and a main road. The Southern corridor linking the industrial, agricultural and mining heartland of South Africa to Mozambique developed at a faster pace, as the rehabilitation of the railroads of the other two corridors were delayed by disagreements between the private parties involved in the construction work. The main railroad in the Maputo corridor was rebuilt in 2008.

The Maputo corridor serves both Southern Mozambique and Northeastern South Africa (see figure 1). In South Africa, there are two comparable corridors linking Johannesburg to the port of Cape Town on the western seaboard and Johannesburg to the port of Durban, approximately 700 km South of the port of Maputo. Both of these have functional railroads.

3.2 Identification

There are two main challenges to identifying a causal relationship between access to rail transport and firm performance: the non-random placement of railroads and the potential selection of firms into areas that are better served by transport links. Railways are often constructed to connect areas experiencing high levels of economic growth, or as greenfield investments built ahead of demand with the purpose of stimulating economic activity. Each of these cases could lead to an over or under estimation of the impact of rail on firm performance. The second main challenge is that firms can self-select into locations (and industries) better served by transport networks, leading to selection bias.

To mitigate concerns with the endogenous placement of railroads and firms I adopt a two pronged-approach. In South Africa, I exploit the fact that the layout of the Maputo railroad is arguably exogenous to the current geographic location of firms. The layout of the Mozambican railway was determined in the 19th century, primarily to serve the needs of the South African mining industry by providing it with a fast connection to the sea. The line was destroyed in the 1980s due to civil war in Mozambique. In the mid 2000s, the high capital requirements of building a new line determined that the old line would be rebuilt. In the meantime, the depletion of South African mineral reserves changed the spatial location of several mining companies, patterns of economic activity changed from mining to manufacturing and agri-business, and the advent of containerization in the mid-80s vastly expanded the range of products that could be shipped by rail. As a result, the current railway, with the old layout, serves a very different set of industries and firms than what it was originally intended to.

The main empirical approach is then to instrument exposure to rail with the geographic distance (by road) between each firm and the closest station of the rebuilt railway. This instrument is shown to satisfy the relevance condition as it is correlated with the share of rail transport used by each firm, as well as the exclusion restriction since distance to a rail station is unlikely to affect firm performance apart from its impact on rail usage. To further control for observed and unobserved differences between the geographic location of firms and industry level transport technology I include province and industry fixed effects. To further mitigate the possibility of firms selecting into treatment (understood as being close to a railway), I also present results that restrict the analysis to firms established in a given sector and location at least 8 years before the rehabilitation of the railroad.[4]

In Mozambique, I take advantage of the existence of "control" transport corridors, in which firms once had access to a historical railroad that is still nonoperational today.[5] This provides a unique opportunity to compare the performance of similar firms across the treated corridor (Maputo) and the control corridors (in Central and Northern Mozambique), through a straightforward differences-and-differences approach that accounts for historical advantages of particular regions with previous access to rail. Heterogeneity in firm location (and consequently in distance to the railway) provides an additional layer of variation in exposure to the rail treatment, enabling a triple-differences estimate of the impact of rail on firm performance. Both "treatment" and "control" firms are located within a radius of 200 km from the respective corridor.

While there are two additional transport corridors connecting Johannesburg to the Ports of Cape Town and Durban in South Africa, both of these corridors are already served by a railway. As a result, adopting the same differences-in-differences strategy with the South African sample of firms renders estimates that are not directly comparable to those obtained with the Mozambican sample.

3.3 Data

This study relies on three main sources of primary and secondary data. First, I conduct two waves of a firm-level survey in 2006 and 2011, before and after the rehabilitation of the Maputo railroad in 2008. This survey of approximately 900 firms elicits information on firms' transport strategies and general firm performance indicators. The survey was conducted among approximately 450 Mozambican firms randomly selected from all three corridors (Maputo, Central and Northern) and 450 South African firms selected from the Maputo corridor as well as the Cape Town and Durban

[4] The results are robust to considering longer cutoffs.

[5] While all three corridors were slated for development at the same time, the rebuilding of the railroads has been delayed until at least 2018 given contractual disagreements between the private parties involved in the works.

corridors. In both cases, the sample was stratified by firm size and industry.

The main sampling frames from which the samples were drawn were based on government listings of registered firms. Refusal rates were low (about 15% of the sample on average) though attrition rates were high (about 70%), translating into an unbalanced panel for both countries.[6] Firms that exited the sample in the follow-up survey were replaced by a randomly selected firm drawn from the same size, age and industry strata.

To identify changes in the cost of road transport potentially triggered by the rehabilitation of the railroad, I conduct a trucking survey of 220 firms in both South Africa and Mozambique, which elicits information on the cost of road transport. The sample of trucking companies was drawn in a two-step process. 60% of the sample in each country was drawn from a sampling frame consisting of all registered trucking companies in the Department/Ministry of Transport while the remaining 40% of trucking companies were sampled in the field, in areas where informal truckers tend to congregate such as lorry parks or the entrance to the main port. Enumerators identified every third truck entering the lorry park as a respondent, on randomly selected days of the week, and randomly determined times of the day. These surveys are therefore representative of both formal and informal trucking markets in both countries. Transport prices were further verified through an audit study: an additional sample of 80 trucking companies were contacted (following a mystery client format) and asked for a quote for a the shipment of a standard 20 inch container on the Maputo transport corridor. Prices of rail transport for similar cargo were obtained from the transport parastatal managing the rail services.

[6] For further discussion of selection issues see section 5.2 of Robustness Checks

4 Impact of Railroads on Firm Performance

4.1 Descriptive Statistics: Firms and Transport Costs

Tables 1 and 2 present the descriptive statistics of firms located in the "treated" corridor of Maputo, and the "control" corridors in both Mozambique and South Africa. There is significant variation in the distance (measured by road) between each firm and the nearest station of the railway. The connection between each firm and the station of the railroad was, in most cases, through a well-maintained paved road (for 93% of the firms in South Africa and 78% of the firms in Mozambique).

4.2 Empirical Analysis of Railway Impact on South African Firms: an Instrumental Variables Approach

To test for the impact of rail usage on firm performance I estimate the following equation:

$$Log(\frac{Y}{L})_{iklt} = \alpha + \beta_1 * Rail_{iklt} + \Gamma' X_{it} + \gamma_k + \omega_l + \mu_t + \epsilon_{iklt} \quad (1)$$

Where Y/L_{it} represents firm output per worker for firm i, located in province$l$, in industry k, in period t. Firm output is measured as sales, which are CPI adjusted with a base year of 2005 to facilitate intertemporal comparisons.[7] $Rail$ represents the share of firm i's transport costs represented by rail; while γ_k represent industry fixed effects; ω_l province fixed effects and μ_t year fixed effects. The vector of firm characteristics X_{iklt} includes firms' capital-labor ratio (measured as a firm's netbook value of capital CPI adjusted at 2005 prices), and controls for management characteristics like gender, race and level of experience of the manager. Equation (1) is thus interpretable as a Cobb Douglas value-added function featuring constant returns to scale.

As discussed in section 3.2 estimating the impact of infrastructure projects on firm performance raises the concern of a potential correlation between project placement, firm location and unobserved

[7]CPI deflators are used given the lack of Producer Price Indeces available for Mozambique

changes in the local economic environment. Historically better connected regions might attract new rail construction and more efficient firms might self-select into better connected regions. This will over-estimate β_1 due to omitted location specific historical advantages in exposure to colonial railroads, which might also attract entry of more efficient firms. In the particular setting under analysis, these concerns are mitigated by the fact that the new railway followed the layout determined by the 19th century geography of business due to the high cost of a greenfield investment, and by the advent of containerization, which greatly expanded the range of services and industries that could be served by the railway relative to when it was first built. This setup suggests an instrumental variables (IV)-industry/province fixed effects estimator (Holl 2011), in which a firm's access to rail is instrumented with the distance between the firm and the closest station of the historical railroad. Industry fixed effects control for observed and unobserved time invariant industry characteristics such as its level of transport intensity and the suitability of cargo for rail transport (which was unlikely to change between 2006 and 2011). I then use a Generalized Methods of Moments (GMM) model so that estimates are both consistent and efficient (Woolridge 2002). Robust standard errors are clustered at the industry level.

4.3 Discussion of Results: Instrumental Variables

Table 3 presents the main results. Across all specifications, rail usage has no significant effect on firm performance in South Africa. The elasticity of firm sales to rail usage is very close to zero and not statistically significant. The OLS estimates in Column (1) and (2) differ substantially in magnitude from the just-identified IV estimates in columns (3)-(5) confirming the endogeneity of rail usage. Including industry fixed effects does not significantly alter the magnitude of the coefficients, which may reflect the lack of substantial variation across industries on the impact of rail.

While the p-value for the first stage F stat suggests that distance to a working station of the rail is a valid instrument, the minimum eigenvalue statistic for a Stock and Yogo (2005) test is low, raising the concern that the instrument may be weak. To account for this possibility, in column (5)

I present results using a limited information maximum likelihood (LIML) estimator, which has been shown to have better finite-sample properties than the two-stage least squares estimator, particularly in the presence of weak instruments (Stock and Yogo 2005). Using similar specifications, I find no evidence that the impact of rail differs across firm size, or that there is any impact of access to railways on the share of a firm's costs determined by transport or the firm's inventory levels (results available upon request).

4.4 Empirical Analysis of Railway Impact on Mozambican firms: Differences-in-Differences

In Mozambique, I adopt a differences-in-differences approach to overcome the limitation of the non-random placement of rail and the endogenous location of firms. This allows me to control for any underlying trend in firm/industry performance in the particular corridor under study, or any historical advantages for a firm (or region) that had access to railroads in the 19th century. This motivates the following estimating equation that compares outcomes in "treated" firms against the corresponding changes in outcomes for "control" firms:

$$Log(\frac{Y}{L})_{ik} = \alpha + \beta_1 Treated\,Corridor_{ik} + \delta * Treated\,Corridor_{ik} * POST + \\ + \beta_2 POST + \Gamma' X_{ik} + \gamma_k + \epsilon_{ik} \quad (2)$$

where TC represents a treated corridor and the coefficient of interest is δ.

In the simplest version of this empirical stategy, I resort to a binary treatment variable indicating that a firm is "treated" if it is within a 200 km radius of the main corridor that rebuilt the railway and a "control" firms is located within a 200 km radius of a corridor that did not. Since this differentiation may be too crude given the potential for spillovers within provinces, I also use the distance between each firm and the railway in each corridor as capturing a more precise treatment effect. This translates into the following triple-differences equation:

$$Log(\frac{Y}{L})_{ik} = \alpha + \beta_1 TC_{ik} * Distance_{ik} + \phi * TC_{ik} * Distance_{ik} * POST +$$
$$+\beta_2 POST + \beta_3 TC_{ik} * POST + \beta_3 Distance_{ik} * POST + \Gamma' X_{ik} + \gamma_k + \epsilon_{ik} \quad (3)$$

In this case, the coefficient of interest is ϕ capturing the differential impact of distance to rail in a treated province relative to proximity in a non-treated corridor.

4.5 Discussion of Results: Difference-in-Differences

The results are presented in Table 4. While the difference-in-differences estimates suggest an overall negative impact of access to railroads on firm sales, the triple-differences estimates that exploit variation in the location of firms suggest no detectable impact.[8] Following Angrist and Han (2004) and Crump, Hotz, Imbens and Mitnik (2009), in column (5) I prescreen the estimating sample for treatment and control firms with overlapping distributions of covariates. Propensity scores are estimated (logit) based on a vector of firm and industry-level characteristics such as size, length of establishment, sector and history of sales. Results remain unchanged. When regressions are run separately for large and small firms, I detect no differential effect of railways on firms of different sizes.

[8]When the analysis is restricted to firms that began operations ten years before the Maputo railroad was rebuilt, the results remain unchanged.

5 Robustness Checks

5.1 Placebo Tests in Comparable Transport Corridors (South Africa)

In Table 5 I run placebo regressions in the "control" corridors of South Africa, instrumenting access to rail with the distance between a firm and the closest station of the respective railroad. The goal is to detect if distance to a historical railroad captures important unobserved historical advantages or firm characteristics that could explain the main results. Reassuringly, these 'placebo' corridors never display spurious effects driven by the location of the railroad relative to firms.

In Table 6 I extend the differences-in-differences analysis to the South African context, identifying as "control" firms those located in the alternative corridors of Cape Town and Durban.

5.2 Differences-in-Differences: the Parallel Trend Hypothesis

The validity of the differences-in-differences identification strategy for Mozambican firms relies on the assumption that firms in the "treated" and "control" corridors would have had common trends in sales and other important characteristics such as the number of workers in the absence of the railroad. This is what makes the changes in outcomes for "control" firms a good counterfactual for changes in outcomes of a "treated" firm. I test for the common trend assumption directly in Table 7, using data for firms in 2003, which was recalled during the 2006 survey. Averages are close and differences are not statistically significant at conventional levels. In the main specifications, I also include interactions between the post-treatment variable and time-varying firm characteristics such as ownership and capital investments to ensure that the results are not driven by differential trends in either of these variables across time.

5.2.1 Selection and Sampling

An additional empirical concern stems from the unbalanced nature of the firm panel data due to high, and potentially non-random, attrition rates. Table 8 (Panel A) presents tests for equality of means (with unequal variances) of important firm-level characteristics in 2006 between firms that remained in the panel and firms that exited the panel in the second wave of the survey. These characteristics include the level of firm sales per worker, the net book value of firm capital per worker, the number of workers and the length of establishment of the firm. All means are moderately close and equality is not rejected at conventional levels of significance. Panel B in Table 8 suggests that the firms sampled in 2006 and 2010 -the latter including replacements- are also similar based on important exogenous characteristics such as the age of the firm and the location of the firm relative to the railroad.

As a further test of the main results for both South Africa and Mozambique, I restrict the analysis to the sample of firms observed in both waves of the survey (balanced panel). Estimating the model in first differences (Table 9) and allowing for differential trends in industry, length of establishment, location and ownership type, reveals no significant impact of railways on firm performance in South Africa or in Mozambique.

6 The Importance of Soft Transport Infrastructure

While there may be many reasons behind the limited effect of access to railways on firm performance, one possible driver is the poor quality of the soft infrastructure of rail transport. Design and data constraints prevent me from firmly establishing a causal link, but I present suggestive qualitative evidence on how monopolistic practices in the management of rail services in the Maputo corridor, namely uncompetitive pricing and selective access to rail slots, can dampen demand for rail by eroding service provision.

Table 10 compares prices for rail transport on the Maputo corridor relative to similar rail corridors in the region. With the exception of the DRC, rates per ton-km on the Maputo corridor are on average up to 50% higher relative to prices practiced in similar railroads in the region. To compare the cost of rail relative to alternative transport modes available to firms, I conduct an original survey of trucking companies operating in the Maputo corridor to elicit actual road transport rates for standard cargo. Table 10 compares road and rail prices for a standard 20 inch light container (full). The table suggests that rail transport is uncompetitively priced relative to road transport (by a factor of 2).

The main firm survey also provided (mostly qualitative data) on how gaining access to rail slots was problematic, as large volumes transported for a subset of client appeared to be prioritized relative to new, smaller clients who were interested in consolidating cargo and shipping smaller volumes. Further research is warranted to establish the importance of these institutional constraints in depressing demand for rail.

7 Conclusions

Despite mixed evidence on the causal link between investments in railways and economic growth (Fogel 1964; Fishlow 1966; Rostow 1960; Wright 1990; Attak et al 2009; Banerjee et al 2012), recent years have brought significant investments in railroads in the developing world as a means to removing important transport constraints to firm competitiveness and economic growth. Since investments in railway infrastructure tend to be costly and difficult to reverse, documenting the magnitude and the functional form of the impact of railways on economic growth is critical for the optimal design of future transport policies.

This study contributes to the debate on the economic relevance of the railroads by providing new evidence on the relationship between investments in railways and short-term changes in firm-level performance for a major railway in Southern Africa that connects South Africa to Mozambique. It does so by tracking the performance of a sample of over 900 firms, before and after the rebuilding of an historical railroad.

In South Africa, the main identifying assumption is that the historical layout of the railroad is exogenous to the current location of business. Access to rail transport is instrumented with the distance between each firm and the closest station of the railroad, while industry and province fixed effects control for permanent features of firms, their location and their required transport technology. The results suggest that the railway had a negligible impact on firm performance in South Africa.

In Mozambique, differences-in-differences and triple-differences estimations compare the performance of firms in the transport corridor served by the new railroads, relative to similar transport corridors that did not experience any changes in access to rail during the period under analysis. There is also no significant impact of the railroads on Mozambican firms. While data and design constraints prevent me from firmly establishing the determinants of the limited impact of rail, I provide suggestive qualitative evidence that it could stem from distorted pricing strategies and selective distribution of rail slots. These findings may therefore highlight the high complementarity between institutional reform and infrastructure investment, and related challenges of policy sequencing that can significantly dampen the impact of the investments in hard infrastructure currently underway in the developing world.

An important caveat is that the analysis discussed in this paper is restricted to the short-term effects of railroads on firm performance, as the window of analysis is of only four years. The particular setting under analysis is however one in which the railway in all five corridors was not perceived as a greenfield investment (ie built ahead of demand) but as responding instead to pent up demand for transport services in the region. As a result, the effect of the railroad in relieving binding transport constraints was plausibly expected to be felt even in the short-run. Extending the analysis to a longitudinal study remains an important area of future research.

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9 Figures

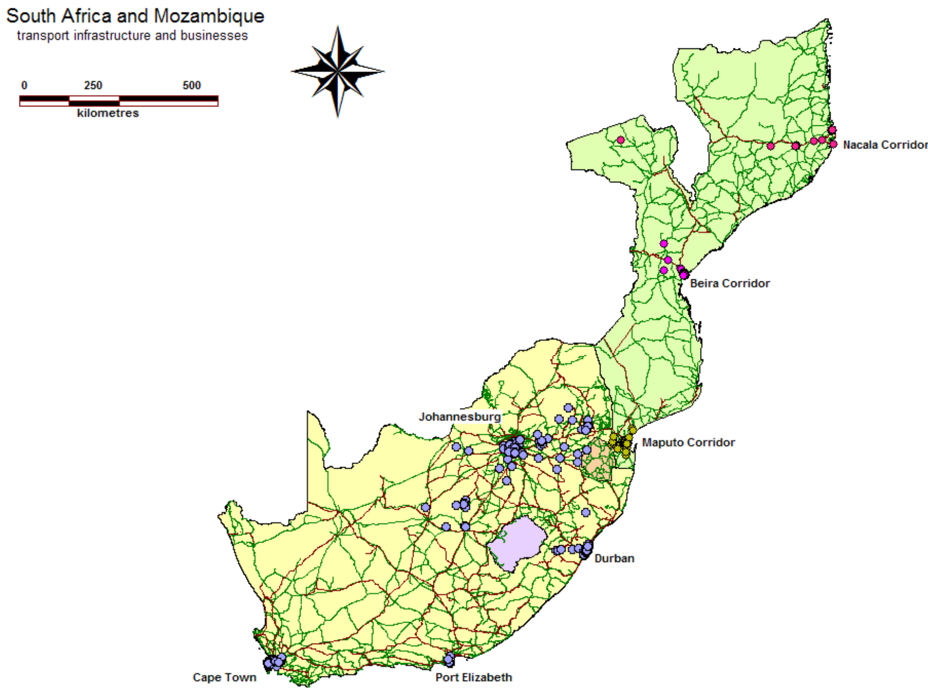

Figure 1: Transport Corridors in Southern Africa. Mozambique (in green): Maputo; Beira (Central Corridor) and Nacala (Northern Corridor). South Africa (in yellow): Maputo; Cape Town and Durban. Dots represent surveyed firms.

10 Tables

Table 1: **Descriptive Statistics: Firms in South Africa**

YEAR	2006			2010		
Transport Corridor	**MAPUTO**	**Durban**	**Western Cape**	**MAPUTO**	**Durban**	**Western Cape**
Distance train station (km)	3.7	1.8	1.9	2.9	1.2	1.3
	(4.5)	(1.8)	(1.8)	(3.09)	(1.03)	(1.64)
Distance to Port $\frac{Rail}{Road}$ (km)	1.2	0.83	0.86	1.2	1.2	0.9
	(0.54)	(0.4)	(0.4)	(0.4)	(3.1)	(0.23)
Number of Employees	47	47	58	65	51	67
	(75)	(55)	(80)	(89)	(65)	(75)
Sales (USD, CPI adjusted, 2005)	5,883,333	3,050,000	6,216,667	9,266,667	5,050,000	2,566,667
	(17,333,333)	(6,816,667)	(16,166,667)	(18,666,667)	(12,100,000)	(25,666,667)
Capital (USD, CPI adjusted, 2005)	2,200,000	1,197,320	1,916,667	3,766,667	543682	1,783,333
	(8,950,000)	(6,383,333)	(17,000,000)	(27,500,000)	(1,274,719)	(8,333,333)
Percentage of Firms Importing	33	43	56	49	61	78
Percentage of Firms Exporting	15	13	26	39	32	33
Share of Road Transport	79	72	80	73	81	81
Percentage Black Ownership	31	38	20	24	15	30
Firm Age	19.6	23.17	23.9	24.11	28.6	30.7
	(16.8)	(18.5)	(20.1)	(22.07)	(24.5)	(23.2)

[a] Source: Original Firm Survey.

Table 2: **Descriptive Statistics: Firms in South Africa**

YEAR	2006			2010		
Transport Corridor	**MAPUTO**	**Central**	**Northern**	**MAPUTO**	**Central**	**Northern**
Distance to train station (km)	4.5	12.2	3.3	4.02	2.6	3.3
	(6.9)	(31.3)	(11.7)	(5.54)	(2.5)	(4.6)
Distance to Port $\frac{Rail}{Road}(km)$	2.7	0.85	1.72	0.6	1.3	1
	(17.3)	(1.54)	(1.09	(1.21)	(3.8)	(0.02)
Number of Employees	22.4	19.8	32.96	32.6	8.4	12.7
	(42.6)	(43.8)	(68.06)	(57.9)	(11.9)	(21.04)
Sales (USD, CPI adjusted, 2005)	476,628	81,265	259,188	582,896	169,917	425,783
	(2,450,159)	(286,274)	(661,614)	(2,391,796)	(822,646)	(2,237,188)
Capital (USD, CPI adjusted, 2005)	1,761,375	144,830	2,413,407	251,771	1,108,211	34,048
	(4,306,039)	(341,676)	(7,059,311)	(1,345,263)	(5,339,838)	(169,262)
Percentage of Firms Importing	34%	19%	23%	52%	16%	52%
Percentage of Firms Exporting	4%	7%	9%	4%	4%	7%
Share of Road Transport	80%	90%	74%	85%	87%	90%
Percentage Black Ownership	72	80	78	58	78	62
Firm Age	17.6	19.01	16.3	14.08	13.6	9.9
	(12.1)	(12.9)	(9.6)	(13)	(13.04)	(7.6)

[a] Source: Original Firm Survey.

Table 3: **Impact of Rail on Firm Performance: South Africa - IV Results**

	Dependent Variable: Log Sales/Worker				
	(1)	(2)	(3)	(4)	(5)
RAIL	-0.00316	-0.00461	0.0530	0.0531	0.03
	(0.00556)	(0.00482)	(0.144)	(0.144)	(0.08)
Log Capital/Worker	0.258**	0.259**	0.220*	0.220**	0.2**
	(0.0851)	(0.0878)	(0.0922)	(0.0922)	(0.09)
Constant	10.19***	10.51***			
	(1.645)	(1.769)			
N	204	204	194	194	154
adj. R^2	0.189	0.228			
			First Stage Regression		
Distance to Rail			-0.016**	-0.016**	-0.289**
			(0.07)	(0.07)	(0.09)
F test excluded instruments (P-value)			0.04	0.04	0.0411
Kleibergen-Paap Wald rank test			5.11	5.11	5.35
Industry Fixed Effects	No	Yes	Yes	Yes	Yes
Province Fixed Effects	No	Yes	Yes	Yes	Yes
City	Yes	Yes	Yes	Yes	Yes
Owner characteristics	Yes	Yes	Yes	Yes	Yes
Firm Age	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes

[a] Standard errors in parentheses.

[b] Results significant at *** 1%, **5% and *1%

[c] Column (1) represents standard OLS, column (2) OLS with industry and province fixed effects; columns (3), (4) and (5) an instrumental variables specification in which the variable RAIL is instrumented with the distance between a firm and the closest station on the railroad. Column (3) presents the estimates for a GMM model and Columns (4) and (5) a limited-information maximum likelihood model. In Column (5) the sample is restricted to firms established 10 years before the railway was rebuilt.

Table 4: **Impact of Rail on Firm Performance: Mozambique-Differences in Differences**

	Dependent Variable: Log Sales/Workers				
	(1)	(2)	(3)	(4)	(5)
ldcapital_tL	0.256***	0.254***	0.257***	0.346***	0.322***
	(0.0305)	(0.0310)	(0.0307)	(0.0388)	(0.0325)
prov_treated	-0.592**	-0.597**	-3.529**	-3.378**	-0.306
	(0.175)	(0.151)	(0.967)	(0.916)	(0.307)
prov_treated_post	-0.589**	-0.640***	-0.494***	-0.431**	-0.0767
	(0.190)	(0.152)	(0.101)	(0.125)	(0.0950)
post	-0.173	9.178***	0.203*	0.584**	0.102
	(0.150)	(1.776)	(0.0794)	(0.189)	(0.309)
dist_tstt_post			0.326*	0.309*	0.245
			(0.138)	(0.142)	(0.124)
dist_tst_trim			-0.305*	-0.295	-0.216
			(0.138)	(0.144)	(0.122)
dist_tst_pt_post			-0.249	-0.237	-0.202
			(0.147)	(0.148)	(0.127)
dist_tstt_pt			0.281	0.269	0.195
			(0.147)	(0.151)	(0.116)
N	365	365	373	368	322
adj. R^2	0.332	0.335	0.342	0.399	0.458
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes
City Fixed Effects	Yes	Yes	Yes	Yes	Yes
Owner Characteristics	Yes	Yes	Yes	Yes	Yes
Firm Age	Yes	Yes	Yes	Yes	Yes
Covariates*POST	No	Yes	No	Yes	Yes

[a] Standard errors in parentheses.

[b] Results significant at *** 1%, **5% and *1%

[c] Columns (1) and (2) present the differences-in-differences estimates while Columns (3)-(5) present the results of the triple differences estimator. Columns (5) represents the triple differences estimates with the sample restricted to observations for which there is common support across treatment and control groups (with a propensity score between 0.2 and 0.85). *LogCapital/Workers* corresponds to the natural log of a firm's capital (net book value of capital assets+1), *Distance* corresponds to the distance between each firm and the closest station on the railroad.

Table 5: **Impact of Rail on Firm Performance: South Africa-IV Placebo**

	Dependent Variable: Log Sales/Worker			
	OLS	OLS/FE	IV	IV
	(1)	(2)	(3)	(4)
Log Capital/Workers	0.0790	0.0676	0.0635	0.0635
	(0.0446)	(0.0431)	(0.0469)	(0.0469)
RAIL	-0.0202*	-0.0215*	0.0642	0.0642
	(0.00909)	(0.00846)	(0.387)	(0.387)
N	137	133	131	131
adj. R^2	0.025	0.085		
Industry Fixed Effects	No	Yes	Yes	Yes
Province Fixed Effects	No	Yes	Yes	Yes
City	Yes	Yes	Yes	Yes
Owner characteristics	Yes	Yes	Yes	Yes
Firm Age	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes

[a] Standard errors in parentheses.

[b] Results significant at *** 1%, **5% and *1%

[c] Sample restricted to the corridors of Durban and Cape Town. Column (1) represents standard OLS, column (2) OLS with industry and province fixed effects; columns (3) and (4) an instrumental variables specification in which the variable RAIL is instrumented by the distance between a firm and the closest station on the railroad. Column (3) presents the estimates for a GMM model and Column (4) a limited information maximum likelihood model.

Table 6: **Impact of Rail on Firm Performance: South Africa- DD Regressions**

	Dependent Variable: Log Sales/Workers					
	(1)	(2)	(3)	(4)	(5)	(6)
ldcapitalNBVL	0.131***	0.114**	0.0983*	0.130***	0.114*	0.0937*
	(0.0310)	(0.0381)	(0.0354)	(0.0317)	(0.0390)	(0.0391)
prov_treated	0.713	-0.193	3.837*	0.696	-0.341	3.937*
	(0.515)	(1.754)	(1.576)	(0.562)	(1.931)	(1.713)
prov_treated_post	-0.751**	-0.742**	-3.872**	-0.752**	-0.767*	-3.950*
	(0.187)	(0.241)	(1.263)	(0.214)	(0.259)	(1.381)
post	0.303*	0.252	-2.185	0.299*	0.250	-2.702
	(0.118)	(0.127)	(1.312)	(0.119)	(0.123)	(1.286)
biz_st_pt_post				0.000210	0.00728	-0.00228
				(0.0206)	(0.0197)	(0.0200)
biz_st_pt				0.00681	0.00680	0.00652
				(0.0106)	(0.0110)	(0.0115)
biz_st_post				0.00172	-0.0000409	0.00315
				(0.00783)	(0.00700)	(0.00736)
_cons	11.43***	11.68***	13.44***	11.43***	11.68***	13.75***
	(0.741)	(0.686)	(1.171)	(0.746)	(0.699)	(1.420)
N	471	387	471	471	387	471
adj. R^2	0.097	0.096	0.104	0.092	0.091	0.100
Industry Fixed Effects	No	Yes	Yes	Yes	Yes	Yes
Province Fixed Effects	No	Yes	Yes	Yes	Yes	Yes
City	Yes	Yes	Yes	Yes	Yes	Yes
Owner characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Firm Age	Yes	Yes	Yes	Yes	Yes	Yes
Covariates*POST	No	No	Yes	No	Yes	Yes

[a] Standard errors in parentheses.

[b] Results significant at *** 1%, **5% and *1%

[c] Sample restricted to Control Firms located in the Western Cape (excluding the Durban corridor). Columns (1)-(3) present the differences-in-differences results and Columns (4)-(6) present the triple difference estimates. Columns (2) and (5) restrict the sample to firms established in the corridor at least 10 years before the railroad was rehabilitated. Columns (3) and (6) include the interaction Covariates*POST. In Column (6) the interaction between the variables POST and Owner Characteristics (Gender and Race) drops out due to multicollinearity.

Table 7: **Parallel Trends in Mozambique**

	2003		**2006**	
	Treatment Firms	**Control Firms**	**Treatment Firms**	**Control Firms**
Number of Workers	21.3	25.3	22.4	23.8
	(32.9)	(58.7)	(42.6)	(52.4)
Sales per worker (CPI adjusted to 2005 Prices)	16,097	8,053	16,952	6,697
	(40,591)	(17,771)	(44,244)	(26,208)

Table 8: **Selection Firm Survey**

	South African Companies			**Mozambican Companies**		
	Panel	**Exit**	**Difference (p-value)**	**Panel**	**Exit**	**Difference (p-value)**
Distance to Rail	3	4.8	0.18	3.8	3.6	0.87
	(0.27)	(1.3)		(0.5)	(1.3)	
Firm Age	26.9	25.2	0.33	21.26	21.2	0.93
	(1.5)	(0.88)		(0.57)	(0.97)	
Number of Workers	111	56	0.0003	31	19.6	0.004
	(14.02)	(4.7)		(3.7)	(1.73)	
Sales per worker	574462	372754	0.0005	1,560,615	19,430	0.6
	(52712)	(22212)		(1520742)	(4058)	
Capital	103499	79324	0.14	1,608,765	1,530,829	0.87
	(14416)	(7595)		(339,445)	(225,615)	
	2006 Sample	**2010 Sample**		**2006 Sample**	**2010 Sample**	
Distance to Rail	4.07	3.4	0.2	3.8	3.63	0.79
	(0.46)	(0.3)		(0.5)	(0.24)	
Firm Age	25.7	27.6	0.26	21.24	21.5	0.8
	(0.95)	(1.48)		(0.5)	(0.77)	

Table 9: **Impact of Rail on Firm Performance: First Differences (PANEL)**

	Dependent Variable: Δ Log Sales/Workers			
	Mozambique		South Africa	
	(1)	(2)	(3)	(4)
Δ Log Capital/Workers	0.21***	0.206***	0.083*	0.105**
	(14.06)	(5.54)	(0.03)	(0.03)
Industry	0.022	0.019	-0.007	0.02
	(1.84)	(1.53)	(0.03)	(0.04)
City	0.00835	0.0509	0.003	0.003
	(0.37)	(1.06)	(0.007)	(0.02)
Distance		-0.006		0.08
		(0.17)		(0.12)
Distance*Prov Treated		0.0368		-0.06
		(0.71)		(0.12)
Prov Treated	-0.295	-0.505	0.133	0.08
	(1.92)	(1.09)	(0.123)	(0.372)
N	112	56	299	158
adj. R^2	0.325	0.44	0.03	0.02
Owner Characteristics	Yes	Yes	Yes	Yes

[a] Standard errors in parentheses.

[b] Results significant at *** 1%, **5% and *1%

[c] Sample restricted to firms in the panel.

Table 10: **Comparison of Rail and Road Rates**

	Rate per ton-km (USD)
Road Transport	0.05
Mozambican Rail Corridor	0.10
DRC	0.15
Tanzania	0.04
Zambia	0.05
Zimbabwe	0.05

[a] Sources: World Bank and Independent Trucking Survey in the Maputo Corridor conducted by the author

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