

Sharma, Somnath; Kant, Shashi; Mishra, Ranjeeta; Azhgaliyeva, Dina

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Market access and firm performance: Evidence based on GIS analysis of road network and manufacturing-plant-level data from India

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ADBI Working Paper Series

**MARKET ACCESS AND FIRM PERFORMANCE:
EVIDENCE BASED ON GIS ANALYSIS OF
ROAD NETWORK AND MANUFACTURING-
PLANT-LEVEL DATA FROM INDIA**

Somnath Sharma, Shashi Kant,
Ranjeeta Mishra, and Dina Azhgaliyeva

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Somnath Sharma and Shashi Kant are Assistant Advisers at the Reserve Bank of India. Ranjeeta Mishra is a Consulting Economist at the Reserve Bank of India. Dina Azhgaliyeva is a Research Fellow at the Asian Development Bank Institute in Tokyo, Japan.

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Please contact the authors for information about this paper.

Email: somnathsharma@rbi.org.in, skant@rbi.org.in, ranjeetamishra@rbi.or.in, dazhgaliyeva@adbi.org

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Asian Development Bank Institute
Kasumigaseki Building, 8th Floor
3-2-5 Kasumigaseki, Chiyoda-ku
Tokyo 100-6008, Japan

Tel: +81-3-3593-5500
Fax: +81-3-3593-5571
URL: www.adbi.org
E-mail: info@adbi.org

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Abstract

This paper investigates whether better access to markets through an improved road network plays a role in improving the profitability of firms in India. We construct a district-level market access index using Indian road network shapefiles, district boundaries, and nightlight raster images and estimate the shortest driving distances for districts using the road network. Using the annual survey of industries data for India during the period 2001–2015, we show that market access through improved road connectivity resulted in a lower dispersion of ROA between 2001 and 2015 in India.

Keywords: India, road infrastructure, firm productivity, market access index, electricity deficit, road length

JEL Classification: D22, D24, H54

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1. INTRODUCTION

Infrastructure plays an indispensable role in economic development and job creation. Infrastructure projects may have a positive effect on the economic growth of a region. Infrastructure development, such as roads, railways, water supply, and electricity, can lead to the growth of the region surrounding that infrastructure (Yoshino, Azhgaliyeva, and Mishra 2021; Yoshino et al. 2021). Transport infrastructure can improve connectivity and the ease of doing business, thereby leading to greater sales and profitability. Measuring the spillover effects of infrastructure is important for attracting investments in infrastructure. Numerous studies have quantitatively examined the spillover effects of infrastructure on the economies of various countries, and most studies confirm the positive spillover effects of such infrastructure (Yoshino and Abidhadjaev 2017; Yoshino, Azhgaliyeva, and Mishra 2021; Yoshino et al. 2021; Azhgaliyeva et al. 2021; Azhgaliyeva and Kalyuzhnova 2021; Yoshino et al. 2022). However, the impact of infrastructure varies by period (construction period, short-term, medium-term, and long-term), infrastructure type (transportation, water, energy, etc.), connectivity (local or connected), population density, access to other infrastructure, economic growth, etc. (Azhgaliyeva and Kalyuzhnova 2021). Most of the above literature measures the impact of infrastructure using a binary variable before and after construction/use of infrastructure, which has many limitations. Unlike other papers, this paper uses a newly calculated market access index as a measure of road connectivity using geospatial data (road network shapefiles, district boundaries, and nightlight raster images) in addition to economic data.

We investigate whether better access to markets through an improved road network plays a role in improving profitability. We construct a district-level market access index using Indian road network shapefiles, district boundaries, and nightlight raster images and estimate the shortest driving distances for districts using the road network. Using the annual survey of industries data for India during the period 2001–2015, we examine whether the manufacturing enterprises in the states that have better access to markets through improved connectivity of roads do better in terms of profitability. We measure profitability with an indicator, namely return on assets. More specifically, if the firms are located in the states with better connectivity to the markets, they will have easier access to the markets to sell their products and thereby increase their profitability. It should also result in a lower dispersion in return on assets. As an alternate specification, we also test our hypothesis using the dispersion of marginal revenue product of capital.

2. LITERATURE REVIEW

The seminal work of Krugman (1991) led to the development of the new economic geography literature. It argues that the uneven spatial distribution of industrial activities is an outcome of market processes under conditions of agglomeration economies. In relation to endogenous growth theory, it further highlights the mechanisms through which transport and communication infrastructure augments productivity (Fujita, Krugman, and Venables 2001). In the pioneering work of Porter (1990), the author underscored the importance of industrial clusters in yielding a competitive advantage for firms and regions. In a similar vein, several studies have pointed out that geography has a central role to play in determining economic growth.

The related literature on agglomeration economies largely focuses on the role of infrastructure, communication, input access, and available markets in the development of industrial agglomerations (Markusen 1996). These factors play a significantly higher role for the development of industrial agglomerations in developing countries; especially, the countries characterised with poor infrastructure and centralized institutions. However, as the costs of transport and communication decline, access to markets becomes easier. Less costly access to distant markets leads to an improvement in sales outside the home state or province (Porter 1996). A similar effect is confirmed by Yoshino et al. (2021) where they find that access to broadband Internet has a strong positive impact on the total sales across firm sizes. It is argued that with improvements in transport infrastructure, market expansion and increased integration will ensue. The structural change may take place through gains from trade, shifts in technology, and agglomeration (Lakshmanan and Chatterjee 2005). Gunasekera, Anderson, and Lakshmanan (2008), in their study on analysis of the impact of expansion of highways in Sri Lanka, using firm-level data, confirm the increase in firm productivity as a result of structural change in the production process. They confirm that the construction of highways induced a shift in the choice of firms to deploy capital and labor, with firms located close to the highway becoming more capital intensive, and firms located far from the highway becoming more labor intensive.

Transportation infrastructure is a crucial factor contributing to economic growth. While developed countries possess dense transport networks, developing countries often suffer from underinvestment in infrastructure and thus have a sparse road network. At firm level, studies have shown that a reduction in input tariffs is associated with a larger increase in firm productivity in towns that are better connected to other regional markets (Fiorini, Sanfilippo, and Sundaram 2019). Firms re-optimize their choice of supplier after the arrival of better highways. Decreased transportation costs have a direct impact on their profitability (Ghani, Goswami, and Kerr 2016).

A study based on the Chinese manufacturing sector from 1998 to 2007 highlights that an expansion of the highway network reduced inter-regional trade costs and affected resource allocation among firms. For the manufacturing sector overall, the highway expansion contributed to 24% of the observed productivity growth, 40% of the decline in productivity dispersion, and 16% of the output growth. However, the magnitude of these effects may differ substantially across industries and locations, owing to the distributional impact of changes in trade costs (Huang and Xiong 2017).

In the case of India, Lall (2007) uses a pooled data set of Indian states and finds that transportation and communication infrastructure positively affects output growth. The study also points out that the effect of better transport and communication networks on economic growth is larger in poorer states. Ghani, Goswami, and Kerr (2016) investigate the relationship between firm performance and infrastructure; however, they focus on the manufacturing sector only. A number of papers in recent years have looked at the impacts of the “golden quadrilateral” program—a large highway upgrade program from India connecting four major metros—but the focus of these studies has been at an aggregate level either on the urban manufacturing sector or on economy-wide income and efficiency gains (Datta 2012; Ghani, Goswami, and Kerr 2016; Asturias, García-Santana, and Ramos 2019).

In a recent paper, Banerjee, Duflo, and Qian (2020) show that proximity to transportation networks positively affects per capita GDP levels across sectors, but does not affect per capita GDP growth. They argue for the role played by factor mobility in determining the economic benefits of infrastructure development.

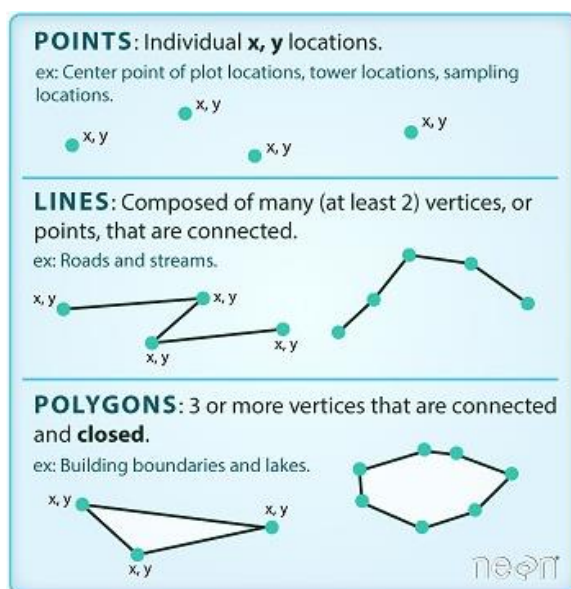
This paper contributes to the literature by taking a micro approach in a developing country context. We use firm-level data in addition to geographical road network data to estimate the effects of a road network on firm profitability. This paper particularly relates to the work by Gibbons et al. (2019) on the effects of new road infrastructure on firms. We build on these studies by applying the market access approach.

3. DATA AND METHODOLOGY

3.1 Market Access Index

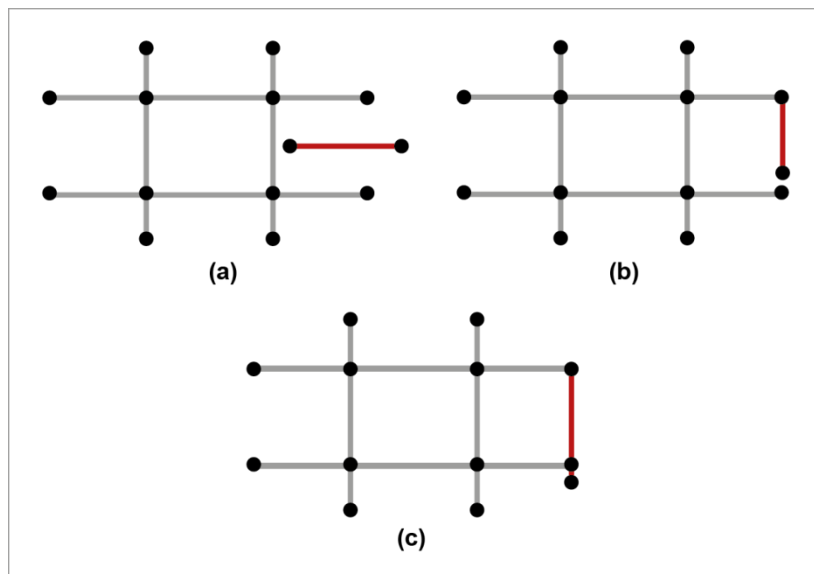
We create a district-wise market access index (MAI) using three data sets, namely Indian road network shapefiles, district boundaries, and nightlight raster images. A road's GIS shapefile is essentially a digital representation of a 2-D map consisting of points, lines, and polygons. Points represent geographical coordinates, i.e., longitude and latitude, lines, and start and end points. A series of such lines connected with each other forms a polyline. Road networks are represented by polylines in GIS data sets. Polygons, e.g., district boundaries, are bounded entities made up of polylines (1).

Figure 1: Components of GIS Shapefile



Source: Colin Williams (NEON). <https://www.earthdatascience.org/courses/use-data-open-source-python/intro-vector-data-python/spatial-data-vector-shapefiles/>.

We calculate the shortest driving distances for districts using a road network from Open Street Maps (OSM). OSM data for India have been available and updated annually since 2014. This data set is a large GIS object in the form of a shapefile of road infrastructure that existed at a given point in the past (Figure 2). As it is crowdsourced, it contains topological errors such as undershoot, overshoot, dangling arcs, etc. Such errors lead to critical connectivity issues for the converted igraph object and, as a consequence, cause failures in calculating the shortest paths (Lu et al. 2018). We obtain the corrected shapefile using GRASS tools in the QGIS application.

Figure 2: Common Types of Topological Errors

Source: Shp2graph: Tools to Convert a Spatial Network into an Igraph Graph in R.

The shapefile is converted into a graph object using the Shp2Graph library in R to enable the calculations of graph algorithms for finding shortest distances. We derive the main connected network as it is a prerequisite for the graph algorithms to work. We also make use of the district boundaries published by the International Steering Committee for Global Mapping on the Texas GeoData Portal to find the centroids of the districts and overlay them on the road network using geospatial libraries in R (ISCGM 2016). The road's spatial lines are integrated with district centroid spatial points using the points2network function. It should be noted that the centroids of districts may not fall exactly on the road lines, resulting in the creation of a network that cannot be analyzed using standard graph theoretic algorithms. Therefore, we look for the nearest nodes on the road infrastructure network that can represent the centroids of districts most accurately. There are more accurate approaches; however, they come at the cost of a dramatic increase in computation time (Lu et al. 2018). Shortest distance calculations were performed using Dijkstra's algorithm through igraph implementation in R.

Longer driving distances from a district to the centers of major economic activity would imply a lower market access index for the district and vice versa. We use nighttime intensity as a proxy for economic activity in districts. Nighttime intensity is the monthly average radiance of night-time data from the Visible Infrared Imaging Radiometer Suite (VIIRS) Day/Night Band (DNB), which is made freely available by Google Earth. The data processing involves overlaying the vector file of district boundaries over the median nighttime raster composite for the year 2014 and taking a summation over pixels bounded by the district boundaries. The median composite of the nighttime images ensures that the images are free from cloud and other abnormal perturbations to a large extent. For each district i , the MAI was calculated by weighting the inverse of squared distances from all other districts j with their corresponding nighttime intensity (Figure 3). In essence, the MAI captures the weighted degree to which a district is connected to all other districts, with their economic activity being proxied by nighttime intensity and the reciprocal of squared distances being the weights. The squared distances are inspired by gravity models as is the case with the market access indicator constructed in Roberts (2016).

$$MAI_i = \sum_j \frac{NTL_j}{d_{ij}^2}$$

We scale the index between 0 and 100 using the min-max scaler.

Figure 3: Nightlight Intensity of Indian Subcontinent



State-wise average market access is provided in the table below (Table 1):

Table 1: State-wise Average Market Access Index

States	Mean	Std. Dev.	States	Mean	Std. Dev.
Andhra Pradesh	13.58	4.85	Kerala	9.63	2.45
Assam	5.06	2.97	Madhya Pradesh	19.76	4.71
Bihar	16.99	6.09	Maharashtra	17.77	12.44
Chandigarh	48.74	0.00	Manipur	1.69	0.58
Chhattisgarh	12.68	3.56	Meghalaya	3.76	1.25
Dadra and Nagar Haveli	21.14	0.00	Mizoram	0.60	0.59
Daman and Diu	19.95	16.96	Nagaland	4.94	5.62
Delhi	76.81	0.00	Odisha*	11.59	3.30
Goa	8.81	0.33	Pondicherry	20.21	12.84
Gujarat	18.44	6.41	Punjab	36.40	11.18
Haryana	60.49	21.13	Rajasthan	21.42	9.19
Himachal Pradesh	12.49	8.03	Tamil Nadu	17.32	6.74
Jharkhand	16.42	3.44	Tripura	2.48	1.85
Karnataka	17.77	12.43	Uttar Pradesh	33.88	17.31
			Uttaranchal	15.62	9.84
			West Bengal	16.86	10.33

* In 2011, the Government of India approved the name change of the State of Orissa to Odisha. This document reflects this change. However, when reference is made to policies that predate the name change, the formal name Orissa is retained.

3.2 Return on Assets

We use Annual Survey of Industries (ASI) data published by the Ministry of Statistics and Programme Implementation (MOSPI). These are establishment-level microdata pertaining to registered manufacturing firms. Factories with over 100 workers belong to the “census scheme” and are surveyed every year, while smaller establishments belong to the “sample scheme” and are surveyed every three to five years. As survey data may result in biased population estimates, we use the ASI multiplier to produce estimates valid for the population of registered factories in India. The ASI cross-sectional data are available in the public domain but the firm identifiers are not consistent across years, thereby rendering a panel regression estimation impossible. However, ASI also makes available panel data set that has establishment identifiers allowing us to construct a plant-level panel for the entire 2001–2015 sample. The final number of enterprises after merging and cleaning the data from 2001 to 2015 is given below in Table 2.

Table 2: Number of Enterprises

States	Number of Enterprises	%	Cumulative Frequency
Andhra Pradesh	49,885	7.64	7.64
Assam	14,117	2.16	9.8
Bihar	9,962	1.53	11.33
Chhattisgarh	9,950	1.52	12.85
Dadra and Nagar Haveli	6,540	1	13.85
Delhi	15,863	2.43	16.28
Goa Daman and Diu	13,029	2	18.28
Gujarat	60,673	9.29	27.57
Haryana	28,111	4.31	31.88
Himachal Pradesh	9,706	1.49	33.37
Jharkhand	9,513	1.46	34.82
Karnataka	41,139	6.3	41.12
Kerala	24,406	3.74	44.86
Madhya Pradesh	18,902	2.9	47.76
Maharashtra	79,504	12.18	59.94
Odisha	11,511	1.76	61.7
Punjab	36,192	5.54	67.24
Rajasthan	28,735	4.4	71.64
Tamil Nadu	91,435	14.01	85.65
Uttar Pradesh	51,115	7.83	93.48
Uttaranchal	11,716	1.79	95.27
West Bengal	30,860	4.73	100
Total	652,864	100	

For cleaning and merging the ASI data from 2001 to 2015, we use Allcott, Collard-Wexler, and O’Connell (2016).

We define the ROA as the ratio of earnings before interest and tax payments (EBIT) to total assets (TA). We estimate that as follows:

$$ROA = \frac{\text{Net Value Added}}{\text{Total Assets}} \quad (1)$$

3.3 Data on Industrial Credit, Net State Domestic Product, Gross Fixed Capital Formation, Road Length, Railways Length, and Price

We obtain the industrial credit data from the Basic Statistical Returns (BSR) of Scheduled Commercial Banks in India published by the Reserve Bank of India from 2000–2001 to 2015–2016.

The pdf version of the BSR is available until 2001–2002. Data after 2001–2002 are available in Excel format. We take the data on net state domestic products and gross fixed capital formation from 2000–2001 to 2015–2016 from the *Handbook of Statistics on Indian States* published by the Reserve Bank of India. We use three-digit commodity price deflators (with 2004–2005 as base) by groups and sub-groups (yearly averages) produced by the Office of the Economic Adviser-Ministry of Commerce and Industry as available in the commodity-based table Index Numbers of Wholesale Prices in India.

3.4 Data on Business Projects and Number of Pending Civil Cases

We use the CapEx database of the Centre for Monitoring Indian Economy (CMIE). It provides information and insights on the new build-up of capacities in India in the short- or medium-term future. Using this database, we find the state-wise number of outstanding and shelved business projects in India from 2001 to 2015. We take the number of pending civil cases (as a measure of contract enforcement) from Indiastat.

4. REGRESSION SPECIFICATION

Our interest here is in testing the initial hypothesis we made, i.e., to see if the better market access in terms of better road connectivity results in a lower dispersion of the ROA (measured as the coefficient of variation and as Theil's index). Please note that our method for testing this hypothesis is indirect since we look at the dispersion of ROA at the state level as we do not have firm-level market access. We control for other factors that may affect the ROA dispersion, namely credit availability, electricity deficit, the ratio of stalled projects to total projects in the state, the per industry number of pending civil cases in the state, and infant mortality.

4.1 Variable Explanations

Market Access Indicator

We estimate the district-level market access index as follows:

$$MAI_i = \sum_j \frac{NTL_j}{d_{ij}^2}.$$

We scale the index between 0 and 100 using the min-max scaler. We then take the state-level average of this index.

Profitability depends on many other factors, for example, business environment, human development, and state-specific conditions. For this, we control for a variety of variables that may affect the return on assets.

Credit Availability

We take the ratio of state-wise credit to net state domestic product as a measure of availability of credit in the states. A higher ratio means a better availability of credit to the markets where the manufacturing enterprises are located.

Electricity Deficit

Electricity is one of the important inputs in the manufacturing sector. Unavailability or an uneven electricity supply affects the output of manufacturing plants. The availability of a proper electricity supply to a locality is measured by an indicator called “electricity deficit.” This deficit is estimated by examining the total supply of electricity and the total demand for electricity in a state. If the demand is more than the supply of electricity, we refer to it as “electricity deficit.” It is estimated in percentage terms. A high deficit means a bad supply of electricity in that state.

Ratio of Stalled Projects to Total Projects

This variable is one of the indicators of the business environment in the states. It is calculated as the ratio of stalled commercial projects to the total number of running commercial projects. If the number of stalled commercial projects is high compared to the number of total running projects, it means that there are some discrepancies in the business condition in the state, which are hindering the progress of commercial projects.

Per-Industry Number of Pending Civil Cases

Civil cases are all cases excluding criminal cases. Civil cases also include commercial dispute cases, contract breaking, cheating, etc. If the number of pending civil cases is high in a state, it means that the courts are overburdened and the resolution of commercial disputes will take time. As a result, if manufacturing enterprises fall into any dispute, they will have to engage their resources and money to resolve such cases. The per-industry number of pending civil cases is calculated as the ratio of the total number of pending civil cases in the state at a particular time to the total number of manufacturing enterprises in the state at that time.

Infant Mortality

The infant mortality rate is calculated as the number of deaths of infants under one year of age in a given year per 1,000 live births in the same year in the same state. This is often used as an indicator of human development, especially health, in a state. There can be several other indicators of human development, such as the school enrollment ratio or other indicators related to education. Literature suggests that human capital is a significant determinant of productivity (Tamura 2006; Kalemli-Ozcan 2002). States with better human development are considered to have a better labor force. Here we take one of the most basic measure of health indicators. A labor force that is healthy means they will be more productive in the work they do and this will have a positive effect on ROA.

Using the above variables as the control variables, we look at the impact of the MAI on the dispersion of ROA. The benchmark model specification is given below:

$$\begin{aligned}
 ROADispersion_{s,t} = & \alpha_s + \gamma_t + \beta_1 MAI_s \\
 & + \beta_2 CreditNSDP_{s,t} \\
 & + \beta_3 ElectricityDeficit_{s,t} \\
 & + \beta_5 ShareofStalledProjects_{s,t} \\
 & + \beta_6 PerEnterprisePendingCivilCases_{s,t} \\
 & + \beta_7 InfantMortality_{s,t} + v_{s,t}
 \end{aligned} \tag{2}$$

where s denotes states and t year, and α_s represents the state-level fixed effect. We control for state-level fixed effects and time fixed effects and cluster the standard errors at the state level.

A summary of the variables discussed above is given below in Table 3.

Table 3: Summary Statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
ROA Theil's	272	2.366613	0.7750701	1.17947	3.57206
Market Access Index	288	23.10562	17.93174	5.061305	76.81
Credit to NSDP Ratio	333	55.56979	56.38402	6.836161	372.1976
Electricity Deficit %	338	-5.404438	5.616599	-22.5	7.8
Share of Stalled Projects out of Total	352	2.916715	9.095967	0	152.9115
Per-Enterprise Pending Civil Cases	316	7.257961	3.896778	1.389143	19.38576
Infant Mortality	352	45.64205	18.16425	9	95

5. RESULTS

We present here regression estimations based on the above regression specifications using ROA dispersion utilizing Theil's index. The results are presented in Table 4.

5.1 Market Access

Using the empirical model, we test whether the manufacturing enterprises in the states with a better access to markets through improved connectivity of roads do better in terms of reduced dispersion of ROA. More specifically, if firms are located in states with better connectivity to markets, they will have easier access to these markets to sell their products. This should result in a lower dispersion in return on assets, and thus a negative impact of market access index (from 0 to 100) on dispersion of ROA.

From alternate specifications with different variables, we find that market access through improved road connectivity resulted in a lower dispersion of ROA during the period 2001–2015 as the coefficient of the MAI is found to be negative and statistically significant. Our results show, as expected, that market access has a negative and statistically significant impact (at the 5% level of significance) on the dispersion of ROA. Our results imply that improvements in market access will lead to an equitable access

to resources and markets for manufacturing plants and to greater convergence. We also run this regression using an alternate specification using Theil's Index of Marginal Revenue Product of Capital (MRPK) (column (2) in Table 4). We find that improved access to markets leads to a reduction in the dispersion of MRPK.

Table 4: Regression Results Using ROA Theil's Index

	(1)	(2)	(3)	(4)	(5)	(6)
	Theil's ROA	Theil's MRPK	Theil's ROA	Theil's MRPK	Theil's ROA	Theil's MRPK
Market Access Index	-0.082** (-2.790)	-0.056*** (-4.830)			-0.026* (-2.010)	-0.023*** (-4.640)
Port Distance			0.002** (2.790)	0.001*** (4.830)	0.001** (3.200)	0.001*** (4.710)
Credit to NSDP Ratio	0.001 (1.120)	0.0004 (1.600)	0.001 (1.120)	0.0004 (1.600)	0.001 (1.120)	0.0004 (1.600)
Electricity Deficit %	-0.001 (-0.230)	0.0003 (0.220)	-0.001 (-0.230)	0.0003 (0.220)	-0.001 (-0.230)	0.0003 (0.220)
Share of Stalled Projects out of Total	0.001 (0.130)	-0.0002 (-0.160)	0.001 (0.130)	-0.0003 (-0.160)	0.001 (0.130)	-0.0003 (-0.160)
Per-Enterprise Pending Civil Cases	0.035** (2.640)	0.008 (1.570)	0.035** (2.640)	0.008 (1.570)	0.035** (2.640)	0.008 (1.570)
Infant Mortality	0.010* (2.200)	0.004** (2.680)	0.010* (2.200)	0.004** (2.680)	0.010* (2.200)	0.004** (2.680)
Constant	3.232*** (5.200)	1.506*** (6.330)	1.437*** (6.160)	0.278*** (3.850)	2.007*** (7.500)	0.774*** (8.290)
State Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	225	238	225	238	225	238
Adjusted R-squared	0.942	0.472	0.942	0.472	0.942	0.472

Numbers in parenthesis are t-statistics.

*** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

5.2 Market Access

Using the empirical model, we test whether the manufacturing enterprises in the states with a better access to markets through improved connectivity of roads do better in terms of reduced dispersion of ROA. More specifically, if firms are located in states with better connectivity to markets, they will have easier access to these markets to sell their products. This should result in a lower dispersion in return on assets, and thus a negative impact of market access index (from 0 to 100) on dispersion of ROA.

From alternate specifications with different variables, we find that market access through improved road connectivity resulted in a lower dispersion of ROA during the period 2001–2015 as the coefficient of the MAI is found to be negative and statistically significant. Our results show, as expected, that market access has a negative and statistically significant impact (at the 5% level of significance) on the dispersion of ROA. Our results imply that improvements in market access will lead to an equitable access to resources and markets for manufacturing plants and to greater convergence. We also run this regression using an alternate specification using Theil's Index of Marginal Revenue Product of Capital (MRPK) (column (2) in Table 4). We find that improved access to markets leads to a reduction in the dispersion of MRPK.

As an alternate measure of market access, we take the distance of the district from the nearest port (columns (3) and (4) in Table 4). We find that the higher the average distance from the nearest port, the higher the dispersion of ROA and MRPK. This finding also validates our claim that access to markets affects the profitability of firms in India. Our results hold good for ROA and MRPK dispersion even when we take both the MAI and the distance from the nearest port (columns (5) and (6) in Table 4).

5.3 Control Variables

We use the per-industry number of pending civil cases (the ratio of total pending civil cases in the state) as a measure of contract enforcement in industries. The results, as expected, show that a greater number of pending civil cases increases the dispersion of ROA, implying a large variation in ROA profiles across firms.

We find that infant mortality, which is a rough measure of human development indicator (greater infant mortality means a bad human development condition), results in a greater dispersion of ROA, which gives an indication that firms with a higher ROA may be attracting a better quality of human capital than firms with a lower ROA, thereby increasing the ROA dispersion. This finding is also as expected.

Table 4 reports the effects of increased credit availability to firms on the dispersion of ROA. Column [1] represents the result of the benchmark regression. From the regression results, we find that market access through improved road connectivity resulted in a lower dispersion of ROA from 2001 to 2015 as the coefficient of the MAI is found to be negative and statistically significant.

We also find that the share of stalled projects to the total number of commercial projects in the states, which is an indicator of better governance, is significant. This means that ROA dispersion is greater in states that are faced with governance issues. Bad judicial conditions, which are measured as the per-enterprise number of pending civil cases, increase the dispersion of ROA. In states with a poor governance setup, it may be typical for some firms with high-profile connections in political and judicial machinery to work their way through the system, while those that are not so privileged may have to struggle to get the necessary permits and licenses. This could result in a higher dispersion of ROA.

5.4 Robustness Checks

We set up alternate specifications with mean ROA as the regressor.

$$\begin{aligned}
 \text{MeanROA}_{s,t} = & \alpha_s + \gamma_t + \beta_1 \text{MAI}_s \\
 & + \beta_2 \text{CreditNSDP}_{s,t} \\
 & + \beta_3 \text{ElectricityDeficit}_{s,t} \\
 & + \beta_5 \text{ShareofStalledProjects}_{s,t} \\
 & + \beta_6 \text{PerEnterprisePendingCivilCases}_{s,t} \\
 & + \beta_7 \text{InfantMortality}_{s,t} + v_{s,t}
 \end{aligned} \tag{3}$$

The results are presented in Table 5 below:

Table 5: Regression Results Using Mean ROA

	(7)	(8)	(9)
	Mean ROA	Mean ROA	Mean ROA
Market Access Index	0.0989** (2.790)		0.115** (3.180)
Port Distance		-0.002** (-2.790)	-0.0003* (-2.420)
Credit to NSDP Ratio	0.0001 (0.140)	0.0001 (0.140)	0.0001 (0.140)
Electricity Deficit %	0.012 (1.210)	0.012 (1.210)	0.012 (1.210)
Share of Stalled Projects out of Total	-0.001 (-0.260)	-0.001 (-0.260)	-0.001 (-0.260)
Per-Enterprise Pending Civil Cases	-0.066* (-2.560)	-0.066* (-2.560)	-0.066* (-2.560)
Infant Mortality	0.009 (1.250)	0.009 (1.250)	0.009 (1.250)
Constant	-1.645* (-1.950)	0.532* (1.960)	1.437*** (6.160)
State Fixed Effect	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes
Observations	264	264	225
Adjusted R-squared	0.537	0.537	0.942

Numbers in parenthesis are t-statistics.

*** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

We find that in the states where the market access is good, the mean return on assets of firms also tends to be high. We also find that the mean ROA of firms located in states farther away from ports is marginally lower than the mean ROA of firms located in states near ports.

Additionally, we also check for the differential impact of the MAI on ROA and MRPK dispersion contingent upon the distance from a port. We find that the differential impact of the MAI is fairly low. The corresponding results are presented in Table A1.

6. CONCLUSIONS AND POLICY IMPLICATIONS

Using the annual survey of industries data for India during the period 2001–2015, we examine whether manufacturing enterprises in states with better access to markets through improved connectivity of roads do better in terms of profitability as measured by return on assets.

This paper provides empirical evidence for governments to focus on improving market access. We establish that better road access to markets reduces the dispersion of ROA across firms as better infrastructure is a public good that helps in improving the productivity of all firms at the same time. We also find that judicial conditions measured as per-industry pending civil cases in states are associated with a greater dispersion of ROA. An improved road infrastructure reduces transportation costs and assists in

creating a better business environment by reducing the misallocation of capital. We also use an alternate specification of return from capital as the marginal revenue product of capital (MRPK). We find that the improvement in market access results in a lower dispersion of MRPK. Our results hold when we take the alternate measure of market access as the distance from the nearest port as we find that the dispersion of ROA and MRPK is associated positively with the distance from the nearest port.

This paper has a few limitations, mainly due to data availability. Because of the absence of district identifiers for enterprises in the ASI data, the district-level market access index had been averaged at the state level. As market access can vary substantially within the same state, district identifiers for enterprise-level data would lend greater credence to the study. In addition to this, we make use of the crowdsourced road network available until 2015, which may have its own limitations due to user reporting biases.

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APPENDIX

We also check the differential impact of the MAI on ROA dispersion with port distance as the moderating variable. We find that a better MAI leads to a reduction in dispersion when we make it contingent on port distance; however, the reduction in ROA dispersion is significantly small.

Table A1: Regression Results Using Interaction of MAI and Port Distance

	(10)	(11)	(12)	(13)
	Theil's ROA	Theil's MRPK	Theil's ROA	Theil's MRPK
Market Access Index	-0.061** (-2.660)	-0.044*** (-4.830)	-0.007 (-0.180)	-0.049** (-3.090)
Port Distance			0.002** (2.750)	0.0002 (0.610)
MAI*Port Distance	-0.00005** (-3.200)	-0.00003*** (-4.710)	-0.00003 (-0.680)	-0.00004* (-2.280)
Credit to NSDP Ratio	0.001 (1.120)	0.0004 (1.600)	0.001 (1.120)	0.0004 (1.600)
Electricity Deficit %	0.001 (0.230)	0.0003 (0.220)	0.001 (0.230)	0.0003 (0.220)
Share of Stalled Projects out of Total	0.001 (0.130)	0.0003 (0.160)	0.001 (0.130)	0.0003 (0.160)
Per-Enterprise Pending Civil Cases	0.035** (2.640)	0.008 (1.570)	0.035** (2.640)	0.0084 (1.570)
Infant Mortality	0.010* (2.200)	0.004** (2.680)	0.010* (2.200)	0.004** (2.680)
Constant	2.686*** (5.870)	1.179*** (6.890)	1.648* (2.320)	1.276*** (4.450)
State Fixed Effect	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes
Observations	225	238	225	238
Adjusted R-squared	0.942	0.472	0.942	0.472

Numbers in parenthesis are t-statistics.

*** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.