Transport Infrastructure, City Success and Market Access in China: Primate vs secondary cities

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Questions of Interest

- China built a massive national expressway system in under 10 years (2000-2010)
  - Other developing countries are engaged in massive transport infrastructure projects

- How do new national highway networks influence the level and spatial distribution of economic activity?
- Our focus:
  - Improved access to domestic markets vs. international markets
  - Spatial heterogeneity in impacts especially for domestic access
    - Under Chinese factor market restrictions

- Basic issues in making inferences
  - Non-random allocation of roads
  - Interdependence of network – own city linkages affect all other cities' access
    - Hard to define control group
    - Hard to distinguish reallocation vs growth absent a structural model

2 methodological approaches

- What are the tradeoffs between methodological approaches in addressing these questions?

1. Conventional single equation: causal effects of road measures on city outcomes
  - Can deal with non-random assignment (appropriate pseudo-randomization)
  - Have specific infrastructure measures: the actual policy instrument
  - ***In principle: only gives slope coefficient: effect of change in localized allocation of highways to one city, relative to the equilibrium allocation***

2. Eaton-Kortum (2002) structural type approach (Donaldson & Hornbeck 2014; Alder 2015) with calibration
  - Ricardian trade: Accounts for complicated linkages across regions and g.e. price effects
    - But specific structure (Ricardian trade): may fail in a first order way to explain the data
  - Relationship to conventional single equation:
    - Model generates a market access measure for each city (like a gravity measure). Can use in a regression equation

Findings for conventional regression model

- **Single equation regressions** suggest:
  - Overall, increases in city's regional road network (OR **domestic** market potential/access measures) have **negative** effects on city population
    - **Heterogeneity:** Increases in city's regional road network increase output and population **in *regional primate cities,*** *at expense of others*
  - Increase in access to coastal ports increases local population, GDP and GDP per capita
    - No regional primate differential
- Speculation on role of regional primates from regression analysis
  - China has substantial labor market frictions where mobility between regions is much lower that within regions (Tombe and Zhu, 2015)
  - With NEG scale economies within region, could envision primates gaining manufacturing (with greater diversity) and peripheral cities loosing.
    - Suggests regional hierarchies

Literature

- Highway or rail effects in a general equilibrium model
  - Donaldson and Hornbeck (2015), Alder (2015), Tombe and Zhu (2015) and Sotelo (2015) use EK model
  - Other structural approaches
    - Fajgelbaum and Redding (2014) and many more
- Hierarchy models:
  - Christaller (1933);
  - Fujita Krugman and Mori (1999) and Tabuchi and Thisse (2011): economies on lines or circles
- Regressions:
  - Banerjee, Duflo & Qian (2012); Faber (2014) and Storeygard (2016)

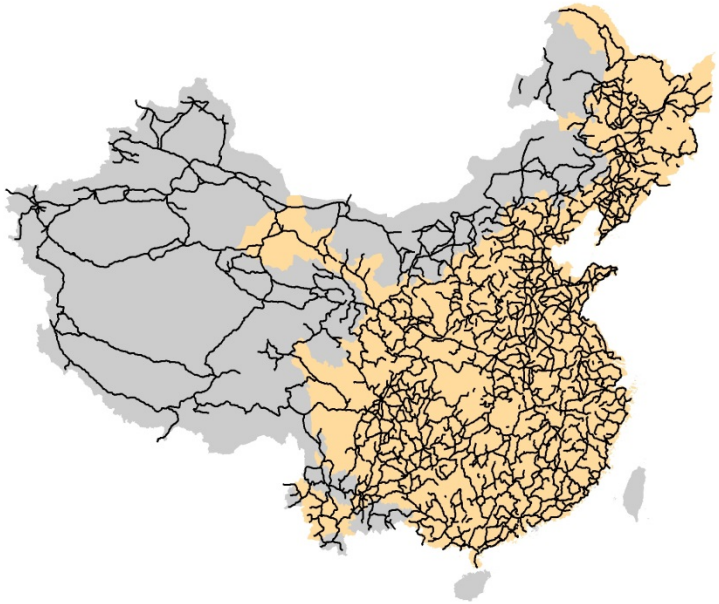
Context

- In 1990:
    - Urban China is a planned economy
    - Very limited inter-prefecture trade
        - Most inter-prefecture and even intra- provincials shipments by rail
            - Roads in 1990 move about 5% of ton-kms nationally
            - Mostly roads unpaved and used only for within-prefecture transport of agricultural goods from farms and manufacturing goods to farms
    - Strong restrictions on labor mobility
- By 2010:
    - Largely a free market economy in *goods* allocation
    - Largely complete national express highway system with over 35% of ton-kms by road
    - However, factor markets still have strong government role
- Focus on 2010 levels (long run equilibrium), rather than 90-10 changes because 1990 is not a market context

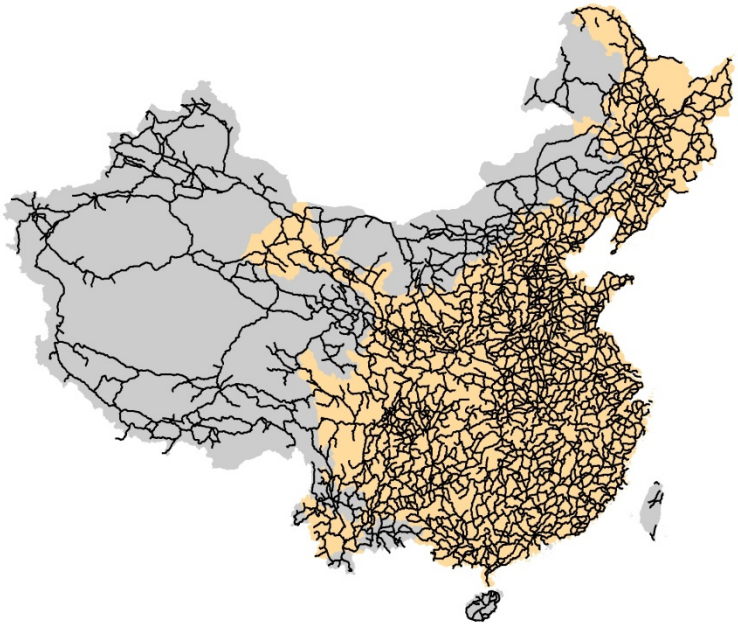
Data

- DATA
  - 282 prefectures in Han China (over 85% of the population)
  - Have demographic censuses for 1982, 1990, 2000, 2010
  - Have prefecture GDP numbers for 1990, 2000, 2010 (University of Michigan on line and printed yearbooks)
  - Digitize paper maps of roads in various years including 1962. later maps (like 2010) distinguish 3 levels of roads
- ROADS
  - Road maps over many years.

1962 roads



1990 roads



Limited access highways

1999

2010

Conventional infrastructure approach

(in regression analysis)

- As a key exercise, want the direct causal effects of **road infrastructure** (direct policy measure) near prefecture cities on prefecture outcomes (GDP and population)
    - Weight expressways as 90/25 & the rest as 1: count of efficiency units within 450 kms
        - Also used measures of local "market potential" (EK market access domestic and international components; gravity)
- Second measure is driving time to coast **port**. Perhaps can think of varying it independently of what goes on in other cities
- Will distinguish regional primates (Rank 1 cities)
    - Largest city in 1982 within a 6 hour drive over 1962 network at 90 kms per hour: 9% of cities are regional primates.

    Tried 4 or 5 hours as well: similar results. We prefer smaller number of primates

Conventional approach in the paper

$$\ln y_{it} = a + \beta \ln L_{it} + \psi E_{it} + X_i \delta + u_{it}$$

$$L_{it} = a_1 + \beta_1 \ln L_{i62} + \psi_1 E_{i62} + X_i \delta_1 + \eta_{it}^1$$
$$E_{it} = a_2 + \beta_2 \ln L_{i62} + \psi_2 E_{i62} + X_i \delta_2 + \eta_{it}^2.$$

- Ln y may be population or GDP in 2010
- Also have versions with :
  - Ln GDP outcome, controlling and instrumenting for population (Card migration instrument): effectively GDP per capita
  - 1990-2010 growth in population
- Slope coefficients: effect for one city of better access, “holding other cities constant”
  - Feedback effects included: effects reflect not just own links to regional markets, but also other cities links to the own city and their links (thru own city) to other cities which affects demand for own city products

Identification challenges

- Highways built to serve growing, more productive, export cities
  - Unobservables driving regional incomes also predict modern highway construction
  - Need instruments that influence market access but not through *own or other prefectures' output or components* thereof conditional on controls
    - Suggest using aspects of travel costs only (not weighted by GDP)
- Use 1962 road network as a source of identifying variation.
  - Instrument for 2010 efficiency units with 1962 road units within 450km *outside* own prefecture
  - Instrument for current travel time to nearest port with travel time to the nearest port over the 1962 road network
- 1962 roads give rights of way for new highways so induce (cheaper) construction over old roads
  - 1962 roads built just to move food from local farms to cities. Not designed for inter-prefecture trade (poor quality)
  - Also can use 5-7 plan

First stage

	log 2010 Road Efficiency Units within 450 km	log 2010 Time to Nearest Port	log 2010 Prefecture Population	log 2010 EK Market Access	log 2010 Domestic Market Access	log 2010 External Market Access
Instruments						
log 1962 Roads within	**1.05*** **	-0.30**	-0.056	**0.081*** **	**0.088*** **	0.059***
450 km, excl own pref	(0.04)	(0.13)	(0.058)	(0.0076)	(0.0083)	(0.0081)
log 1962 time to nearest	-0.016*	**0.72*** **	-0.025	**-0.0029** **	-0.00073	**-0.0093*** **
port at 2010 highway speeds	(0.01)	(0.072)	(0.019)	(0.0014)	(0.0016)	(0.0015)
Migration instrument	1.8e-07*	-8.7e-07**	**1.2e-06*** **	2.3e-08**	2.5e-08**	1.6e-08*
	(8.72e-08)	(4.1e-07)	(3.3e-07)	(9.6e-09)	(1.2e-08)	(9.6e-09)
Controls	yes	yes	yes	yes	yes	yes
R-squared	0.88	0.88	0.92	0.81	0.75	0.88

Notes: Each column is a separate representative first stage regression. Each regression includes 282 observations.

Bold: instrument assigned to the variable

Controls: **1982 industrial mix (role of agric.),** education, pref and centre city population; area of pref (2005) and centre city (1990), pref and centre city roughness; **distance to coast,** & **provincial capital**.

Table 4: Infrastructure Regressions				
		Decomposition		POP Growth
	log Prefecture GDP, 2010	log Prefecture Pop, 2010 reallocation	log Prefecture GDP, 2010	D_censuspop 9010_pref
log Road Eff. Units within 450 km of Prefecture City	-0.029	-0.12**	0.100	-0.13***
	(0.13)	(0.06)	(0.11)	(0.04)
log Driving time to nearest international port	-0.16**	-0.10*	-0.047*	-0.069**
	(0.07)	(0.05)	(0.03)	(0.03)
log Prefecture Population, 2010			1.09***	
			(0.14)	
Complete set of controls	Yes	Yes	Yes	Yes
First stage F	236	236	**5.14**	236

- Negative effects of access to local regional markets, ON AVERAGE
- **A lot of GDP effects are reallocation**
- Col 4 gives growth equation: confirmation of levels (with aspects differenced out)
  - After population movements possible
- **HOW explain negative overall regional access effect on population?**

Table 6: Market Access Regressions						
					“ Decomposition”	
	log Prefecture GDP, 2010		log Prefecture Pop, 2010		log Prefecture GDP, 2010	
			Reallocation		for given population	
log Market Access	2.91*		0.63		2.04*	
	(1.61)		(0.93)		(1.24)	
log Domestic Market Access		**-8.79***		**-6.84****		**-1.20**
		(4.59)		(3.42)		(2.10)
log External Market Access		13.3**		8.54*		3.82*
		(5.73)		(4.62)		(2.13)
lcensuspop2010_pref					1.19***	1.11***
					(0.12)	(0.13)
Complete set of controls	yes	yes	yes	yes	yes	yes
First stage F	68.2	20.8	68.2	20.8	8.67	10.7

- Coefficients do not match what is predicted by EK model

$$MA_o = \sum_d \tau_{od}^{-\theta} \frac{Y_d}{MA_d} + \frac{\tau_{ox}^{-\theta} E}{\sum_d \tau_{dx}^{-\theta} \frac{Y_d}{MA_d}}; \quad (1) \quad (CMA_0 = P_0^{-\theta})$$

$$E = \frac{Y_x}{CMA_x}[\sum_d (Y_d / MA_d)\tau_{dx}^{-\theta}]; \; x: \text{foreign} \; (1a)$$

Table 5: Infrastructure regressions with heterogeneity				
	log Prefecture GDP, 2010	log Prefecture Pop, 2010	log Prefecture GDP, 2010	D_censuspop 9010_pref
log Road Eff. Units within	-0.13	**-0.16**** (-0.10)	0.056	-0.16***
450 km of Prefecture City	(0.14)	**(0.07)**	(0.11)	(0.05)
X Rank 1 Prefecture	0.44**	**0.25***** (0.24**)	0.16	0.23***
	(0.19)	**(0.09)**	(0.16)	(0.07)
log Driving time to nearest	-0.18**	**-0.11*** (-0.11***)	-0.051*	-0.075**
international port	(0.08)	**(0.06)**	(0.03)	(0.03)
X Rank 1 Prefecture	0.080	0.032 (0.043)	0.043	0.0096
	(0.08)	(0.05)	(0.05)	(0.03)
log Prefecture Pop, 2010			1.13***	
			(0.12)	
Rank 1 Prefecture	-5.16**	-2.82**	-1.97	-2.43***
	(2.26)	(1.15)	(1.85)	(0.86)
Full set of controls	Yes	Yes	Yes	Yes
First stage F	161	161	**4.25**	161

- Regional primate: biggest city in 1982 population within 6 hour drive on 62 roads
- With better local highways, regional primates gain population at expense of other cities
  - Hierarchy-NEG effects?
  - Could be other: Favoured in capital & infrastructure allocations for domestic production?
    - Better highways interact with this
- No heterogeneity for access to the coast:
  - Export activities access FDI & long distance migration

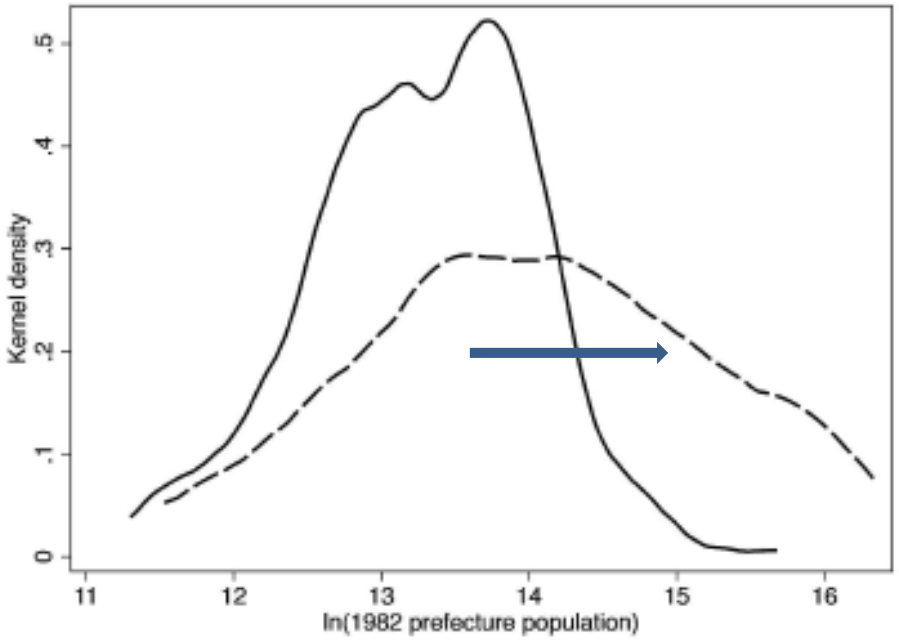
Robustness on rank: Go to 57 prefs: primate in 1982 population within 4 hours on 62 roads at high speed				
		Components		
	logGDP2010	logPOP2010	logGDP2010	D_logPOP9010
lall2_road_2010_km_disk450	-0.19	-0.21***	0.031	-0.22***
	(0.16)	(0.078)	(0.13)	(0.059)
Xrank1_all2road2010km450	0.37**	0.21***	0.15	0.21***
	(0.16)	(0.075)	(0.14)	(0.057)
lpd_road_2010	-0.20**	-0.13*	-0.059*	-0.090**
	(0.089)	(0.071)	(0.035)	(0.038)
Xrank1_lpdroad2010	0.083	0.062	0.017	0.038
	(0.076)	(0.055)	(0.044)	(0.030)
lcensuspop2010_pref			1.07***	
			(0.14)	
Observations	282	282	282	282
First stage F	155	155	3.92	155

Other evidence

- Regional primates focused more on domestic production
- TBD: diversity of manufactures and changes over time 98-11
  - Regional primates versus others
  - Mean normalized HHI in 1998 is same in primates vs non-primates.
  - Both means rise (more specialization with market reforms) but mean for non-primates rises more.

Regional primates (9% of cities)

Dashed lines for primates; rest solid lines



- 1982 prefecture populations:

Larger on average, but also considerable overlap in size

- For counties with national economic zones: regional primates more focused on domestic production.
- Here show employment;

same for book value or value added

Primates have 239% [206%] more national economic zones in 2005 [but average only 60% more people]

Counterfactual

- **Remove expressway** (set spend to 25kms)
- See city-by-city regression effects on population
- Force national constraint so changes over all cities sum to zero.

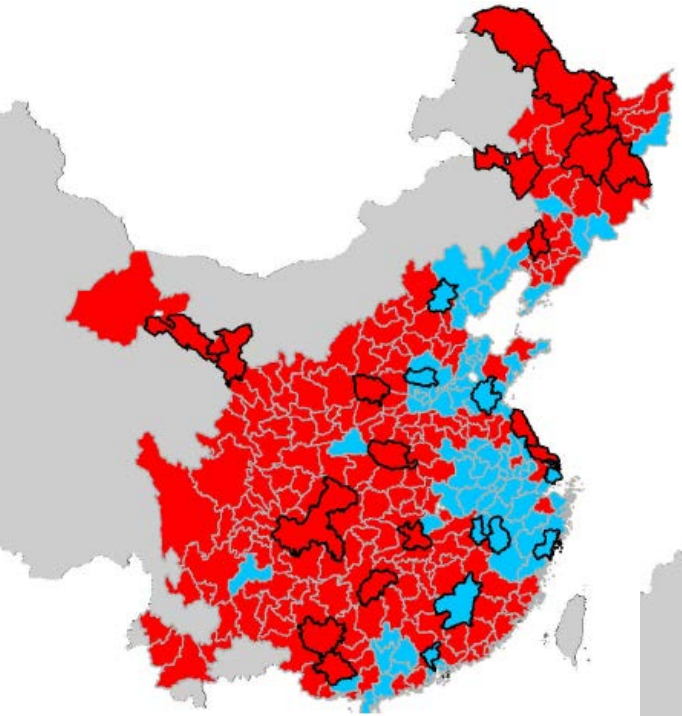
Model

Table 7: I**mpacts of Downgrading Expressways**			
Counterfactual-Actual Means with Standard Deviations in Parentheses			
	Highways at 25 kph	Time to port: 25 kph	Both
Changes in pop. counts (overall),	497,608	-516,872	0
	(414,346)	(404,330)	(381,028)
Changes in pop counts,	508,379	-547,987	0
(with reg primate)	(577,749)	(401,093)	(533,654)
Component: Changes in regional	-660,645	-656,733	-1,091,474
primates	(614,332)	(587,348)	(853,214)
Component: Changes in rest.	627,108	-536,942	110,853
	(421,111)	(377,000)	329,620)

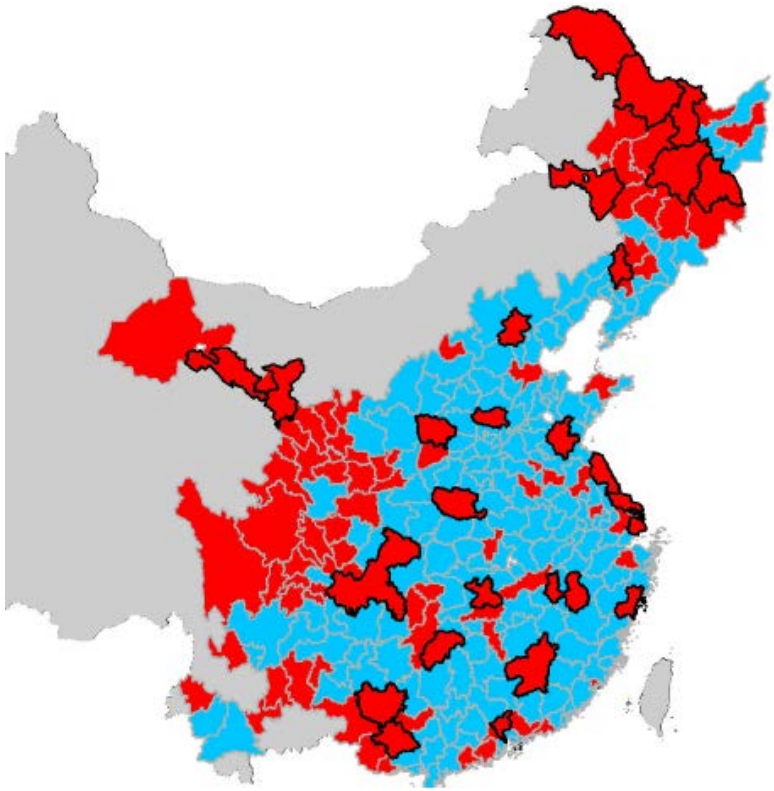
Notes: Counterfactuals in Columns 1 and 2 are not normalized to sum to 0 change.
Counterfactual in Column 3 is renormalized to sum to 0 aggregate population change.
Model base counterfactual in column 4 is constructed to have zero aggregate population change.

No regional primate differentials vs. differentials

Winners (blue) vs losers (red)



No differentials: Winners In heartland



Differentials

- **Primates lose**
- **Winners are non-primates who lose local roads**
- **But ones not cut-off from ports**

Main Conclusions

- Coastal access important to all
  - In a country with export driven growth as a policy
- Regional hierarchies matter, with highways causing population to move toward regional primate cities away from others, based on *local market access* differentials
    - Role of factor market restrictions: regional labor markets
    - Economic hierarchies
- Regression analysis tells us about directions of marginal effects
  - Little to say about welfare.
    - Even if GDP pc improved, need to account for price changes & general equilibrium effects
  - Can identify causal effects at the margin.
  - Informs modeling

Thank You