Regional Economic Impacts of Highway Projects

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Please note that the specific results presented here represent work in progress subject to revision and should not be cited

Introduction

- ***Massive expenditure on inter-regional transport infrastructure:***
  - e.g. EU (TEN-T), China (NEN), India (“Golden Quadrilateral”), East & Southern Africa (“North-South Corridor”)

- ***Twin policy objectives:***
  - (1) efficiency
  - (2) spatial equity

- ***NEG $\Rightarrow$ objectives may not be compatible:***
  - NEG (e.g. Fujita *et al*, 1999) $\Rightarrow$ spatial distribution of activity = eqbm outcome of agglomeration & dispersion forces on location decisions
  - $\downarrow$ transport costs $\rightarrow$ Δ in *relative* strength of both types of force
  - Overall outcome depends on structural characteristics of economy

Introduction

- ***On-going research programme to better understand impacts of major inter-regional highway projects:***
  - ***Aim:*** use multi-region NEG models & detailed GIS road network data to evaluate impacts on key economic indicators & welfare (aggregate & regional levels)
  - Combines estimation of key structural parameters with simulation of full model to identify impacts
  - GE nature of approach ⇒ capture economy-wide impacts that missed by standard impact evaluation toolbox & *ex ante* CBA of transport projects
  - Application to China's National Expressway Network- 331 prefectural level regions
  - ***Still work in progress***- results on impacts based on:

    (1) restricted version of full model

    (2) "short-run" only (⇒ immobility of labour)

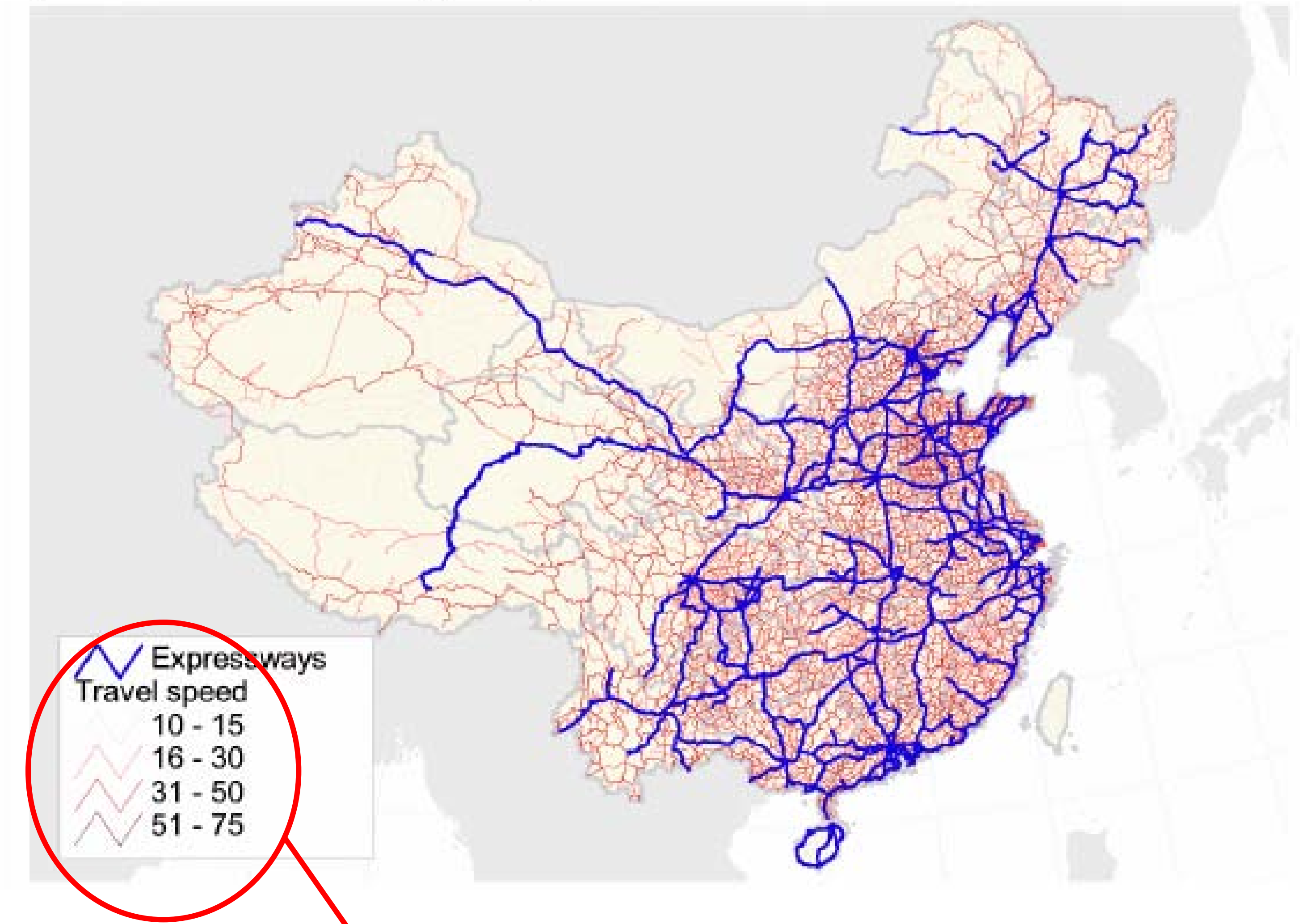
⇒ main aim: illustrate methodology & report on estimation of key structural parameters; detailed final results subject to revision

Overview of China's NEN

- ≈ 35,000 km of expressway (4-lane highways) constructed 1992 – 2007
- Speed limit of 120 km/h compared to 80 km/h on earlier built national highways
- Connects all provincial capitals & cities with registered urban population > 0.5 million
- US $40 billion + invested p.a.
- Construction concentrated between 1997-2007

Overview of China's NEN

Figure A 2: Road network with expressways



Design speeds used to calculate minimum estimated travel times using Dijkstra algorithm

Overview of Model

- Builds on Fujita *et al* (1999, chp. 7) & Fingleton (2007)
- 2-sectors (urban & rural), N regions

- ***Urban sector:*** standard Dixit-Stiglitz-Krugman set-up:
  - CES sub-utility fn. for varieties (σ = elas. of substitution)
  - Fixed labour requirement (s) for each firm/variety: $AL = s + ac(i)$
  - A = labour efficiency, allowed to vary across regions
  - Iceberg transport costs = T_{ir}^{C}

- ***Rural sector:***
  - Similar to urban sector, but no fixed labour requirement
  - $\Rightarrow$ (1) possibility of product differentiation between regions (η = elas. of substitution); (2) iceberg transport costs = T_{ir}^{R}
  - $\Rightarrow$ model allows for cross-regional variations in rural sector returns (unlike, e.g. Krugman, 1991)

Solution of model

- Assuming FE in both sectors, but no *inter*-regional L mobility:

$$w_i^C = A_i \left[\sum_{r=1}^{M} Y_r (T_{ir}^C)^{1-\sigma} (G_r^C)^{\sigma-1} \right]^{1/\sigma}$$

Real market access

$$w_i^R = (B_i)^{(\eta-1)/\eta} \left[\sum_{r=1}^{R} Y_r (T_{ir}^R)^{1-\eta} (G_r^R)^{\eta-1} \right]^{1/\eta}$$

$$G_i^C = \left[\sum_{r=1}^{M} \frac{N_r^C}{\theta} (A_r)^{\sigma} (w_r^C T_{ir}^C)^{1-\sigma} \right]^{1/(1-\sigma)}$$

$$G_i^R = \left[\sum_{r=1}^{M} \left(\frac{N_r^R}{1-\theta} \right) (B_r)^{\eta-1} (w_r^R T_{ir}^R)^{1-\eta} \right]^{1/(1-\eta)}$$

$$Y_i = N_i^C w_i^C + N_i^R w_i^R$$

Strategy: (1) estimate wage eqns; (2) use full model to analyse impacts based on transport costs before & after

Stage (1): Estimation

- Several studies have directly estimated NEG-style wage eqn using prefectural-level data (Au & Henderson, 2006; Bosker *et al*, 2009; Moreno-Monroy, 2008), but no study has estimated *separate* wage eqns for urban & rural sectors

- Use 2007 data for 331 prefectural level regions (99 % of agg GDP):
  - w^C**:** urban household disposable income per capita
  - w^R**:** rural household per capita income

Stage (1): Estimation

$$\ln(w_i^C) = \ln(A_i) + \frac{1}{\sigma}\ln(RMA_{i,DOM}^C) + \frac{Y_F (G_F^C)^{\sigma-1}}{\sigma}\left[\frac{1}{RMA_{i,DOM}^C (T_{iport}^C)^{\sigma-1}}\right]$$

$$\ln(w_i^R) = \left(\frac{\eta-1}{\eta}\right)\ln(B_i) + \frac{1}{\eta}\ln(RMA_{i,DOM}^R)$$

where $T_{ir} = 1 + t_{ir}^{0.82}$ (Au & Henderson, 2006)

t_{ir} = minimum estimated travel time

Roberts (2009): under reasonable conditions, travel time = good proxy for measure of GTC, inc VOCs (see also Combes & Lafourcade, 2005); **Hong *et al* (2004):** importance of travel time for Chinese manufacturing firms in selecting between 3PLs

Stage (1): Estimation

$$\ln(w_i^C) = \ln(A_i) + \frac{1}{\sigma}\ln(RMA_{i,DOM}^C) + \frac{Y_F (G_F^C)^{\sigma-1}}{\sigma}\left[\frac{1}{RMA_{i,DOM}^C (T_{iport}^C)^{\sigma-1}}\right]$$

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where $T_{ir} = 1 + t_{ir}^{0.82}$ (Au & Henderson, 2006)

t_{ir} = minimum estimated travel time

Estimation complicated by measurement error (inability to observe price indices), simultaneity & non-linearity (e.g. σ enters def^{n} of urban RMA)

Urban sector

Variable	OLS	OLS	2SLS	2SLS	FGS2SLS	FGS2SLS
Constant	7.06*** (19.01)	5.75*** (13.88)	7.67*** (16.72)	5.92*** (11.01)	4.89*** (14.53)	4.89*** (10.12)
Ln(human)	0.06 (0.59)	0.34*** (4.26)	-0.05 (-0.41)	0.27 (1.23)	-0.02 (-0.14)	0.28 (1.21)
Ln(I pw)	0.06*** (2.65)	0.10*** (5.34)	0.07*** (2.61)	0.10*** (3.45)	0.07*** (2.84)	0.10*** (3.25)
W*ln(human)	-0.26** (-2.11)	-0.20 (-1.60)	-0.29** (-1.97)	-0.18 (-1.35)	-0.30** (-2.27)	-0.18 (-1.36)
W*ln(I pw)	0.10*** (2.76)	0.14*** (4.35)	0.04 (0.99)	0.12*** (3.55)	0.07* (1.83)	0.12*** (3.50)
Ln(NMA_{dom})	0.16*** (13.52)	0.10*** (8.67)	0.18*** (6.82)	0.11* (1.74)	0.18*** (5.64)	0.11 (1.53)
$MP_{internat}$	98.59 (0.85)	115.16 (1.35)	1356.96*** (4.07)	643.74*** (2.90)	822.70*** (2.99)	590.54*** (2.59)
λ	-	-	-	-	0.34*** (9.07)	0.18*** (10.97)
Prov. dummies	No	Yes	No	Yes	No	Yes
σ *ER*	6.31 622.44	9.79 1126.76	5.65 7668.51	8.76 5641.55	5.68 4672.77	9.14 5400.08
R-sq R-sq(adj)	0.54 0.53	0.78 0.75	0.39 0.37	0.75 0.72	0.60 0.59	0.76 0.74

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R-sq R-sq(adj)	0.54 0.53	0.78 0.75	0.39 0.37	0.75 0.72	0.60 0.59	**0.76 0.74**

Rural sector

Variable	OLS	OLS	2SLS	2SLS	FGS2SLS	FGS2SLS
Constant	3.84*** (16.73)	3.40*** (11.29)	3.91*** (15.18)	3.58*** (11.30)	2.61*** (13.12)	3.08*** (11.01)
Ln(human)	0.59*** (4.66)	0.63*** (6.01)	0.53*** (3.38)	0.41** (2.31)	0.39** (2.48)	0.38** (2.03)
Ln(I pw)	0.07*** (5.40)	0.09*** (7.74)	0.07*** (5.19)	0.09*** (7.62)	0.07*** (6.07)	0.09*** (7.45)
W*ln(human)	0.53*** (3.26)	0.64*** (3.88)	0.53*** (3.26)	0.47*** (2.69)	0.54*** (3.43)	0.45** (2.54)
W*ln(I pw)	0.12*** (5.77)	0.10*** (4.91)	0.11*** (4.76)	0.08*** (3.61)	0.07*** (2.88)	0.07*** (3.09)
Ln(NMA)	0.12*** (7.47)	0.12*** (7.87)	0.14*** (4.31)	0.22*** (4.08)	0.18*** (4.83)	0.23*** (3.93)
λ	-	-	-	-	0.38*** (10.90)	0.17*** (8.24)
Prov. dummies	No	Yes	No	Yes	No	Yes
η	8.39	8.41	7.38	4.48	5.55	4.30
R-sq R-sq(adj)	0.71 0.71	0.86 0.84	0.71 0.71	0.85 0.83	0.78 0.78	0.85 0.84

Variable	**OLS**	**OLS**	**2SLS**	**2SLS**	**FGS2SLS**	**FGS2SLS**
Constant	3.84*** (16.73)	3.40*** (11.29)	3.91*** (15.18)	3.58*** (11.30)	2.61*** (13.12)	**3.08*** (11.01)**
Ln(human)	0.59*** (4.66)	0.63*** (6.01)	0.53*** (3.38)	0.41** (2.31)	0.39** (2.48)	**0.38** (2.03)**
Ln(I pw)	0.07*** (5.40)	0.09*** (7.74)	0.07*** (5.19)	0.09*** (7.62)	0.07*** (6.07)	**0.09*** (7.45)**
W*ln(human)	0.53*** (3.26)	0.64*** (3.88)	0.53*** (3.26)	0.47*** (2.69)	0.54*** (3.43)	**0.45** (2.54)**
W*ln(I pw)	0.12*** (5.77)	0.10*** (4.91)	0.11*** (4.76)	0.08*** (3.61)	0.07*** (2.88)	**0.07*** (3.09)**
Ln(NMA)	0.12*** (7.47)	0.12*** (7.87)	0.14*** (4.31)	0.22*** (4.08)	0.18*** (4.83)	**0.23*** (3.93)**
λ	-	-	-	-	0.38*** (10.90)	**0.17*** (8.24)**
Prov. dummies	No	Yes	No	Yes	No	**Yes**
η	8.39	8.41	7.38	4.48	5.55	**4.30**
R-sq	0.71	0.86	0.71	0.85	0.78	**0.85**
R-sq(adj)	0.71	0.84	0.71	0.83	0.78	**0.84**

Stage (2): simulation of impacts

$$w_i^C = A_i \left[\sum_{r=1}^{M} Y_r (T_{ir}^C)^{1-\sigma} (G_r^C)^{\sigma-1} \right]^{1/\sigma}$$

$$w_i^R = (B_i)^{(\eta-1)/\eta} \left[\sum_{r=1}^{R} Y_r (T_{ir}^R)^{1-\eta} (G_r^R)^{\eta-1} \right]^{1/\eta}$$

$$G_i^C = \left[\sum_{r=1}^{M} \frac{N_r^C}{\theta} (A_r)^{\sigma} (w_r^C T_{ir}^C)^{1-\sigma} \right]^{1/(1-\sigma)}$$

$$G_i^R = \left[\sum_{r=1}^{M} \left(\frac{N_r^R}{1-\theta} \right) (B_r)^{\eta-1} (w_r^R T_{ir}^R)^{1-\eta} \right]^{1/(1-\eta)}$$

$$Y_i = N_i^C w_i^C + N_i^R w_i^R$$

Use estimates of σ & η (& importance of international component of RMA in urban sector) together with implied estimates of A_i & B_i to obtain numerical solution of model for transport costs before & after

Stage (2): simulation of impacts

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$$Y_i = N_i^C w_i^C + N_i^R w_i^R$$

⇒ What would have been the levels of urban & rural income per capita & aggregate income in 2007 if the NEN had not been constructed?

Stage (2): simulation of impacts

- ***Simulation based on full model still work in progress → focus on restricted version of model:***

$$w_i^C = A_i \left[\sum_{r=1}^{M} Y_r (T_{ir}^C)^{1-\sigma} (G_r^C)^{\sigma-1} \right]^{1/\sigma}$$

$$w_i^R = (B_i)^{(\eta-1)/\eta} \left[\sum_{r=1}^{R} Y_r (T_{ir}^R)^{1-\eta} (G_r^R)^{\eta-1} \right]^{1/\eta}$$

$$Y_i = N_i^C w_i^C + N_i^R w_i^R$$

  - Ignores endogeneity of prices (⇒ can’t comment on full welfare impacts), but excellent empirical model
  - Results remain provisional

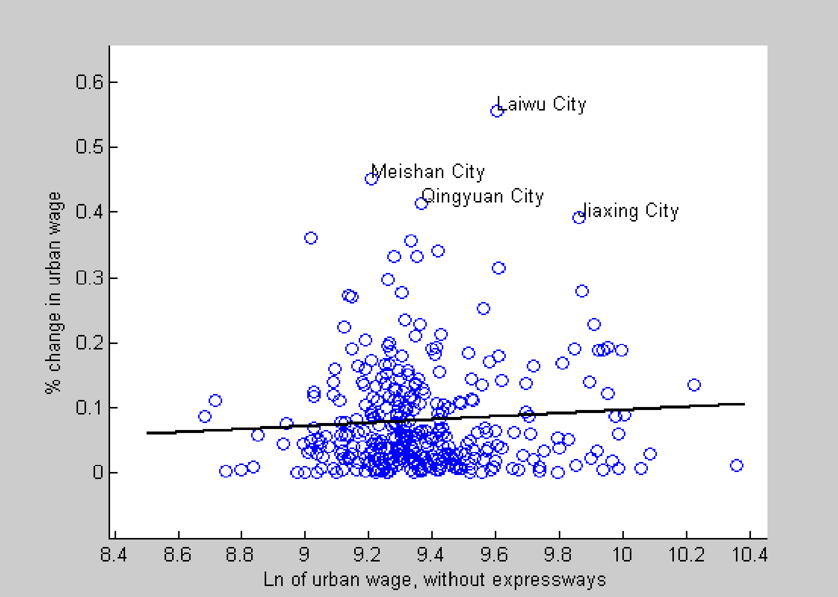
Stage (2): simulation of impacts

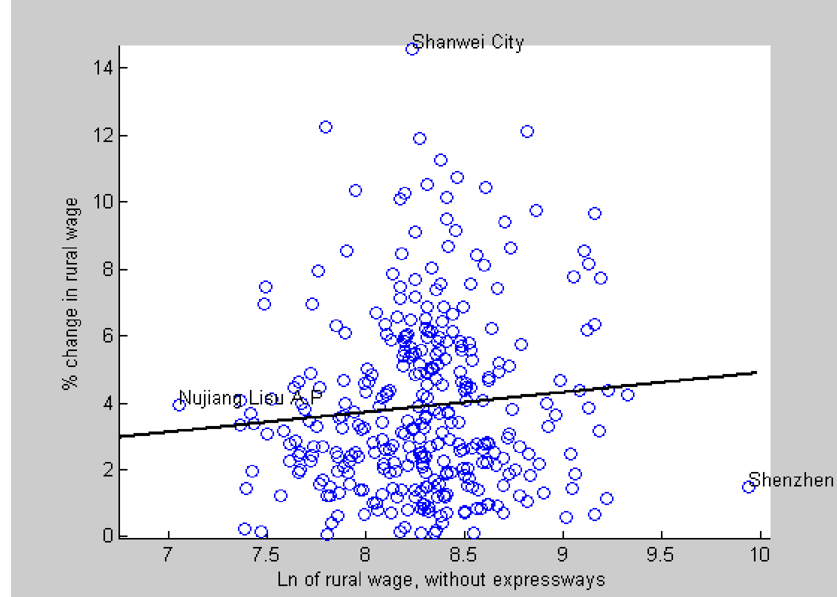
Estimated % Δs in levels of key variables		
	Mean	Median
Income	+ 1.902 %	+ 1.529 %
Urban income p.c.	+ 0.070 %	+ 0.053 %
Rural income p.c.	+ 3.879 %	+ 3.287 %

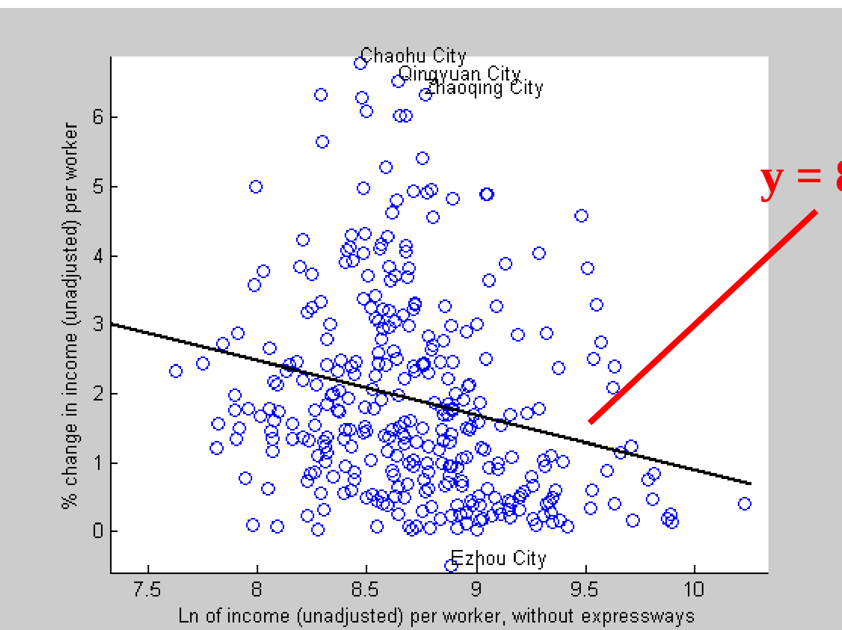
Δ in aggregate "income" = + 1.602 %

- Results reflect weak domestic spatial (demand) linkages in urban sector *vis-à-vis* rural sector (consequence of local protectionism? See Poncet, 2005)

Stage (2): simulation of impacts



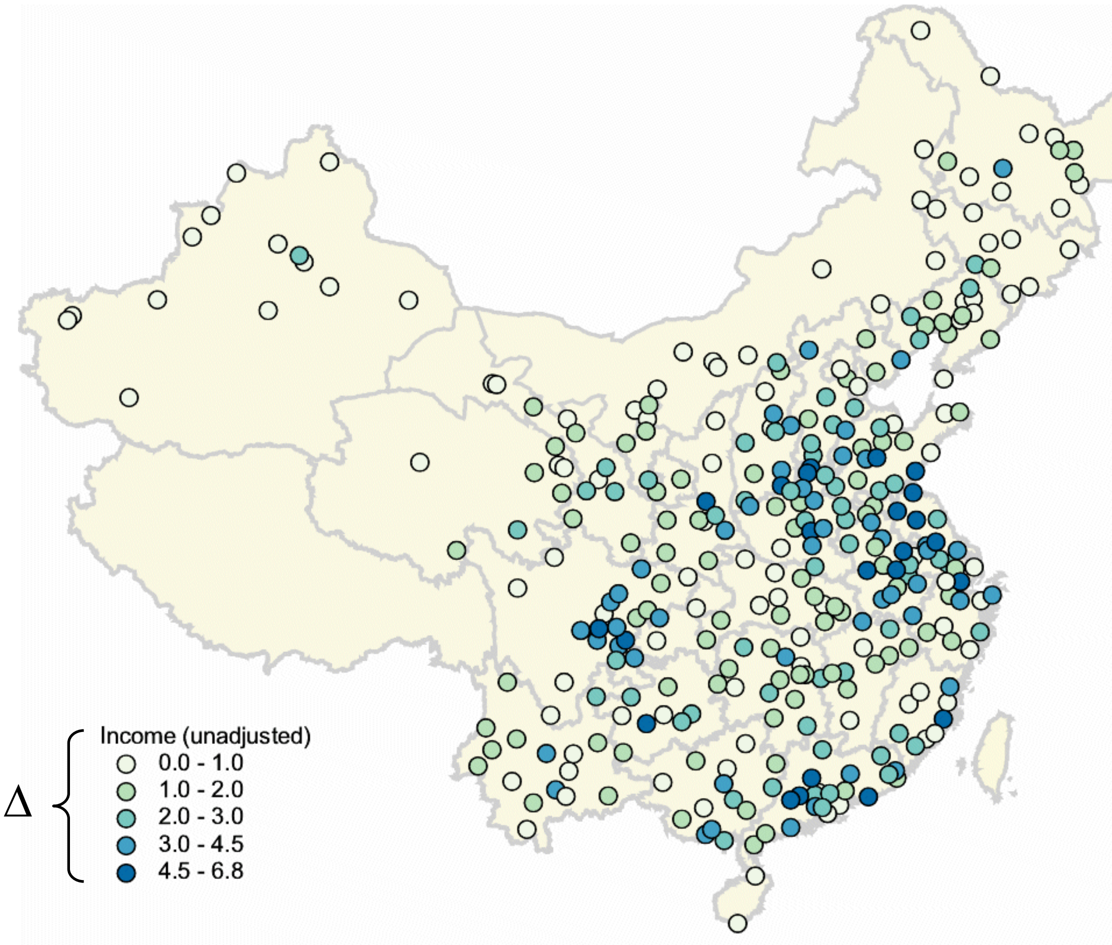




y = 8.83 – 0.79x + ε; t = -4.41

- In terms of overall income, noisy, but some tendency for lagging regions to have benefitted disproportionately given larger rural sectors

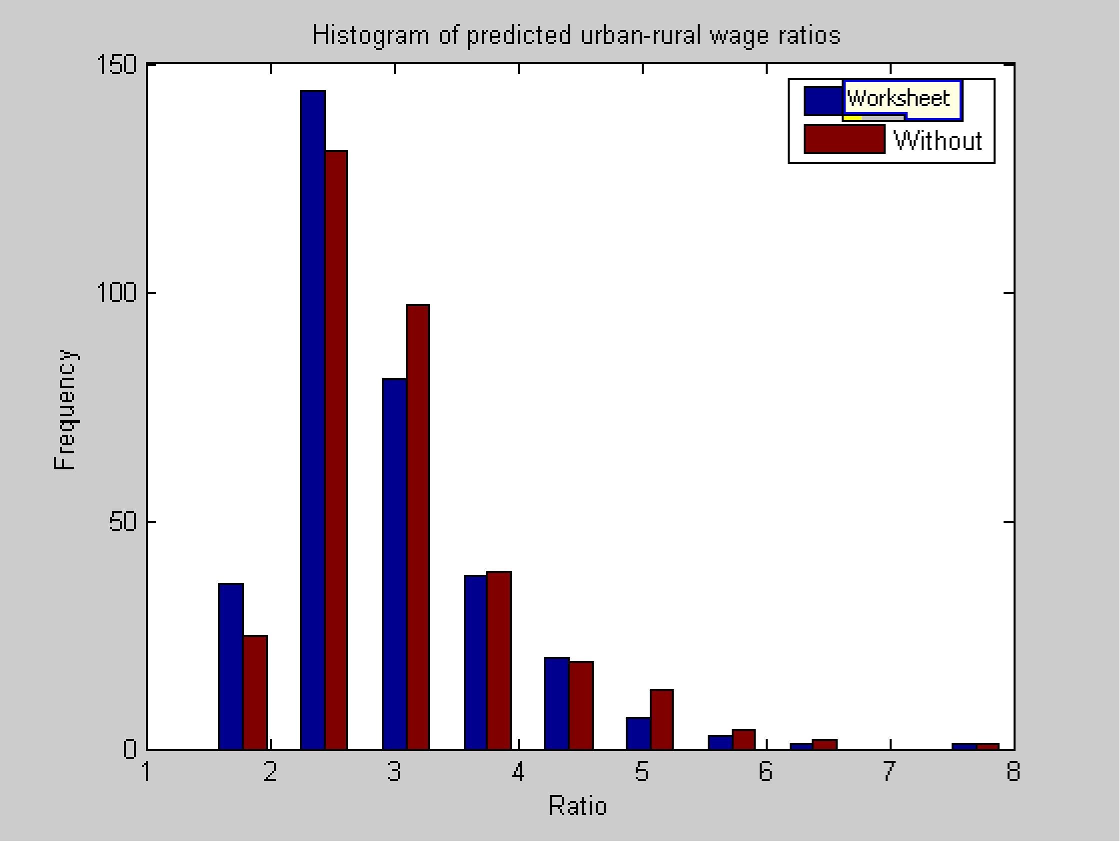
Stage (2): simulation of impacts



% Δ

• But, main winners still appear largely concentrated in Eastern provinces (exception: Sichuan province) → it is lagging regions in closer proximity to prosperous places that appear to have benefitted most

Stage (2): simulation of impacts



Larger income gains in rural sector ⇒ some narrowing of urban-rural income per capita disparities compared to counterfactual

Conclusion

- Research programme to better understand aggregate & spatial impacts of major inter-regional highway projects
- Research based on combined use of multi-region NEG models & GIS techniques $\Rightarrow$ explicitly look at: **(a)** economy-wide development impacts; **(b)** efficiency & spatial equity
- Application to China's NEN remains work in progress (immobility of labour & exogeneity of prices), but important intermediate results
- Weaknesses of NEG approach – modelling of transport costs