Decentralization in China: Discussion of Baum-Snow, Brandt, Henderson, Turner, Zhang

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Graduate Urban Economics, Lecture 4
March 18, 2025

Transportation infrastructure papers (presentation ideas)

1. Baum-Snow, Nathaniel, “Did Highways Cause Suburbanization,” QJE 2007
2. Banerjee, Duflo, Qian, “On the Road,” JDE 2020
3. Duranton, Morrow, and Turner, ”Roads and Trade,” ReStud 2014
4. Storeygard, Adam, “Further on Down the Road,” ReStud, 2016
5. Donaldson, Dave, “Railroads of the Raj,” AER 2015
6. Donaldson, Dave, Hornbeck, Richard, “Railroads and American Economic Growth,” QJE, 2016

Many others listed in (or citing) Redding and Turner handbook article, “Transportation Costs and the Spatial Organization of Economic Activity,” 2014

Decentralization in China

Baum-Snow, Brandt, Henderson, Turner, Zhang,
Review of Economics and Statistics, 2017

Main Questions of Paper

What is the main question of this paper?

How did the dramatic increase in China's transportation infrastructure affect the spatial distribution of 1) residents 2) employment 3) output?

Sub-questions:

- How does the effect of radial highways compare to ring roads?
- Does railroad infrastructure have a different effect than road infrastructure?
- What is the effect of prefecture level (地区) population on central city population?

Why write this paper? Motivations and Contributions

How do they motivate their question? Why do we care about this topic?

Authors write that transportation infrastructure has both large welfare effects on residents and changes the "urban form" of a city

Therefore, if planners and politicians wish to choose optimal transportation infrastructure levels, they should know how infrastructure level, and infrastructure types, affects urban form

Contributions according to authors:

1. Most decentralization papers look at US or developed countries (ex: Baum-Snow, QJE 2007); this paper gives evidence for important developing country.
2. Looks at role of different *types* of transportation infrastructure
3. Considers additional outcome variables: 1) employment 2) output

Modelling Framework

Does this paper use a model?

No explicit model, but follows closed-city version of monocentric city model for empirical implications and specification

- How do they use the monocentric city model?
- Are they using the “closed city” or “open city” version?
- What does this model suggest about employment and output changes?

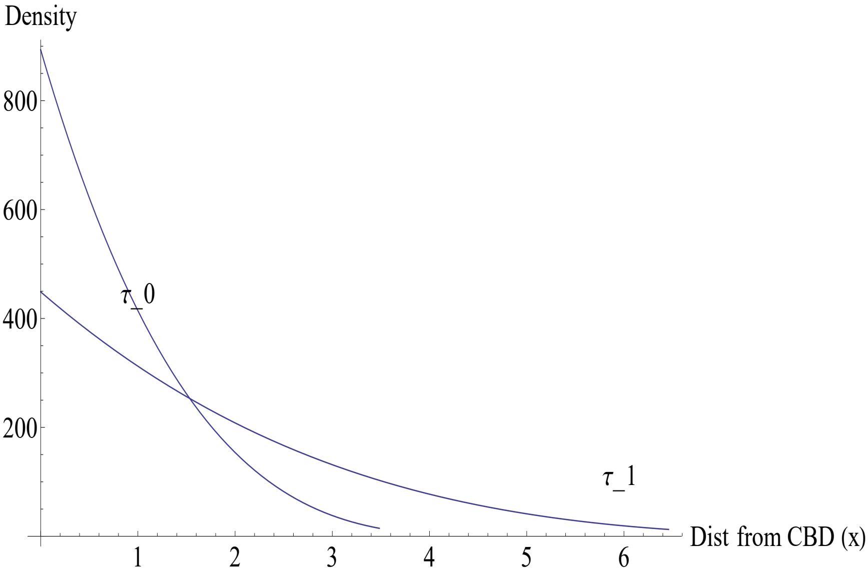
Closed City: Decrease in Transportation Cost

What happens to u, $\bar{x}$, price and density gradients?

1. Equilibrium utility increases
2. Fringe expands $\bar{x}_1 > \bar{x}_0$
3. Price gradient *rotates*: for $x < x^*$ $p(x)$ declines, $x > x^*$ $p(x)$ increases
4. Where price falls density falls, density rises where price rises

Basically more distant locations become more attractive, decreasing demand for central locations

Example: Closed City, Transportation Cost Decrease



Open City: Decrease in Transportation Cost

The open city implies that utility does not change, thus population adjusts to ensure spatial equilibrium (same utility as rest of country)

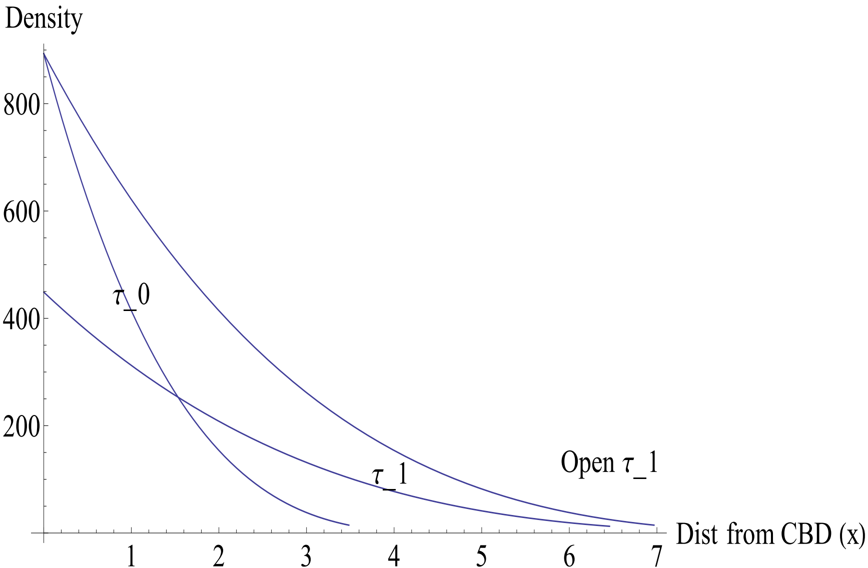
Population will increases, the fringe $\bar{x}$ expands, prices and density increase everywhere–but does density increase more in center (centralization) or exterior (suburbanization)?

Duranton+Puga (2015): let x_c be some location between center and fringe (land rent $\bar{R}$), then:

$$\frac{N_c}{N} = \frac{R(0) - R(x_c)}{R(0) - \bar{R}} \tag{1}$$

When τ declines, land rent increases at all locations *except* the center (which has no commuting), thus we know numerator decreases while denominator is constant

Ex: OPEN City, Transportation Cost Decrease



Data

Data Requirements

So how do they actually do this, what data do they need?

Independent variables: road measures, railroad measures, control variables

Outcome variables: population measures *within* cities, GDP (output), employment

All data must by varying over time; this means spatial boundaries must be consistent over time

City Definition

Have population data from 1982, 1990, 2000, and 2010 Chinese censuses

Have administrative boundary maps (source unclear–statistical yearbooks, China Data Center maps?) for 1990, 2000, 2005, 2010

Focus on 257 prefectures (地区) in Han provinces using 2005 boundaries, each with a core city (市辖区)

Define the core-city (y_{tc}) by 1990 status; ex, the urban 区 of 1990 Beijing

Remainder of prefecture is defined as "hinterland"; total prefecture defined as y_{tp} (includes core-city)

Prefectural Data Map

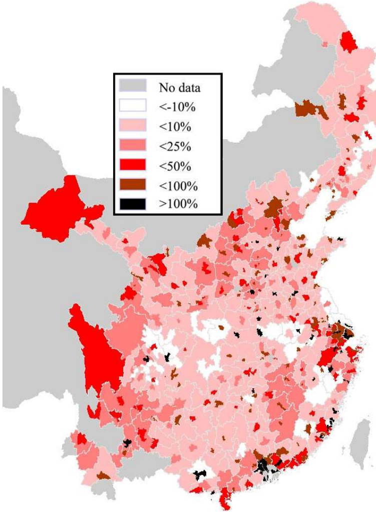


Figure 1a: 1990-2010 Population Growth in Central Cities and Prefecture Remainders

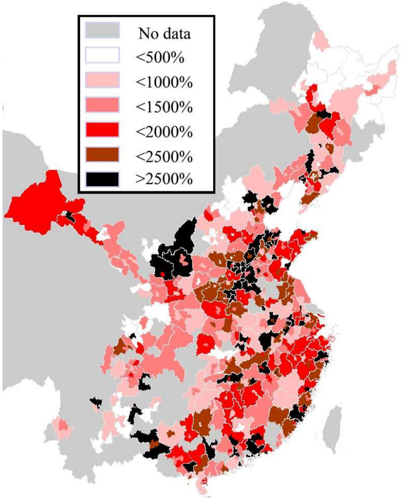


Figure 1b: 1990-2010 Industrial Sector GDP Growth in Central Cities and Prefecture Remainders

Defining Core Cities

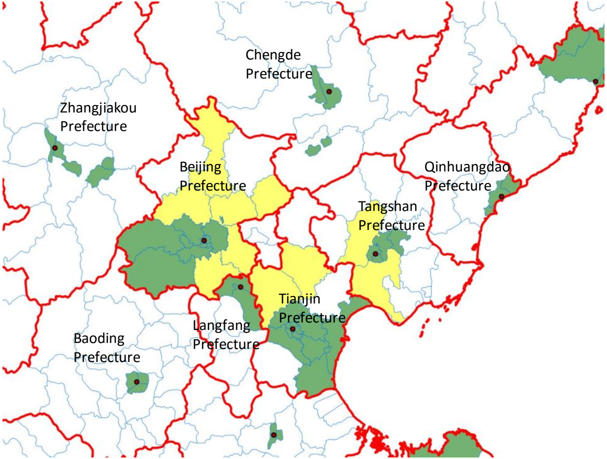


Figure 2: Beijing Area Political Geography Thick lines indicate 2005 definition prefecture boundaries and thin lines indicate county/urban district boundaries. Dark shaded regions are 1990 central cities and light shaded regions are 1990-2010 central city expansions.

Transportation Infrastructure

Digitize maps road and rail maps from 1962, 1980, 1990, 1999, 2005, 2010

Then calculate measures of 1) radial highways 2) ring roads 3) radial railways

Radial roads (rail): count number of intersections of road with 5k and 10k circle around CBD

Ring road measure a bit more complicated (all details in paper)

Questions:

1) What does it mean to "digitize a map?" How is it done? Why necessary?

2) How can one define the CBD?

Digitizing Maps: Georeferencing

In order to digitize a map (an image) you need to translate points on the map into geographic coordinates; this is called "georeferencing"

In the simplest case, we use a linear transformation, which requires a minimum of 3 points. Let x_0, y_0 be the original x, y coordinates and x_1, y_1 the new geographic coordinates. Then:

$$x_1 = \alpha + \alpha_1 * x_0 + \alpha_2 * y_0$$
$$y_1 = \beta + \beta_1 * x_0 + \beta_2 * y_0$$

If there are distortions or non-linearities then you can use higher order equations. Of course, the way we actually do this is just to tell a program which points on the image match which coordinates, the more the better, and then the software does the math

Once this process is complete you can then use GIS software for calculations (ex: distance calculations, computing intersections, defining spatial overlays)

Defining CBD: brightest lights

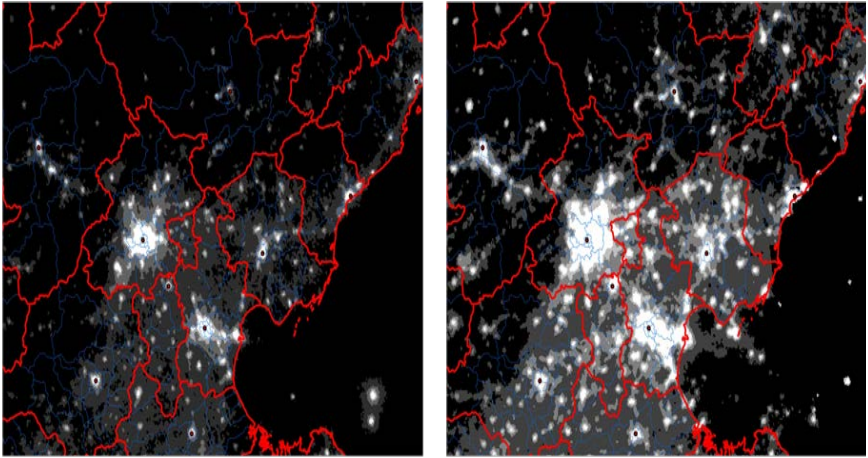


Figure 4. Lights at night for Beijing area The left figure is for 1992 and the right figure is for 2009.

Radial Road Index Construction: Index=6

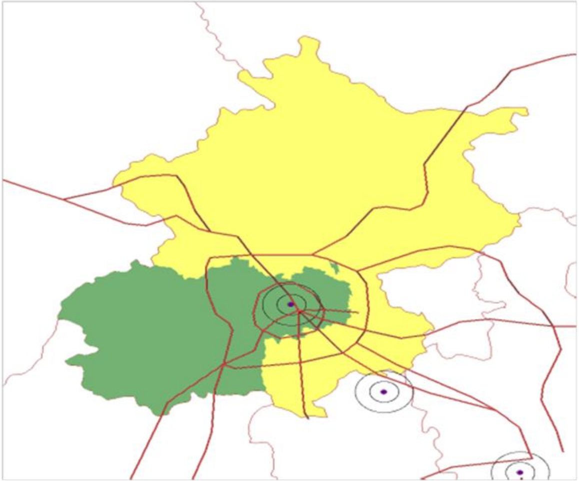


Figure 3a: Radial Road Index for the Beijing Region
Index is the minimum count of roads crossing the indicated 5km and 10 km CBD distance rings.

Empirical Strategy

Basic specification

Basic question is how some central city outcome y_{tc} is affected by changes to measures of the transportation network r_t

$$\ln y_{tc} = A_0 + A_1 r_t + A_2 \ln y_{tp} + \beta_0 x + \delta + \epsilon_t \quad (1)$$

Why do they include prefectural outcome $\ln y_{tp}$ on right hand side? Note: c subscripts dropped for r,δ,ϵ

Transportation infrastructure r_t should affect $\ln y_{tc}$ directly but may also affect indirectly through $\ln y_{tp}$

Note: here we see reference to open city prediction; also similar to DP equation $N_c/N = (R(0) - R(x_c))/(R(0) - \bar{R})$

Thus coeff A_1 has interpretation of effect of r_t on $\ln y_{tc}$ for constant $\ln y_{tp}$

What is δ? Could δ make r_t endogenous, example? How to get rid of δ?

Time differenced specification 1

$$\ln y_{tc} = A_0 + A_1 r_t + A_2 \ln y_{tp} + \beta_0 x + \delta + \epsilon_t \tag{1}$$

Authors worry that effect of RHS variables in 1990 differs from later years since China was closer to planned economy in 1990

$$\begin{aligned}\ln y_{1990c} =& (A_0 + \triangle A_0) + (A_1 + \triangle A_1) r_{1990} + (A_2 + \triangle A_2) \ln y_{1990p} + \\ & (\beta_0 + \triangle \beta_0) x + \delta + \epsilon_{1990}\end{aligned} \tag{3}$$

Subtract 3) from 1):

$$\begin{aligned}\triangle_t \ln y_c =& - \triangle A_0 + A_1 \triangle_t r - \triangle A_1 r_{1990} + \\ & A_2 \triangle_t \ln y_p - \triangle A_2 \ln y_{1990p} - \triangle \beta_0 x + \triangle_t \epsilon\end{aligned} \tag{4}$$

Time differenced specification 2

$$\triangle_t \ln y_c = -\triangle A_0 + A_1 \triangle r_t - \triangle A_1 r_{1990} + A_2 \triangle_t \ln y_p - \triangle A_2 \ln y_{1990p} - \triangle \beta_0 x + \triangle_t \epsilon \tag{4}$$

Finally, authors note that r_{1990} was effectively zero, thus $\triangle_t r = r_t$ (ex: $\triangle_{2010} r = r_{2010} - r_{1990} = r_{2010}$):

$$\triangle_t \ln y_c = -\triangle A_0 + A_1 r_t + A_2 \triangle_t \ln y_p - \triangle A_2 \ln y_{1990p} - \triangle \beta_0 x + \triangle_t \epsilon \tag{5}$$

This is specification they estimate, mostly using 257 prefecture changes from 1990-2010

Any potential identification issues with this specification?

Endogeneity

$$\triangle_t \ln y_c = -A_0 + A_1 r_t + A_2 \triangle_t \ln y_p - \triangle A_2 \ln y_{1990p} - \triangle \beta_0 x + \triangle_t \epsilon \quad (5)$$

Authors worry about potential endogeneity of r_t, $\triangle_t \ln y_p$, and $\ln y_{1990p}$

- Transportation networks may be built more in growing or expanding cities
- Migration decisions may reflect city unobservables (ex: unobserved productivity changes) and are thus correlated with $\triangle_t \ln y_p$ and $\triangle_t \epsilon$
- Lastly, $\ln y_{1990p}$ may mechanically correlate with outcomes (ex: if big in 1990 then maybe changes can be larger–some kind of level and changes correlation)

Endogeneity of Transportation

What was their identification strategy for endogenous transportation network changes?

IV strategy: instrument with 1962 road network, similar to Baum-Snow (QJE 2007)

Why relevant: post-1990 urban highways follow 1962 roads because government already has "rights of way" and 1962 roads connected to local street networks

Exclusion restriction:
1962 roads only correlated with 1990 and 2010 outcomes through highways; not built in anticipation of modern cities (ex: modern commuting)

Use a similar strategy to instrument for post-1990 railroads

Instrumenting for transportation infrastructure

Infrastructure plans as instruments: idea is that plan was designed for a purpose different from sources of potential endogeneity

- Baum-Snow (QJE 2007) instruments for radial highways outside US cities with a 1947 national highway system plan; argues 1947 plan designed for military and trade across cities, *not* to link suburbs with central cities
- Jerch et al. (JUE 2024): use 2003 Beijing subway plan, argue designed for defense (in 1957) and not current growth trends
- Hsu and Zhang (JUE 2014): use 1987 national expressway plan in Japan (expansion of network)

Historical transportation networks: this paper, Duranton and Turner (AER 2011, ReStud 2012) and with Morrow (ReStud 2013). Idea is that historical infrastructure provides “rights of way”

Exogenous geographical features and construction costs: Dinkelman (AER 2011), Faber (ReStud 2014), Donaldson (AER 2016), Hu and Xu on high speed rail in China (WP 2024)

Endogeneity of Non-city Prefecture Population

How did they address this identification issue?

Bartik shock (Bartik 1991) or Migration shock (Card 2001) method:

- Basic idea is to predict future flow with past distribution
- Bartik: use percentage of total industry *i* employment in city *c* from some earlier period interacted with *national-level* shock to industry to predict outcome in city *c*
- Migration shock: use past distribution of migrants interacted with national level to predict current level in a city.
- Migration example: 10% of Chinese immigrants in US choose to live in San Francisco area in 1990, if there are 200k Chinese immigrants in 2010 then predict 20k will settle in SF.
- This paper: interact fraction of out-migrants from each province going to each prefecture from 1985-1990 with total number out-migrants from each province 1995-2000

Migration Shock Discussion

Very useful and versatile instrument

Key identifying assumption: past migration flows are uncorrelated with current unobservables affecting outcomes

Example violation: if out-migrants make cities *increasingly* more productive, or there are serially correlated shocks attracting multiple generations of migrants, then 85-90 migration flow would be correlated with unobserved productivity changes

Authors argue that since 85-90 migration is from “pre-market reform period” identification assumption is likely to hold

Lastly $\ln y_{1990p}$: replace $\ln y_{1990p}$ with $\ln y_{1982p}$

Again, must assume that shocks in 1990 are uncorrelated with 1982

Results and Interpretation

All Variables Summary Statistics

Table A1: Summary Statistics

	Mean	Stdev	Min	Max
Panel A: Transport Measures and Instruments				
2010 radial highways	3.81	2.03	0	12
1999 radial highways	2.89	1.74	0	8
ln(highway kms in prefecture remainder, 2010)	6.17	0.81	0.40	8.20
2010 ring road indicator	0.29	0.45	0	1
2010 radial railroads	1.85	1.26	0	6
ln(railroad kms in prefecture remainder, 2010)	4.55	1.42	0	6.71
1962 radial highways	2.04	1.38	0	6
ln(roads kms in prefecture remainder, 1962)	5.33	1.01	0.00	7.33
1962 ring road indicator	0.05	0.22	0	1
1962 railroad rays	1.16	1.25	0	5
ln(railroad kms in prefecture remainder, 1962)	2.83	2.17	0	6
Card migration instrument	0.07	0.13	0	1.18
Panel B: Dependent Variables				
Δln(central city population, 1990-2010)	0.41	0.31	-0.25	1.75
Δln(prefecture population, 1990-2010)	0.14	0.20	-0.25	1.83
Δln(central city industrial GDP, 1990-2010)	3.19	0.61	1.15	5.30
Δln(central city employed residents, 1990-2010)	0.23	0.33	-0.38	1.66
Δln(central city residents working in manuf., 1990-2010)	-0.19	0.75	-2.46	1.87
Δln(central city manufacturing employment, 1995-2008)	0.33	0.59	-0.89	3.21
Panel C: Control Variables				
ln(central city area)	7.11	0.95	4.63	9.91
ln(prefecture area)	9.32	0.74	6.94	12.03
provincial capital indicator	0.10	0.30	0.00	1.00
ln(prefecture population, 1982)	14.86	0.66	12.65	17.11
fraction high school or more in prefecture, 1982	0.12	0.04	0.02	0.29
share employed in manufacturing, 1982	0.12	0.09	0.01	0.46
ln(km to coast)	5.24	1.88	-5.38	7.38
fraction of pref. high school or more in central city, 1982	0.37	0.21	0.05	1.00
fraction of pref. manufacturing emp in central city, 1982	0.50	0.22	0.09	1.00
fraction of pref. population in central city, 1982	0.27	0.19	0.02	1.00

Notes: Statistics are for the primary sample of 257 prefectures except for the growth in central city industrial GDP, which we only observe for 241 cities.

Growth Summary Statistics

Table 1: Growth in Aggregate Population and GDP by Location 1990-2010

	Population Growth (257 Prefectures)		Lights Growth (257 Prefectures)		Real Industrial GDP Growth (189 Prefectures)	
	Central City	Prefecture Remainder	Central City	Prefecture Remainder	Central City	Prefecture Remainder
Mean in 1990	955,683	2,953,557			9.28	6.56
1990-2000	25%	4%	52%	94%	158%	343%
2000-2010	23%	1%	33%	36%	277%	300%
1990-2010	54%	5%	102%	165%	873%	1673%

Notes: The 257 prefectures used to build the numbers in the first four columns is our primary sample. We do not include 1990 means for lights because levels of lights are difficult to interpret. The smaller sample for the final two columns reflects data limitations. Of the 189 prefectures, statistics for 93 prefecture remainders include imputed information for 1990. Industrial GDP is deflated with provincial deflators and is in 100 million RMB.

Interested in whether transportation leads to slower city growth than otherwise, not absolute decline

Outline of Specifications

$$\triangle_t \ln y_c = -\triangle A_0 + A_1 r_t + A_2 \triangle_t \ln y_p - \triangle A_2 \ln y_{1990p} - \triangle \beta_0 x + \triangle_t \epsilon \qquad (5)$$

Estimate main specification above using 1) OLS 2) IV

For each estimation method, run multiple specifications looking at different transportation measures (instruments not strong enough to pool) and adding different control variables

Do a number of robustness checks (not in slides) excluding West, using eq 4, showing evidence cities didn't decentralize in pre-reform period (Table A3), dropping large cities

Then look at transport effect on industrial GDP and manufacturing workers (still eq 5, diff dep var)

OLS Specification

Table 3: OLS Relationships Between Tansport Infrastructure and Population Outcomes

	Δ ln(CC Pop) 1990-2010					
	(1)	(2)	(3)	(4)	(5)	(6)
2010 radial highways	0.0097	-0.0114**	-0.0118**	-0.0123**		-0.0108*
	(0.0088)	(0.0050)	(0.0050)	(0.0048)		(0.0055)
ln(highway kms in prefecture remainder, 2010)			0.0221			
			(0.0276)			
2010 radial railroads				0.0105		
				(0.0100)		
2010 ring road indicator					0.0320	0.0273
					(0.0322)	(0.0323)
Δ ln(Pref Pop) 1990-2010		0.9212***	0.9113***	0.9221***	0.9075***	0.9230***
		(0.0641)	(0.0691)	(0.0650)	(0.0655)	(0.0630)
Base controls	No	Yes	Yes	Yes	Yes	Yes
Observations	257	257	257	257	257	257
R-squared	0.004	0.490	0.491	0.492	0.488	0.492

Notes: Each column shows coefficients from a separate OLS regression of the variable listed at top on transport infrastructure types listed at left and the indicated set of control variables. Base controls include ln(central city area), ln(prefecture area), a provincial capital indicator, ln(prefecture population, 1982), fraction high school or more in prefecture, 1982 and share employed in manufacturing in prefecture, 1982. Standard errors in parentheses are clustered by province.

Estimates are small in magnitude

First Stage

Table 2: First Stage Regressions

	2010 Radial Highways (1)	1999 Radial Highways (2)	2010 Radial Railroads (3)	2010 Ring Highway Indicator (4)	Δln(Prefecture Pop) 1990-2010 (5)
1962 radial roads	0.361***	0.350***	0.0211	-0.0234	-0.00462
	(0.0860)	(0.0801)	(0.0345)	(0.0228)	(0.00594)
1962 radial railroads	0.177	0.166*	0.373***	0.00517	0.00453
	(0.107)	(0.0924)	(0.0528)	(0.0326)	(0.00851)
1962 ring road indicator	-0.617	-1.082***	-0.232	0.522***	-0.0237
	(0.427)	(0.302)	(0.305)	(0.146)	(0.0322)
ln(central city area)	0.125	-0.0527	-0.0135	-0.181***	-0.0265**
	(0.123)	(0.123)	(0.0937)	(0.0288)	(0.0126)
ln(prefecture area)	0.0419	0.239	-0.0551	0.0294	-0.0431
	(0.205)	(0.178)	(0.167)	(0.0454)	(0.0266)
provincial capital indicator	1.369**	1.239**	0.198	0.0910	0.162***
	(0.507)	(0.492)	(0.237)	(0.115)	(0.0293)
ln(prefecture population, 1982)	0.703***	0.302*	0.435***	0.0747	-0.0818***
	(0.190)	(0.150)	(0.133)	(0.0605)	(0.0287)
fraction high school or more	4.523	1.846	4.586**	-0.203	-0.188
in prefecture, 1982	(2.671)	(3.227)	(2.191)	(0.913)	(0.377)
share employed in manufacturing	-4.416**	-1.513	-1.403**	0.360	0.0833
in prefecture, 1982	(2.079)	(1.997)	(0.661)	(0.374)	(0.175)
Card migration instrument	2.08e-06*	2.05e-06***	-1.01e-06	-2.36e-07	7.61e-07**
	(1.10e-06)	(6.92e-07)	(7.09e-07)	(1.40e-07)	(3.02e-07)
constant	-9.114***	-4.596**	-4.783**	0.196	1.890***
	(2.762)	(2.080)	(2.043)	(0.895)	(0.564)
Observations	257	257	257	257	257
R-squared	0.330	0.340	0.252	0.242	0.500

Notes: Each column shows coefficients from a separate OLS regression of the variable listed at top on the variables listed at left. The final covariate is the instrument for 1990-2010 prefecture population growth constructed using 1985-1990 migration pathways, as is explained in the text. Standard errors in parentheses are clustered by province. *** p<0.01, ** p<0.05, * p<0.1

Each instrument matches dependent variable; why controls?

First Stage

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	(1.10e-06)	(6.92e-07)	(7.09e-07)	(1.40e-07)	(3.02e-07)
constant	-9.114***	-4.596**	-4.783**	0.196	1.890***
	(2.762)	(2.080)	(2.043)	(0.895)	(0.564)
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Each instrument matches dependent variable; why controls?

"Because the coefficient on 1962 radial roads is statistically identical in these two regressions, this instrument does not predict changes in roads between 1999 and 2010, noting that these road measures are not directly comparable. These facts mean that we cannot empirically isolate effects of radial highways built between 1999 and 2010."

IV Specification: how do results compare to OLS?

Table 4: IV Estimates of Effects of Transport Infrastructure on Population Outcomes

	Δ ln(CC Pop) 1990-2010					
	(1)	(2)	(3)	(4)	(5)	(6)
2010 radial highways	-0.0067	-0.0423*	-0.0448**	-0.0412*		-0.0587**
	(0.0186)	(0.0223)	(0.0228)	(0.0246)		(0.0259)
ln(highway kms in prefecture			0.0885			
remainder, 2010)			(0.0797)			
2010 radial railroads				-0.0105		
				(0.0485)		
2010 ring road indicator					-0.1873**	-0.2520**
					(0.0916)	(0.1111)
ln(central city area)		-0.1178***	-0.0966***	-0.1188***	-0.1620***	-0.1662***
		(0.0191)	(0.0225)	(0.0205)	(0.0295)	(0.0336)
ln(prefecture area)		0.0508***	-0.0335	0.0495**	0.0388	0.0566**
		(0.0178)	(0.0848)	(0.0194)	(0.0283)	(0.0249)
provincial capital indicator		0.1751**	0.1864**	0.1798**	0.1393**	0.2233***
		(0.0724)	(0.0733)	(0.0766)	(0.0574)	(0.0738)
ln(prefecture population, 1982)		0.1101***	0.0784	0.1140***	0.0699**	0.1387***
		(0.0365)	(0.0549)	(0.0304)	(0.0349)	(0.0443)
fraction high school or more		-0.3790	-0.4185	-0.3062	-0.4779	-0.2465
in prefecture, 1982		(0.3415)	(0.3489)	(0.5070)	(0.4516)	(0.4257)
share employed in manufacturing		-0.2845	-0.2652	-0.2881	-0.0415	-0.2884
in prefecture, 1982		(0.2544)	(0.2717)	(0.2465)	(0.2486)	(0.2904)
Δ ln(Pref Pop) 1990-2010		0.8124***	0.7555***	0.7975***	0.6228***	0.7752***
		(0.1389)	(0.1801)	(0.1657)	(0.1479)	(0.1733)
constant	0.4349***	-0.7535	-0.1754	-0.7846	0.1749	-0.7697
	(0.0971)	(0.5667)	(0.9525)	(0.5151)	(0.5207)	(0.5826)
Observations	257	257	257	257	257	257
First stage F	36.2	13.1	8.81	7.02	7.13	4.05

Notes: Each column shows coefficients from a separate IV regression of the variable listed at top on variables listed at left. All columns have first stages for infrastructure variables and the change in prefecture population 1990-2010. First stage results are in Table 2. Standard errors in parentheses are clustered by province.

Pay attention to F-stats; interpret magnitude of ring roads?

IV Specification: how do results compare to OLS?

Table 4: IV Estimates of Effects of Transport Infrastructure on Population Outcomes

	Δ ln(CC Pop) 1990-2010					
	(1)	(2)	(3)	(4)	(5)	(6)
2010 radial highways	-0.0067	-0.0423*	-0.0448**	-0.0412*		-0.0587**
	(0.0186)	(0.0223)	(0.0228)	(0.0246)		(0.0259)
ln(highway kms in prefecture remainder, 2010)			0.0885			
			(0.0797)			
2010 radial railroads				-0.0105		
				(0.0485)		
2010 ring road indicator					-0.1873**	-0.2520**
					(0.0916)	(0.1111)
ln(central city area)		-0.1178***	-0.0966***	-0.1188***	-0.1620***	-0.1662***
		(0.0191)	(0.0225)	(0.0205)	(0.0295)	(0.0336)
ln(prefecture area)		0.0508***	-0.0335	0.0495**	0.0388	0.0566**
		(0.0178)	(0.0848)	(0.0194)	(0.0283)	(0.0249)
provincial capital indicator		0.1751**	0.1864**	0.1798**	0.1393**	0.2233***
		(0.0724)	(0.0733)	(0.0766)	(0.0574)	(0.0738)
ln(prefecture population, 1982)		0.1101***	0.0784	0.1140***	0.0699**	0.1387***
		(0.0365)	(0.0549)	(0.0304)	(0.0349)	(0.0443)
fraction high school or more in prefecture, 1982		-0.3790	-0.4185	-0.3062	-0.4779	-0.2465
		(0.3415)	(0.3489)	(0.5070)	(0.4516)	(0.4257)
share employed in manufacturing in prefecture, 1982		-0.2845	-0.2652	-0.2881	-0.0415	-0.2884
		(0.2544)	(0.2717)	(0.2465)	(0.2486)	(0.2904)
Δ ln(Pref Pop) 1990-2010		0.8124***	0.7555***	0.7975***	0.6228***	0.7752***
		(0.1389)	(0.1801)	(0.1657)	(0.1479)	(0.1733)
constant	0.4349***	-0.7535	-0.1754	-0.7846	0.1749	-0.7697
	(0.0971)	(0.5667)	(0.9525)	(0.5151)	(0.5207)	(0.5826)
Observations	257	257	257	257	257	257
First stage F	36.2	13.1	8.81	7.02	7.13	4.05

Notes: Each column shows coefficients from a separate IV regression of the variable listed at top on variables listed at left. All columns have first stages for infrastructure variables and the change in prefecture population 1990-2010. First stage results are in Table 2. Standard errors in parentheses are clustered by province.

Pay attention to F-stats; interpret magnitude of ring roads?

1. From paper “The control variable that influences the radial highways’ coefficient the most is log of 1982 prefecture population. More populous prefectures had more roads in 1962 and experienced more rapid central city population growth, reflecting that growth was fueled by within-prefecture migration. Absent the control for 1982 prefecture population, the coefficient on highway rays reflects both the negative causal effect of this infrastructure and the positive effects of the omitted variable.”
2. “Conditional on highway rays, ring road capacity reduces central city populations by about 25%, although the joint F on the first stage is low. Because of low power in the first stage, we cannot identify an additional separate interaction effect between rays and rings. We also note that ring roads and rays may be substitutes in designing urban transport networks, which may be why controlling for ring roads enhances and sharpens the highway ray effect in column 6 relative to column 2, raising the coefficient in magnitude from 0.042 to 0.059.”

Industrial GDP Results: compare panels A and B

Table 8. Effects of Transport on Industrial Sector GDP, 1990-2010

Panel A: IV Results

	Δln(Central City Industrial GDP) 1990-2010							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2010 radial highways	0.0277		0.0514			-0.0103		
	(0.0528)		(0.0635)			(0.0709)		
2010 radial railroads		-0.2388**	-0.2676**	-0.1867**			-0.2364**	-0.3375***
		(0.0971)	(0.1177)	(0.0941)			(0.1130)	(0.0738)
ln(railroad kms in prefecture remainder, 2010)				-0.1174				
				(0.1101)				
2010 ring road indicator					-0.5624**	-0.5738*	-0.7102**	
					(0.2787)	(0.3220)	(0.3351)	
ln(central city area)	0.0846	0.0715	0.0613	0.0271	-0.0260	-0.0268	-0.0736	
	(0.0597)	(0.0608)	(0.0665)	(0.0577)	(0.0518)	(0.0529)	(0.0634)	
ln(prefecture area)	-0.2357**	-0.2494**	-0.2677**	-0.1271	-0.2299**	-0.2268**	-0.2524***	
	(0.1084)	(0.0981)	(0.1081)	(0.1654)	(0.0988)	(0.1016)	(0.0976)	
provincial capital indicator	0.1885	0.3646*	0.3096	0.3700*	0.2798	0.2952	0.4298*	
	(0.1615)	(0.2010)	(0.2123)	(0.1949)	(0.1864)	(0.1861)	(0.2385)	
ln(prefecture population, 1982)	-0.0158	0.1203	0.0785	0.1250	0.0425	0.0541	0.1558	
	(0.1012)	(0.1158)	(0.1092)	(0.1196)	(0.0904)	(0.1161)	(0.1226)	
fraction high school or more in prefecture, 1982	-3.6602**	-1.6142	-1.5647	-1.2734	-3.2130*	-3.1689*	-1.1949	
	(1.5401)	(1.6733)	(1.6212)	(1.6517)	(1.7882)	(1.8777)	(1.9857)	
share employed in manufacturing in prefecture, 1982	-1.0124	-1.3549*	-1.1373	-1.4133**	-1.0416	-1.0882*	-1.2245*	
	(0.6603)	(0.7061)	(0.7173)	(0.6703)	(0.6676)	(0.5614)	(0.6846)	
Δ ln(Pref Pop) 1990-2010	-0.7585*	-0.9617	-1.1525	-0.9942	-0.8840*	-0.8570*	-1.2235	
	(0.4606)	(0.6491)	(0.7139)	(0.6198)	(0.5331)	(0.4837)	(0.7736)	
constant	5.5634***	4.1251**	4.8470**	3.6507*	5.6586***	5.5016***	4.8267**	3.8227***
	(1.5405)	(1.8353)	(1.9399)	(1.9873)	(1.4638)	(1.7195)	(2.0582)	(0.1413)
Observations	241	241	241	241	241	241	241	241
First stage F	10.9	24.3	5.69	5.63	6.67	4.24	3.90	79.2

Panel B: OLS Coefficients on Transport Measures

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2010 radial highways	-0.0131		-0.0098			-0.0170		
	(0.0164)		(0.0154)			(0.0173)		
2010 radial railroads		-0.0388	-0.0369	-0.0367			-0.0413	-0.0722**
		(0.0373)	(0.0364)	(0.0385)			(0.0363)	(0.0318)
ln(railroad kms in prefecture remainder, 2010)				-0.0106				
				(0.0333)				
2010 ring road indicator					-0.1388	-0.1468	-0.1445	
					(0.0857)	(0.0884)	(0.0859)	

Notes: In Panel A, road and rail network measures in 1962 instrument for these measures in 2010 while predicted migration flows instrument for Δln(Pref Pop) 1990-2010. Regression specification in Panel B are the same as Panel A except no variables are instrumented for. Standard errors in parentheses are clustered by province.

Worker Displacement Results

Table 9: Population Versus Employment Decentralization

	Δln(CC Pop) 1990-2010		Δln(CC Working Residents) 1990-2010		Δln(CC Res. Working in Manuf.) 1990-2010		Δln(CC Manufacturing Employment) 1995-2008	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2010 radial highways	-0.0412*	-0.0562**	-0.0438	-0.0620*	0.0087	-0.0086	-0.0008	-0.0063
	(0.0246)	(0.0277)	(0.0351)	(0.0319)	(0.1113)	(0.1102)	(0.0920)	(0.0950)
2010 radial railroads	-0.0105	-0.0047	-0.0475	-0.0404	-0.3499**	-0.3431**	-0.2784**	-0.2762**
	(0.0485)	(0.0551)	(0.0541)	(0.0568)	(0.1623)	(0.1632)	(0.1288)	(0.1294)
ln(central city area)	-0.1188***	-0.1178***	-0.0483**	-0.0472*	0.1933***	0.1944***	0.1207**	0.1211**
	(0.0205)	(0.0249)	(0.0218)	(0.0253)	(0.0653)	(0.0633)	(0.0500)	(0.0497)
ln(prefecture area)	0.0495**	0.0209	0.0472*	0.0124	-0.3591***	-0.3925***	-0.2889***	-0.2995***
	(0.0194)	(0.0204)	(0.0252)	(0.0205)	(0.0880)	(0.0827)	(0.0886)	(0.0810)
provincial capital indicator	0.1798**	0.2693***	0.1329	0.2417***	-0.1535	-0.0493	-0.0377	-0.0048
	(0.0766)	(0.0677)	(0.0936)	(0.0776)	(0.1808)	(0.1771)	(0.1756)	(0.1664)
ln(prefecture population, 1982)	0.1140***	0.1324***	0.1399***	0.1623***	0.5769***	0.5983***	0.3137***	0.3205***
	(0.0304)	(0.0370)	(0.0354)	(0.0362)	(0.1217)	(0.1319)	(0.0953)	(0.1029)
fraction high school or more	-0.3062	0.0626	-1.0917	-0.6429	-4.5088**	-4.0790*	-1.1524	-1.0169
in prefecture, 1982	(0.5070)	(0.4889)	(0.7411)	(0.6174)	(2.1664)	(2.1964)	(1.7197)	(1.6874)
share employed in manufacturing	-0.2881	-0.4811*	-0.2644	-0.4993	-0.5180	-0.7430	0.1401	0.0692
in prefecture, 1982	(0.2465)	(0.2832)	(0.3455)	(0.3283)	(0.9950)	(1.0203)	(0.8528)	(0.8806)
Δ ln(Pref Pop) 1990-2010	0.7975***		0.9705***		0.9294		0.2931	
	(0.1657)		(0.1798)		(0.5857)		(0.5052)	
Δ ln(Pref Emp) 1990-2010		0.7784***		0.9473***		0.9072*		0.2861
		(0.1954)		(0.2008)		(0.5359)		(0.4837)
Constant	-0.7846	-0.7177	-1.6781***	-1.5967***	-5.7078***	-5.6299***	-1.8988	-1.8742
	(0.5151)	(0.6132)	(0.5278)	(0.5674)	(1.8444)	(1.7850)	(1.6025)	(1.5686)
Observations	257	257	257	257	257	257	257	257
First stage F	7.02	4.02	7.02	4.02	7.02	4.02	7.02	4.02

Notes: Each column presents results of IV regressions of the variables listed at top on the variables listed at left. Dependent variables in Columns 1-6 are about central city residents, constructed using 1990 and 2010 census data. The dependent variable in Columns 7-8 is about central city jobs, constructed using the 1995 and 2008 Industrial Censuses. In Columns 1, 3, 5, and 7, the predicted change in prefecture population using migration flows instruments for the actual change. In Columns 2, 4, 6 and 8, the same instrument instead enters for 1990-2010 prefecture employment growth.

Railroads displace manufacturing workers (large effects)

Which industries should decentralize first?

Authors cite Meyer et. al. (1965) and suggest that industry decentralization should depend on weight-to-value ratio (how heavy is good relative to value?)

Suggest that lighter goods should decentralize first because they can take advantage of ring roads and shipment by truck (long distance shipment by rail is cheaper for heavy goods)

Quite interesting ideas, more in Duranton, Morrow, Turner, *Review of Economic Studies*, 2014

Employment Decentralization by Weight-to-Value

Table A4: Employment Decentralization by Industrial Sector - Generalized Shares Specifications

Panel A: High and Medium Weight to Value Ratio Industries

	Heavy weight (food, wood & paper, chemicals, non-metallic, primary metals: SIC13-16,20,22,25-28,31-33)			Medium weight (fab. metals, furniture, plastics, rubber, printing: SIC 21, 23, 24, 29, 30, 34)		
Weight to Value Ratio	0.51 to 0.80			0.22 to 0.35		
	(1)	(2)	(3)	(4)	(5)	(6)
2010 radial highways		-0.0150			0.0654	
		(0.0743)			(0.0989)	
2010 radial railroads	-0.1355*		-0.1342*	-0.2479**		-0.2442**
	(0.0733)		(0.0713)	(0.1231)		(0.1194)
2010 ring road indicator		-0.0866	-0.1439		-0.2070	-0.4136
		(0.3181)	(0.3200)		(0.4177)	(0.4189)
Observations	257	257	257	257	257	257
First stage F	21.5	4.05	4.26	21.5	4.05	4.26

Panel B: Low Weight to Value Ratio Industries

	Textiles, apparel, leather (SIC 17-19)				High tech (SIC 368, 376, 40, 411, 412, 414, 419)			Elec. & non-elec. machinery & equip (non-high tech) [SIC 35-39 (exc. 368, 376), 413, 415]		
Weight to Value Ratio	0.06 to 0.25				0.01			0.12-0.13		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
2010 radial highways	-0.2341*		-0.2959**			-0.2175			-0.0325	
	(0.1291)		(0.1366)			(0.3360)			(0.1116)	
2010 radial railroads		-0.4649**		-0.4571**	-0.6545***		-0.6358**	-0.2360**		-0.2332**
		(0.1885)		(0.2018)	(0.2220)		(0.2872)	(0.1019)		(0.1059)
2010 ring road indicator			-0.9503	-0.8753		-2.0085*	-2.1182*		-0.2328	-0.3251
			(0.6415)	(0.5683)		(1.0631)	(1.1235)		(0.3184)	(0.2937)
Observations	257	257	257	257	257	257	257	257	257	257
First stage F	13.1	21.5	4.05	4.26	21.5	4.05	4.26	21.5	4.05	4.26

Notes: Each column reports coefficients from an IV regression of the 1995-2008 change in ln employment in the indicated manufacturing industries on indicated transport measures and controls. Control variables are the same as in Table 4 Column 2. Panel A does not show the effects of radial highways alone, but as columns 2 and 5 suggest the effects are small and insignificant. Standard errors in parentheses are clustered by province.

Low weight-to-value goods decentralize more

Summary of Results

1. Each radial highway displaces 4% of central city population
2. Each ring road displaces another 20% of central city population–very high estimate!
3. Results are stronger when excluding Western provinces
4. Radial railroads reduce central city industrial GDP by 20% and ring roads displace an additional 50%
5. Each radial railroad causes 35% of central city manufacturing employment to move out–very large!

Concluding Discussion

Conclude with general discussion of welfare impact:

- Transportation improvements increase income net of commuting, allows firms and residents to locate further from center, everyone can consume more space
- Firms can now allocate more space per worker, which may leading to higher wages (if complementarity, not clear discussion)
- Focusing welfare gain on commuting and housing cost reductions: use back of envelope calculation and simulations from earlier paper (Baum-Snow JUE 2007) to conclude total welfare gain of 2-4% of income

Discussion

- Clever paper that uses a variety of sophisticated techniques to make up for lack of data (map digitization, lights-at-night data)
- Careful paper and relates empirical specifications to details of China's institutions
- Additional novelty is distinction between types of roads by geography/shape

Comments?

Additional References

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