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The Spatial Impact of High-Speed Rail on Firm Performance: The Role of Proximity to Urban Cores*

Chun Kuang† Mengying Wei‡ Wenyu Zhu§

Abstract

This paper examines the spatial impact of high-speed rail (HSR) connection on firm performance in China at the micro level using a unique administrative dataset. Connected firms benefit from agglomeration economies and improved market access, but the redistribution of production inputs towards urban cores may have a negative impact on firms in peripheral regions. If these opposing forces are both subject to spatial decay but at different rates, proximity to urban cores could play a crucial role in determining the overall effects of HSR connection on firms. We find that connected firms located farther from urban cores benefit the most, indicating a steeper spatial decay in the redistribution effect relative to the agglomeration effect. This research enhances our understanding of the micro-level spatial impact of HSR on regional development.

JEL Classification: R11, R12, R38
Keywords: high-speed rail, firm performance, regional development

*We are grateful to Wei Cui for his generous assistance in obtaining and working with the data. All errors are our own.

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1 Introduction

It has been 20 years since the first high-speed rail (HSR) line in China became operational in 2003. However, due to data constraints, firm-level evidence of its impact has been limited to selected samples of large firms.[1] This paper aims to fill this gap by utilizing a new administrative dataset encompassing all firms in a prosperous province in China. Our analysis focuses on the spatial impact of HSR on firm performance at the micro level.

Dedicated to passenger travel, the HSR network is designed to promote agglomeration economies, as described by Marshall (1920), through its facilitation of human interactions. While the goal was to connect mega cities and provincial capitals, peripheral regions in between were also connected to promote connectivity and economic development (Lin, 2017). Connected firms benefit from agglomeration economies through knowledge diffusion and enjoy improved market access associated with reductions in transaction costs due to ease of communication (Ahlfeldt and Feddersen, 2018). However, by enhancing factor mobility, HSR also allows for redistribution of production inputs across space, potentially disadvantaging firms in peripheral regions.[2] Consequently, HSR's impact on firms in peripheral regions depends on their proximity to urban cores and the spatial decay rates of these two opposing forces. Specifically, when the redistribution effect decays more rapidly over space than the agglomeration effect, connected firms located farther from urban cores benefit more.

Our findings reveal that firms located farther from urban cores benefit the most from HSR connection, suggesting a steeper decay in the redistribution effect relative to the agglomeration effect. This research provides valuable firm-level evidence on the spatial impacts of China's HSR network, by shedding light on the interplay between different mechanisms at work.

2 Data and Samples

2.1 HSR Data

The HSR data are from the CNRDS database, including information on HSR lines and stations. In our study area from 2012 to 2016, a single HSR segment connecting two provincial capitals became

[1] For example, Kuang et al. (2021) and Liu (2021) study the impact of HSR connection on listed firms in communication-intensive industries, and Tian and Yu (2023) focus on export-oriented industrial enterprises above designated size.

[2] Literature has shown that geographic integration could lead to urban cores growing even larger and denser at the expense of other connected areas (Faber, 2014; Qin, 2017).

operational in the second half of 2013, with seven newly constructed stations in this province. We consider the year 2014 as the treatment year and classify counties as "connected" if any part of them is within 25 km of one of the new stations. Counties within 25 km of previously opened segments or provincial capital stations are excluded. To examine inter-regional differences in HSR's impact, we categorize connected counties based on their proximity to the urban core, distinguishing between those associated with provincial capitals ("urban") and those associated with smaller peripheral cities ("non-urban").[3]

Given that the placement of the HSR route is unlikely to be random and tends to connect politically important and economically prosperous counties between targeted metropolitan areas (Faber, 2014), we seek matched control counties within the same province. These control counties (1) only became connected in later years beyond our sample period,[4] and (2) are of similar pre-connection economic development level and share of tertiary industry.[5] Figure A1 provides a simplified illustration of the different county groups in our sample.

2.2 Firm Data

Our dataset comprises confidential administrative data from a prosperous Chinese province, providing comprehensive information on firm performance, including income statements, balance sheets, and registration records, covering the period from 2012 to 2016. Unlike publicly available samples such as the Annual Survey of Industrial Firms, our dataset includes small and medium-sized firms and extends beyond 2013. To ensure that firm's location decision is not influenced by HSR, we only include firms registered before the groundbreaking ceremony in 2009. Treatment status is determined by firm's county of registration, as address is unavailable due to anonymization.[6] We focus on firms in the tradable sector, following the categorization by Mian and Sufi (2014), as both mechanisms assume a certain level of tradability in the final product.[7]

[3]These "non-urban" counties are indeed farther away than "urban" counties from the provincial capital, and are at least four stations away from the provincial capital at the other end of the segment.

[4]Later connected counties presumably are not fundamentally different from the early connected ones, alleviating potential issues of selection into treatment.

[5]See the Appendix for a more detailed description of the matching procedure. Table A1 presents the balancing test results on county characteristics, and suggests the matched control counties are not statistically different in GDP and tertiary industry share from the treated counties pre-connection.

[6]Without precise locational informaiton, we are unable to examine distance decay with respect to HSR station.

[7]See Table A2 for a list of industries in the tradable sector.

3 Empirical Analysis

We examine the micro-level spatial impact of HSR connection on regional development using firm-level data. HSR connection has two contrasting effects: the agglomeration effect, which promotes knowledge diffusion and improves market access for connected firms, and the redistribution effect, which leads to further concentration of production inputs in urban cores. Under the assumption that these forces decay at different rates over space, we hypothesize that HSR's impact on firm performance depends on firms' proximity to urban cores, with greater benefits observed for firms located farther away when the redistribution effect decays more rapidly than the agglomeration effect over space.

3.1 Inter-Region Proximity

We first investigate the inter-region heterogeneities in HSR's impact by estimating the following specification separately for firms in the urban connected and non-urban connected counties in comparison to those in the matched control counties:

$$Y_{ijct} = \beta * Treat_c * Post_t + \gamma * X_{i,t} + \lambda_i + \pi_{jt} + \varepsilon_{ijct}, \tag{1}$$

where Y_{ijct} is a measure of firm performance for firm i of county c and industry j in year t, the interaction term $Treat_c * Post_t$ indicates county c's HSR connection status in year t, and the vector of $X_{i,t}$ contains firm-year level characteristics.[8] We also include firm fixed effects and industry-by-year fixed effects to account for firm-specific time-invariant heterogeneities and market condition variations common to firms in the same industry. Standard errors are clustered at the firm level to allow for within-firm correlations over time.

Table 1 reports the results for sales (Columns 1-2) and ROA (Columns 3-4) for firms in the tradable sector.[9] Compared with firms in matched control counties, firms in the non-urban connected counties experience significant revenue growth by around 19.4%, while the difference is insignificant for firms in urban connected areas, consistent with a steeper decay in the redistribution effect than the agglomeration effect.[10] Results are similar for ROA.

[8] See Table A3 for summary statistics on firm-level controls.

[9] Table A4 reports coefficients for all variables. Figure A2 presents dynamic treatment effects of HSR on firm sales and ROA located in the urban and non-urban areas, respectively. Although we can only observe two pre-treatment periods, we do not find statistically significant pre-existing differences in trends in performances between firms in the treated and

Table 1: Inter-regional Results

	lnSales		ROA	
	Non-urban	Urban	Non-urban	Urban
	(1)	(2)	(3)	(4)
$Treat \times Post$	0.194***	-0.0102	0.00418***	0.000623
	(0.000)	(0.916)	(0.007)	(0.819)
Observations	57,628	28,023	57,632	28,027
Adjusted R^2	0.722	0.722	0.367	0.442
Firm FE	✓	✓	✓	✓
Industry-Year FE	✓	✓	✓	✓

Notes: Controls include the natural logarithm of firm assets, level of asset tangibility (=fixed assets/total assets), and leverage (=total liabilities/total assets).

3.2 Intra-Region Proximity

Using neighborhood-level location information, we categorize firms within each county group based on their proximity to the urban core. By calculating the Euclidean distances and travel times between the central business district (CBD) of the provincial capital and each neighborhood, we label firms as "near" if their distance does not exceed the group median, and "far" otherwise. Intra-region heterogeneities in HSR's impact are examined in the following specification:

$$Y_{ijcnt} = \beta_1 * Treat_{cn}^{Near} * Post_t + \beta_2 * Treat_{cn}^{Far} * Post_t + \gamma * X_{i,t} + \lambda_i + \pi_{jt} + \varepsilon_{ijcnt}, \quad (2)$$

where $Treat^{Near}$ and $Treat^{Far}$ refer to connected neighborhoods ns with distance or travel time to the urban core not exceeding and above the sample medians, respectively. In Panel A of Table 2, we find firms located farther from the urban core in non-urban connected counties benefit the most from HSR connection. This micro-level pattern is robust to using travel time as the grouping criterion, providing further insight into the interplay between different mechanisms at work.[11] These findings highlight spatial heterogeneities in HSR's impact on firm performance, indicating a steeper decay in the redistribution effect compared to the agglomeration effect.

matched control counties.

[10] As a robustness check, Table A5 report results estimated using firms in the non-tradable sector. Heterogeneities with respect to firms' proximity to the urban core become difficult to detect, consistent with the local nature of non-tradable productions. Using the number of newly registered firms, we examine the spatial impact of HSR on firm entry in Table A6. Our results are in line with that of Lin et al. (2023) and suggest that HSR connection facilitates firm entry.

[11] Results for ROA are in Table A7.

In Panel B of Table 2, we present additional evidence for the redistribution channel by examining firm exit probabilities. The estimation sample excludes observations in 2016 as exit is undefined for the last year in our sample. Reflective of a spatial decay in the redistribution effect of HSR, connected firms in the urban counties exhibit higher exit rates than those in the non-urban counties, in comparison to those in the matched control counties. Moreover, connected firms closest to the urban core experience the largest increase in exit rates, while those in non-urban counties see a decrease in firm exit, with the most significant decrease observed for those located farthest from the urban core. Taken together, our results suggest that while both the agglomeration effect and the redistribution effect are subject to spatial decay, the redistribution effect diminishes more rapidly over space.

Table 2: Intra-regional Results

	Distance		Travel time	
	Non-urban	Urban	Non-urban	Urban
	(1)	(2)	(3)	(4)
	Panel A: lnSales			
$Treat^{Near} \times Post$	0.0434	0.0878	-0.0155	0.0824
	(0.525)	(0.466)	(0.826)	(0.496)
$Treat^{Far} \times Post$	0.295***	-0.161	0.330***	-0.157
	(0.000)	(0.259)	(0.000)	(0.272)
Observations	57,628	28,023	57,628	28,023
Adjusted R^2	0.722	0.722	0.723	0.722
	Panel B: I(Exit)			
$Treat^{Near} \times Post$	-0.0194***	0.0509***	-0.0154***	0.0492***
	(0.000)	(0.000)	(0.006)	(0.000)
$Treat^{Far} \times Post$	-0.0229***	0.0157	-0.0252***	0.0148
	(0.000)	(0.149)	(0.000)	(0.197)
Observations	47,130	23,105	47,130	23,105
Adjusted R^2	0.122	0.141	0.122	0.140
Firm FE	✓	✓	✓	✓
Industry-Year FE	✓	✓	✓	✓

Notes: The same controls as in Table 1 are included.

4 Conclusions

This paper investigates the interplay between the agglomeration effect and redistribution effect of HSR connection on Chinese firms using a comprehensive administrative dataset from a prosperous province from 2012 to 2016. Our findings show that connected firms located farther from urban cores experience greater benefits, highlighting a steeper spatial decay in the redistribution effect relative to the agglomeration effect. This research enhances our understanding of the micro-level spatial impact of HSR on regional development.

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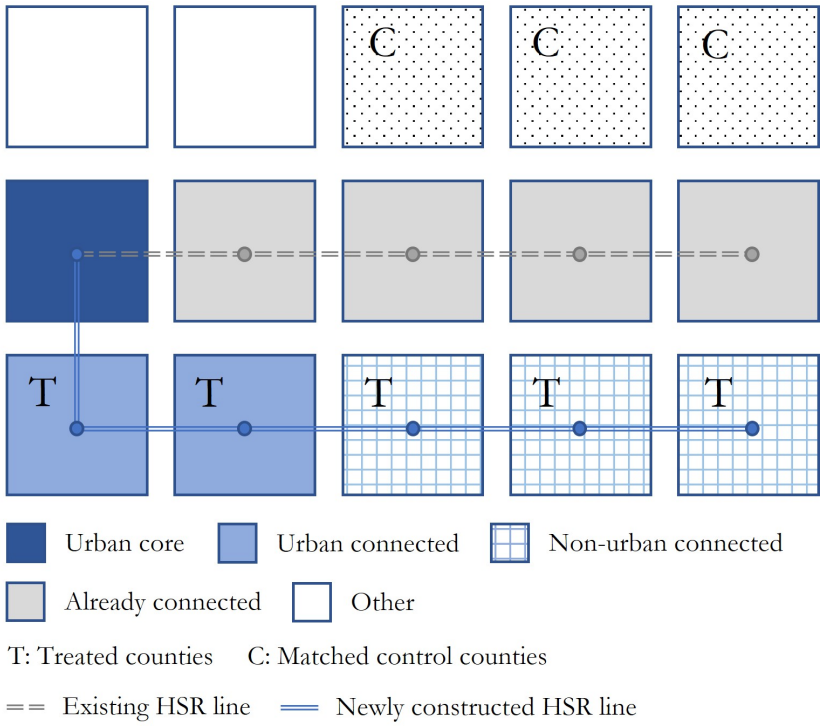
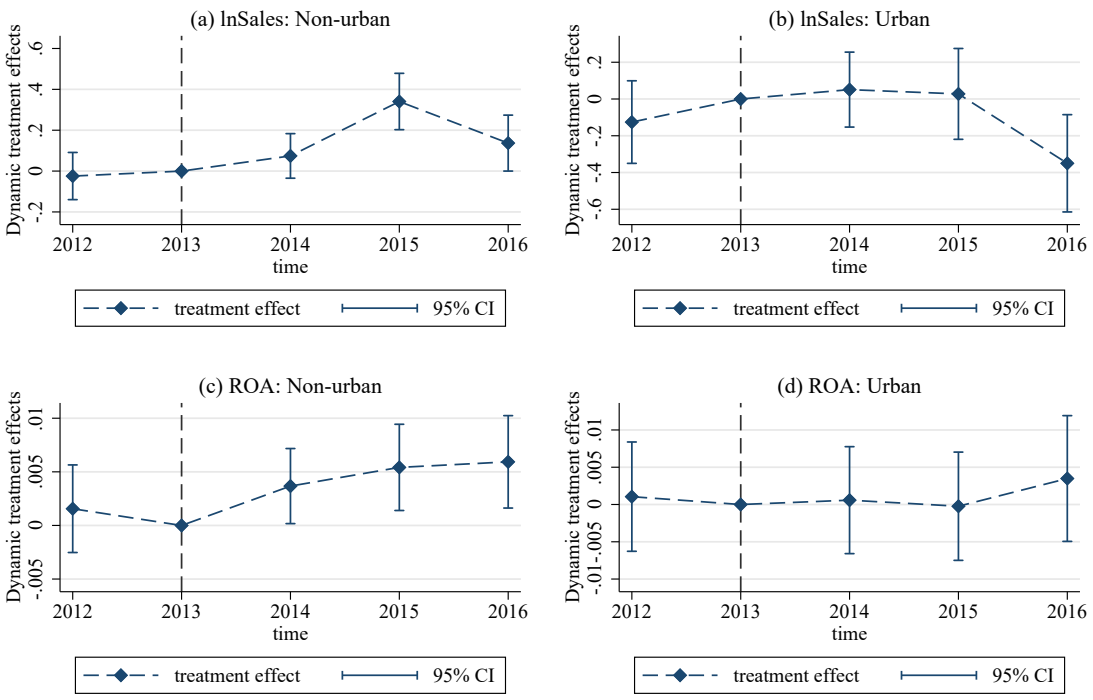
Appendix

Figure A1: Illustration of treated and matched control counties



Notes: "Urban core" refers to the municipal districts of the provincial capital, and "urban connected" area comprises two peripheral counties in the provincial capital. "Non-urban connected" area includes three connected counties in other non-capital cities within the province. Treated counties are those connected by the newly constructed HSR segment in 2013, and matched control counties are later-connected counties in the province with similar pre-connection GDP and industry mix as the connected counties. Already-connected counties and the urban core are excluded from all analyses, as they were already treated. Other counties are either never-treated or unmatched with any of the treated counties.

Figure A2: The dynamic effects of HSR connection on firm performance



Notes: The upper panels plot the estimated dynamic effects of HSR connection on sales for firms in the tradable sector in the non-urban and urban connected counties, respectively. The lower panels plot the estimated dynamic effects of HSR connection on ROA for firms in the tradable sector in the non-urban and urban connected counties, respectively. The same controls and fixed effects as in Table 1 are included.

Describing the Matching Procedures

Since the construction of the HSR segment we study started in 2009, we take the year of 2008 as our pre-connection period to limit the possibility of firms basing their location choices on the construction of HSR network. We look for control counties in the same province within the set of counties (1) that only became connected to the HSR network in later years beyond our sample period, and (2) that were of similar levels of economic development and industry composition in the pre-connection period via nearest neighbor matching without replacement. Our results are robust to alternative matching practices such as matching with replacement.

Table A1: Balancing Test of the Matched Sample

County Characteristics	Samples	Mean		t-test	
		Treated	Control	t	p-value
GDP (100 million CNY)	Unmatched	302.17	129.88	4.13	0.000
	Matched	302.17	199.57	1.25	0.248
%Tertiary	Unmatched	34.81	31.70	1.34	0.191
	Matched	34.81	33.36	0.78	0.459

Notes: This table presents the results of a balancing test on county characteristics before and after the matching procedure. Counties are matched based on the GDP totals and share of tertiary industry in local GDP in 2008. Data are from the provincial statistical yearbook of 2009.

Defining the Tradable Sector

We employ the tradability measure proposed by (Mian and Sufi, 2014). Based on industry-level trade data, a 4-digit NAICS industry is defined as tradable if it has imports plus exports equal to at least $10,000 per worker, or if total imports plus exports for the industry exceeds $500 million. Retail and food services sectors are defined as non-tradable. We employ the 6-digit rather than 4-digit NAICS codes, because 6-digit NIACS can be directly mapped to 4-digit Chinese Industry Classification (CIC) code, whereas the 4-digit NAICS codes group industries differently than the 4-digit CIC codes. We first define a 6-digit NAICS industry as tradable if its 4-digit NAICS industry is defined as tradable by Mian and Sufi (2014), then map it to a 4-digit CIC industry. As a result, one 4-digit CIC could be mapped to multiple NAICS industries, rendering its tradability measure not uniquely defined. To deal with this issue, we restrict our tradable sector sample to manufacturing

industries, and define a 4-digit industry as tradable only if over 80% of its 6-digit NAICS matches are tradable.

Table A2: List of Industries in the Tradable Sector

Industry name	**2-digit industry code**	**No. of 4-digit industry**	**Tradability(%)**
Food processing	13	19	1
Food manufacturing	14	21	1
Tobacco processing	16	3	1
Textile industry	17	26	1
Garments & other fiber products	18	3	1
Leather, furs, down & related products	19	15	1
Timber processing, bamboo, cane, palm fiber, & straw products	20	13	1
Furniture manufacturing	21	5	1
Papermaking & paper products	22	7	1
Printing industry	23	5	1
Cultural, educational & sports goods	24	27	1
Petroleum processing & cooking	25	4	1
Raw chemical materials & chemical products	26	36	1
Medical & pharmaceutical products	27	7	1
Chemical fiber	28	9	1
Rubber& plastics products	29	14	1
Non-metal mineral products	30	34	0.79
Smelting & pressing of ferrous metals	31	4	1
Smelting & pressing of nonferrous metals	32	21	1
Metal products	33	27	1
General purpose machinery	34	45	0.93
Special purpose machinery	35	51	0.94
Manufacture of auto equipment	36	6	1
Manufacture of transport equipment	37	23	1
Electric equipment & machinery	38	31	1
Electronic & telecommunications equipment	39	20	1
Instrumentation & equipment	40	19	1
Other manufacturing	41	5	1
Metal products, machinery, & equipment maintenance	43	10	1

Table A3: Summary Statistics

	Urban Connected Counties				
	p25	p50	p75	Mean	SD
lnSales	12.612	14.498	16.012	12.726	5.528
ROA	-0.014	0.001	0.016	-0.008	0.108
lnAssets	13.846	15.049	16.378	15.032	1.985
Tangibility	0.052	0.190	0.389	0.252	0.242
Leverage	0.304	0.637	0.865	0.610	0.418
Observations			1,544		
	Non-urban Connected Counties				
	p25	p50	p75	Mean	SD
lnSales	13.175	14.698	16.077	13.639	4.609
ROA	-0.011	0.004	0.025	-0.001	0.115
lnAssets	13.940	15.101	16.350	14.909	2.528
Tangibility	0.040	0.133	0.289	0.195	0.200
Leverage	0.165	0.532	0.786	0.504	0.368
Observations			7,613		
	Control Counties				
	p25	p50	p75	Mean	SD
lnSales	13.130	14.607	15.863	13.992	3.610
ROA	-0.011	0.007	0.034	0.005	0.088
lnAssets	13.537	14.600	15.907	14.771	1.722
Tangibility	0.092	0.230	0.430	0.285	0.236
Leverage	0.270	0.593	0.821	0.565	0.374
Observations			4,455		

Notes: This table reports the summary statistics for key variables in our analyses based on the data sample in 2012. Firms registered before 2009 and existed for no less than 3 years during 2012-2016 are included in the data sample. *lnSales* is defined as the natural logarithm of one plus annual sales. *ROA* is the return on assets, which equals net profits over total assets. *lnAssets* is the natural logarithm of firm assets. *Tangibility* is defined as the level of asset tangibility, which equals fixed assets over total assets. *Leverage* is defined as total liabilities over total assets.

Table A4: Inter-regional Results with Controls Reported

	lnSales		ROA	
	Non-urban	Urban	Non-urban	Urban
	(1)	(2)	(3)	(4)
Treat × *Post*	0.194***	-0.0102	0.00418***	0.000623
	(0.000)	(0.916)	(0.007)	(0.819)
lnAssets	1.157***	1.323***	0.0173***	0.0302***
	(0.000)	(0.000)	(0.000)	(0.000)
Tangibility	0.561***	0.494*	-0.0407***	-0.0387***
	(0.002)	(0.084)	(0.000)	(0.001)
Leverage	0.532***	0.548**	-0.0868***	-0.116***
	(0.000)	(0.013)	(0.000)	(0.000)
Observations	57,628	28,023	57,632	28,027
Adjusted R^2	0.722	0.722	0.367	0.442
Firm FE	✓	✓	✓	✓
Industry-Year FE	✓	✓	✓	✓

Notes: This table presents the full set of estimated coefficients in Table 1.

Table A5: Robustness Check: Inter-regional Results using Non-tradable Sector

	lnSales		ROA	
	Non-urban	Urban	Non-urban	Urban
	(1)	(2)	(3)	(4)
Treat × *Post*	0.0604	0.299	-0.00510	-0.00883
	(0.729)	(0.165)	(0.494)	(0.300)
lnAssets	1.278***	0.995***	0.0352***	0.0746***
	(0.000)	(0.000)	(0.000)	(0.000)
Tangibility	-0.0636	-0.885	-0.0753***	-0.0946***
	(0.923)	(0.356)	(0.001)	(0.008)
Leverage	-0.224	0.0653	-0.179***	-0.209***
	(0.423)	(0.854)	(0.000)	(0.000)
Observations	6,460	4,235	6,460	4,235
Adjusted R^2	0.715	0.736	0.519	0.584
Firm FE	✓	✓	✓	✓
Industry-Year FE	✓	✓	✓	✓

Notes: This table reports results estimated using firms in the non-tradable sector from equation (1) for the non-urban and urban connected counties, respectively.

Table A6: Firm Entry Results

	Firm Entry			
	Non-urban	Urban	Non-urban	Urban
	(1)	(2)	(3)	(4)
Treat × *Post*	0.110***	0.0254	0.0879***	-0.00595
	(0.001)	(0.509)	(0.000)	(0.817)
Treat	0.0155	-0.813***	-	-
	(0.474)	(0.000)	-	-
Observations	1,665	1,242	1,665	1,242
Adjusted R^2	0.046	0.284	0.730	0.787
County FE	×	×	✓	✓
Industry-Year-Quarter FE	✓	✓	✓	✓

Notes: The dependent variable is the natural logarithm of the number of newly registered firms in the tradable sector at the county-industry-year-quarter level.

Table A7: Robustness Check: Intra-regional Results using ROA

	ROA			
	Distance		Travel time	
	Non-urban	Urban	Non-urban	Urban
	(1)	(2)	(3)	(4)
$Treat^{Near} \times Post$	0.00314	0.00142	-0.000939	0.000401
	(0.129)	(0.652)	(0.652)	(0.899)
$Treat^{Far} \times Post$	0.00481***	-0.000825	0.00728***	0.00103
	(0.003)	(0.845)	(0.000)	(0.808)
Observations	57,632	28,027	57,632	28,027
Adjusted R^2	0.367	0.442	0.368	0.442
Firm FE	✓	✓	✓	✓
Industry-Year FE	✓	✓	✓	✓

Notes: The same controls as in Table 1 are included.