Valuing Public Goods More Generally: The Case of Infrastructure

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* Disclaimer:

The views expressed in this paper are the authors and should not be interpreted as IBOs.

What is the Value of Public Infrastructure Investments?



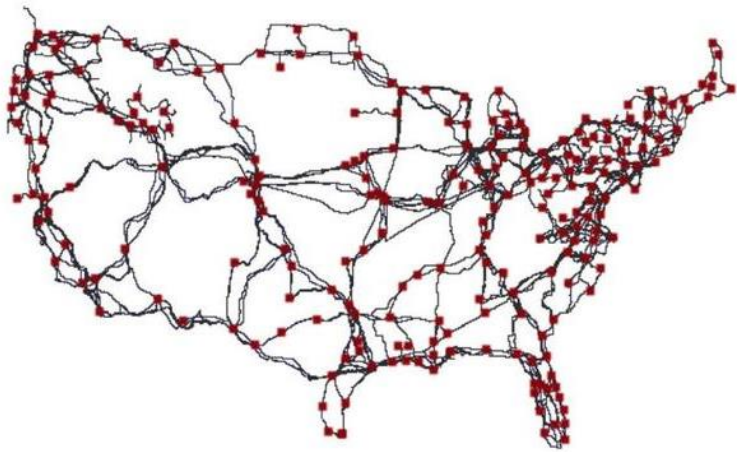
Transportation



Water and Sewage



Energy



Information

Data Sources & Inference of Value to Firms & Households



Land Values: Reflect total local value
Absent externalities outside areas

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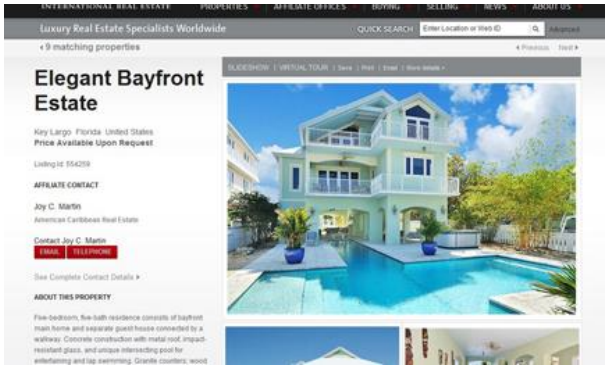
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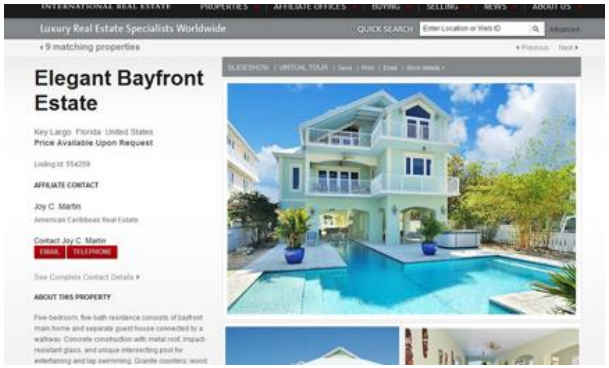
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Population: Signal greater value
Mobility response may be incomplete

Introduction: Determining the Benefits of Public Goods

Providing a complete accounting with no double-counts

- \$X benefit vs. \$1 cost
- Benefits: market (production) & Non-market (quality of life)
- Productivity: distinguish traded ($p \uparrow$) from non-traded ($p \downarrow$)

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Benefits split between landowners, fed govt, & local residents

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4. Applies methods to value urban infrastructure in the United States
   - Recalculates values from original Haughwout (2002) estimates
   - Re-esimates with longer, wider, & deeper panel; clustered s.e.
   - Estimates and interprets city population changes

Related Literature in Urban Theory and Application

- Inter-metropolitain models to value local amenities.
  - Rosen (1979) Roback (1982) wages & rents for QOL & productivity.
  - Glaeser-Gottlieb (2008); Rappaport (2008a,2008b): add housing
  - Albouy (2009, 2016): fed. taxes; extended analytical model
- Non-traded goods and productivity measurement
  - Balassa (1959) and Samuelson (1959): international exchange rates.

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- Non-traded goods and productivity measurement
  - Balassa (1959) and Samuelson (1959): international exchange rates.
- Production function approaches to value public infrastructure
  - Aschauer (1989) national time-series: (implausibly?) huge effects
  - Holtz-Eakin (1994): regional and national data inconclusive
- Metro-level quasi-experimental approaches for transportation
  - Baum-Snow (2008), suburbs; Turner and Duranton (2012) growth
- City-level analysis of infrastructure value with prices
  - Haughwout and Inman (1996) value infrastructure
  - Haughwout (2002) estimates wages and housing-price effects
    - Concludes benefits of infrastructure below costs

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   - Parametrizations (essp mobility) should be treated carefully!

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4. Evidence now suggests infrastructure has higher value
   - Reinterpreted Haughwout (2002) estimates imply larger values
   - New wage esimates higher; housing prices, lower
   - Pop. estimates imply large home-prod. and QOL effects; larger overall value!

Model I: Cities and Households

GE model: Rosen (1979), Roback (1982), Albouy (2009)

- Perfectly competitive input and output markets
- Cities are indexed by $j = 1, ..., J$, each small
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- All prices and quantities uniform within city
- Households/labor, N, mobile and homogenous
  - Full employment; fixed household size
  - Live and work in same city
  - Labor income w^j and non-labor income $I + R$
  - Homothetic, quasi-concave preferences $U(x, y; Q)$
    - Traded good, x, numeraire
    - Non-traded/"home" good y, price p^j
    - Quality of life, Q^j, varies by city
  - Federal income tax τ, rebated lump sum T
  - Mobility $\rightarrow$ utility level, $U(x, y; Q) = \bar{u}$, equal across cities
  - Imperfect mobility with logit style errors, dispersion ψ

Model II: Capital, Land, and Production

- Land, L, immobile, price r^j, *unobserved*
- Capital, K, mobile, uniform price $\bar{\imath}$, *irrelevant*
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- Production CRS except for productivity
  - Traded production $X^j = A_X^j F_X(N_X, L_X, K_X)$
  - Non-tr. production $Y^j = A_Y^j F_Y(N_Y, L_Y, K_Y)$

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- Cities characterized by triple of $(Q^j, A_X^j, A_Y^j) \rightarrow (r^j, w^j, p^j)$
  - Duality theory: unique mapping
  - Framework for underlying quantities in Albouy and Stuart (2015)

Log-Linearized Model Parameters and Possible Values

Parameter	*Nota-tion*	*Chosen Values*	*Haugh-wout**	*Glaeser-Gottlieb**
Non-Labor income		rebate	rebate	absent
Panel A: Values parameterized directly				
Home-goods share	s_y	0.360	0.124	0.200
Traded-good cost-share of land	θ_L	0.025	0.055	0.100
Traded-good cost-share of labor	θ_N	0.825	0.856	0.733
Home-good cost-share of land	ϕ_L	0.233	1.0	0.300
Home-good cost-share of labor	ϕ_N	0.617	0.0	0.400
Marginal tax rate on labor	τ'	0.361	0.0	0.0
Deduction rate for home-goods	δ	0.291	0.0	0.0
Immobility parameter (below)	ψ	0 or ? or ∞	0.0	0.0
Panel B: Parameters derived from theory (see below)				
Income share to land	s_R	0.100	0.173	0.140
Income share to labor	s_w	0.750	0.750*	0.667*
Share of land in traded good	λ_L	0.17	0.28	0.57
Share of labor in traded good	λ_N	0.70	1.0	0.88

*Set for consistency. "Absent" implies absentee owners.

Equilibrium Conditions: *"You get what you pay for."*

Households & firms: trade-offs make equally well off everywhere

1. Quality of Life vs. high local costs, low wages & pop growth
2. Trade-productivity vs. high wages and land values
3. Home-productivity vs. high wages, land values relative to prices

Equilibrium Conditions, Log-Linearized, no deduction ($\delta = 0$)

$$\hat{Q}^j = s_y \hat{p}^j - s_w(1-\tau')\hat{w}^j + \psi \hat{N}^j \tag{1a}$$

$$\hat{A}^j_X = \theta_N \hat{w}^j + \theta_L \hat{r}^j \tag{1b}$$

$$\hat{A}^j_Y = \phi_N \hat{w}^j + \phi_L \hat{r}^j - \hat{p}^j \tag{1c}$$

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Total value of amenities, Ω, given by weighted sum:

$$\hat{\Omega}^j = \hat{Q}^j + s_x \hat{A}^j_X + s_y \hat{A}^j_Y \tag{2}$$

Imperfect mobility: willingness-to-pay declines with population size

$$\hat{WTP} = \hat{Q}^j - \psi \hat{N}^j \rightarrow \hat{Q}^j = \hat{WTP} + \psi \hat{N}^j \tag{3}$$

Approximates logit model when city small to nation

Imperfect mobility: willingness-to-pay declines with population size

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Approximates logit model when city small to nation

Missing land values: Without $\hat{r}^j$ cannot identify trade-prod A_X. from home-prod A_Y: first raise prices, second lowers them

$$\hat{A}_X^j - \frac{\theta_L}{\phi_L}\hat{A}_Y^j = \frac{\theta_L}{\phi_L}\hat{p}^j + \left(\theta_N - \phi_N\frac{\theta_L}{\phi_L}\right)\hat{w}^j. \tag{4}$$

Equilibrium Conditions: Numerical Solutions

		Increase in Log Point		
	Price	Land Val $\hat{r}^j$	Hous Cost $\hat{p}^j$	Wage $\hat{w}^j$
Panel A: Chosen Price Model: Ideal Complete Data				
Household QOL	$\hat{Q}^j$		0.325	-0.499
Firm: Trade-Prod.	$s_x \hat{A}^j_X$	0.016		0.550
Firm: Home-Prod.	$s_y \hat{A}^j_Y$	0.083	-0.360	0.231
Total Value	$\hat{\Omega}^j$	0.100	-0.035	0.280
Panel B: Chosen Parametrization: Housing and Wages Only				
Household QOL	$\hat{Q}^j$		0.325	-0.499
Firm: Trade-Prod.	$s_x \hat{A}^j_X$		0.069	0.506
Firm: Home-Prod.	$s_y \hat{A}^j_Y$		Not identified	
Total Value	$\hat{\Omega}^j$		0.394	0.007
Panel C: Haughwout (2002) Parametrization: Housing and Wages Only				
Household QOL	$\hat{Q}^j$		0.124	-0.750
Firm: Trade-Prod.	$s_x \hat{A}^j_X$		0.048	0.750
Firm: Home-Prod.	$s_y \hat{A}^j_Y$		Not identified	
Total Value	$\hat{\Omega}^j$		0.172	0.000

Price Solutions: "Capitalization" Formulae

Values normalized as a proportion of income

Price solutions under perfect mobility ($\psi = 0$) no deduct ($\delta = 0$)

$$s_R \hat{r}^j = \mu_\tau \left\{ \hat{Q}^j + (1 - \tau' \mu_w)\, s_x \hat{A}^j_X + (1 - \tau')\, s_y \hat{A}^j_Y \right\} \tag{5a}$$

$$s_w \hat{w}^j = \mu_\tau \mu_w \left\{ -\lambda_L \hat{Q}^j + (1 - \tau') \left[(1 - \lambda_L) s_x \hat{A}^j_X - \lambda_L s_y \hat{A}^j_Y \right] \right\} \tag{5b}$$

$$s_y \hat{p}^j = \mu_\tau \mu_w \left\{ (\lambda_N - \lambda_L) \hat{Q}^j + (1 - \tau') \left[(1 - \lambda_L) s_x \hat{A}^j_X - \lambda_L s_y \hat{A}^j_Y \right] \right\}, \tag{5c}$$

- Land values increasing in all value types but not always $\hat{\Omega}^j$
  - Full/100% capitalization into land values plus fiscal externalities.
- Wages rise with trade-prod., *fall* with QOL & home-prod.
- Housing costs rise with QOL & trade-prod.; fall with home-prod.
- Taxes lower local value of amenities that raise wages & lower prices.
  - Complex direct effect on productivity factors

Two Multipliers Affect Capitalization

Wage Multiplier (cost compensation spiral)

Effect: higher wages $\Rightarrow$ higher costs $\Rightarrow$ higher wages $\Rightarrow$, etc.

$$\mu_w \equiv \frac{1}{\lambda_N} = \sum_{k=0}^{\infty} \left(\frac{s_y \phi_L}{s_w} \right)^k \tag{6}$$

Tax multiplier (tax compensation spiral)

Effect 1: higher wages $\Rightarrow$ higher taxes $\Rightarrow$ higher wages, etc.

Effect 2: lower prices $\Rightarrow$ higher taxes $\Rightarrow$ lower prices, etc.

$$\mu_\tau \equiv \frac{1}{1 - \tau' \left[\delta + (1-\delta) \frac{\lambda_L}{\lambda_N} \right]} = \sum_{k=0}^{\infty} \left\{ \tau' \left[\delta + (1-\delta) \frac{\lambda_L}{\lambda_N} \right] \right\}^k \tag{7}$$

Non-traded Goods and Land Interact with Labor Market

"Federal and state expenditures for roads, utilities, drainage, and other improvements" are needed to make vacant land accessible to home builders. (Gruen 2010, p. 2)

Quote highlights infrastructure changes productivity of housing sector

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Also, if non-traded good, Y, made without labor: $\lambda_N = 1$.

- Wage multiplier $\mu_w = 1$: wages 1-1 rise with trad-prod. A_X
- No cost spiral

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*If traded good, X, not made from land L, $\lambda_L = 0$

- Wages don't fall with quality of life, Q.
- Wages or prices w, p invariant to home-prod., A_Y,

Federal taxes and deductions

Federal tax reduces incentives for wage-improving investments

- Trade-productivity penalized
- Quality of life and home-productivity subsidized

Federal housing subsidy provides incentives for higher prices

- Quality of life, Q and home-prod. A_X promoted
- Home-productivity A_Y is penalized
- Counters distortions from τ for A_X or A_Y, increases for Q

Federal Tax Differential and Amenities

$$\frac{d\tau^j}{m} = \tau' \mu_\tau \left[(1-\delta) \left(\frac{1-\lambda_L}{\lambda_N} s_x \hat{A}_X^j - \frac{\lambda_L}{\lambda_N} s_y \hat{A}_Y^j \right) - \left(\delta + (1-\delta) \frac{\lambda_L}{\lambda_N} \right) \hat{Q}^j \right] \tag{8}$$

Simulated Effect of Attributes on Prices

Attribute		Increase in Log Point Val		
		QOL	Trade	Home
		$\hat{Q}^j$	$s_x \hat{A}^j_X$	$s_y \hat{A}^j_Y$
Panel A: No Wage Multiplier; Federal Taxes Neutral				
Land Rents*	$s_r \hat{r}^j$	1.00	1.00	1.00
Wages	$s_w \hat{w}^j$	-0.20	0.81	-0.20
Home-Good Prices	$s_y \hat{p}^j$	0.81	0.81	-0.20
Panel D: Wage Multiplier, Fed. Taxes with Housing Benefits				
Land Rents*	$s_r \hat{r}^j$	1.17	0.66	1.07
Wages	$s_w \hat{w}^j$	-0.27	1.27	-0.24
Home-Good Prices	$s_y \hat{p}^j$	0.90	0.93	-0.18
Fed. Tax Payment*	$d\tau^j / \bar{m}$	-0.17	0.34	-0.07

Based on chosen value parametrization in table 1

- Wage multiplier magnifies wage and home-good price effects
- Federal taxes break full land capitalization; add back in.

Incorporating Population Data, Imperfect Mobility

From Albouy and Stuart (2015) — assume reduced-form for population:

$$\hat{N}^j = \varepsilon_0^{N,Q} \hat{Q}^j + \varepsilon_0^{N,A_X} \hat{A}_X^j + \varepsilon_0^{N,A_Y} \hat{A}_Y^j$$

$\varepsilon_0^{N,Q}$ = elasticity of population with w.r.t. quality-of-life if $\psi = 0$.

Preference heterogeneity parameter (inverse Pareto or logit limit) $\psi \geq 0$

$$\begin{aligned}\hat{N}^j &= \frac{1}{1+\psi\varepsilon_0^{N,Q}} \left(\varepsilon_0^{N,Q} \underline{\hat{Q}}^j + \varepsilon_0^{N,A_X} \hat{A}_X^j + \varepsilon_0^{N,A_Y} \hat{A}_Y^j \right) \\ &= \varepsilon_\psi^{N,Q} \underline{\hat{Q}}^j + \varepsilon_\psi^{N,A_X} \hat{A}_X^j + \varepsilon_\psi^{N,A_Y} \hat{A}_Y^j\end{aligned}$$

Friction multiplier reduces responsiveness to amenities uniformly.

Mysterious ψ value contentious

- Notowidigo (GMM) $\psi = 0.07$
- Suarez-Serrato and Zidar (logit) $\psi = 0.70$

Population responses Imperfect Mobility

Population elasticities closely tied to housing-supply elasticities

- If $\tau = \lambda_L = 0$

$$\varepsilon_0^{N,Q} = \underbrace{\frac{1-\phi_L}{\phi_L}\sigma^Y}_{\eta^{Y,p}} \frac{1}{s_y} + \frac{s_x}{s_y}\sigma_D + 1$$

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$$\varepsilon_0^{N,Q} = \underbrace{\frac{1-\phi_L}{\phi_L}\sigma^Y}_{\eta^{Y,p}} \frac{1}{s_y} + \frac{s_x}{s_y}\sigma_D + 1$$

- Benefits shared between landowners, fed. govt, local renters

$$s_r \hat{r}^j + \frac{d\tau_\psi^j}{m} + \psi \hat{N}^j = \hat{\Omega}_*^j \tag{9}$$

- Changes federal-tax and capitalization process
  - Tax on the real wage increase offered to workers

$$\frac{d\tau_\psi^j}{m} = \frac{d\tau^j}{m} + (\mu_\tau - 1)\psi \hat{N}^j \tag{10}$$

(11)

Imperfect Mobility Amends "Capitalization" Formulae

Shortened formulae with $\hat{N}_0^j$ = counterfactual pop. chg. with full mobility

Price solutions under imperfect mobility

$$s_R \hat{r}_\psi^j = s_R \hat{r}^j - \frac{\psi}{1+\psi\varepsilon_0^{N,Q}} \mu_\tau \hat{N}_0^j \tag{12a}$$

$$s_w \hat{w}_\psi^j = s_w \hat{w}^j + \frac{\psi}{1+\psi\varepsilon_0^{N,Q}} \mu_\tau \mu_w \lambda_L \hat{N}_0^j \tag{12b}$$

$$s_y \hat{p}_\psi^j = s_p \hat{p}^j - \frac{\psi}{1+\psi\varepsilon_0^{N,Q}} \mu_\tau \mu_w \left(\lambda_N - \lambda_L\right) \hat{N}_0^j \tag{12c}$$

- Land values less affected by amenities. Incomplete capitalization
  - Welfare of residents is rising with amenities!
- Wages are increased relatively rise with adjustment
- Housing costs tend to rise less. $\hat{A}_Y^j$ reduces prices more!

Imperfect Mobility Changes Capitalization Effects

	Attribute	Increase in Log Point Val		
		QOL	Trade	Home
		$\hat{Q}^j$	$s_x \hat{A}^j_X$	$s_y \hat{A}^j_Y$
Panel E: Wage Mult., Fed. Taxes/Benefits, and Imperfect Mobility $\psi = 0.07$				
Land Rents*	$s_r \hat{r}^j$	0.75	0.45	0.64
Wages	$s_w \hat{w}^j$	-0.17	1.32	-0.15
Home-Good Prices	$s_y \hat{p}^j$	0.58	0.77	-0.50
Fed. Tax Payment*	$d\tau^j/\bar{m}$	-0.11	0.40	0.00
Local Resident Gains*	$\psi \hat{N}^j$	0.36	0.15	0.36
Panel E: Wage Mult., Fed. Taxes/Benefits, and Imperfect Mobility $\psi = 0.70$				
Land Rents*	$s_r \hat{r}^j$	0.17	0.44	0.09
Wages	$s_w \hat{w}^j$	-0.04	1.37	-0.02
Home-Good Prices	$s_y \hat{p}^j$	0.13	0.58	-0.94
Fed. Tax Payment*	$d\tau^j/\bar{m}$	-0.02	0.44	0.09
Local Resident Gains*	$\psi \hat{N}^j$	0.85	0.35	0.83

Based on chosen value parametrization in table 1. Panel E $\psi = 0.05$

"Capitalization" Formulae with No Mobility

Price solutions with no mobility $\psi \to \infty$ or taxes $\tau = 0$

$$s_R \hat{r}^j_\psi = \left(s_x - \frac{\varepsilon_0^{N,A_X}}{\varepsilon_0^{N,Q}} \right) \hat{A}^j_X + \left(s_y - \frac{\varepsilon_0^{N,A_Y}}{\varepsilon_0^{N,Q}} \right) \hat{A}^j_Y \tag{13a}$$

$$s_w \hat{w}^j_\psi = \left[s_x (1 - \lambda_L) + \lambda_L \frac{\varepsilon_0^{N,A_X}}{\varepsilon_0^{N,Q}} \right] \hat{A}^j_X - \lambda_L \left[s_y - \frac{\varepsilon_0^{N,A_Y}}{\varepsilon_0^{N,Q}} \right] \hat{A}^j_Y \tag{13b}$$

$$s_y \hat{p}^j_\psi = \left[s_x (1 - \lambda_L) - (\lambda_N - \lambda_L) \frac{\varepsilon_0^{N,A_X}}{\varepsilon_0^{N,Q}} \right] \hat{A}^j_X - \left[s_y \lambda_L - (\lambda_N - \lambda_L) \frac{\varepsilon_0^{N,A_Y}}{\varepsilon_0^{N,Q}} \right] \hat{A}^j_Y \tag{13c}$$

- Dependence on quality of life disappears
  - Benefits go directly to households
- Trade and home productivity still have effects

Perfect Immobility Solutions are Interesting

	Attribute	Increase in Log Point Val		
		QOL	Trade	Home
		$\hat{Q}^j$	$s_x \hat{A}^j_X$	$s_y \hat{A}^j_Y$
Panel F: Wage Mult., Fed. Taxes/Benefits, and No Mobility				
Land Rents*	$s_r \hat{r}^j$	0.00	0.13	-0.10
Wages	$s_w \hat{w}^j$	0.00	1.39	0.02
Home-Good Prices	$s_y \hat{p}^j$	0.00	0.52	-1.08
Fed. Tax Payment*	$d\tau^j / \bar{m}$	0.00	0.45	0.12
Local Resident Gains*	$\psi \hat{N}^j$	1.00	0.41	0.98

Based on chosen value parametrization in table 1. Panel F $\psi \to \infty$

Inference of Home-Productivity

Using the combined two zero-profit conditions

$$\hat{A}_X^j = \frac{\theta_L}{\phi_L}\hat{p}^j + \left(\theta_N - \phi_N \frac{\theta_L}{\phi_L}\right)\hat{w}^j + \frac{\theta_L}{\phi_L}\hat{A}_Y^j. \tag{14}$$

"Excess density" not from QOL, due to either trade or home-productivity:

$$\hat{N}^j - \varepsilon_0^{N,Q}\underbrace{[s_y\hat{p}^j - s_w(1-\tau)\hat{w}^j]}_{\hat{Q}^j} = \varepsilon_{N,A_X}\hat{A}_X^j + \varepsilon_{N,A_Y}\hat{A}_Y^j. \tag{15}$$

Solving these two equations simultaneously provides exact identification of productivities $\hat{A}_X^j$ and $\hat{A}_Y^j$.

- Can infer a land value
- Does require knowing these elasticities

Simulated Inference with Population Data

Attribute	Notation	From Log Point Change in Hous Cost $\hat{p}^j$	Wage $\hat{w}^j$	Pop $\hat{N}^j$
Panel D: Chosen Price and Population Model, Perfect Mobility $\psi = 0.00$				
Household QOL	$\hat{Q}^j$	0.325	-0.499	
Firm: Trade-Prod.	$s_x \hat{A}^j_X$	0.005	0.558	0.022
Firm: Home-Prod.	$s_y \hat{A}^j_Y$	-0.333	0.274	0.115
Total Value	$\hat{\Omega}^j$	-0.003	0.333	0.138
Panel E: Chosen Price and Population Model, Imperfect Mobility, $\psi = 0.07$				
Household QOL	$\hat{Q}^j$	0.325	-0.499	0.070
Total Value	$\hat{\Omega}^j$	-0.003	0.333	0.208

- Population strong signal of home-productivity and value
- Conditional on wages and population, home goods do not imply positive values!

Haughwout's Methodology of Valuing Infrastructure

Infrastructure measure for central cities

- Perpetual inventory method: adds investments from 1905.
- Exponential depreciation for 1) equipment 11%, 2) construction 1.8%, 3) land & existing strucutures 1.3%: by 2000 $428 billion total
- Infrstructure stocks entered in levels and logarithms.
- Assumed a pure public good: congestion not estimated!

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Outcomes: Wages and Housing prices from American Housing Survey

- Quality adjusted for worker skills and housing characterisitcs.
- For 33 cities from 1971 to 1992.
- *We had difficulty replicating worker sample: by place of work?*

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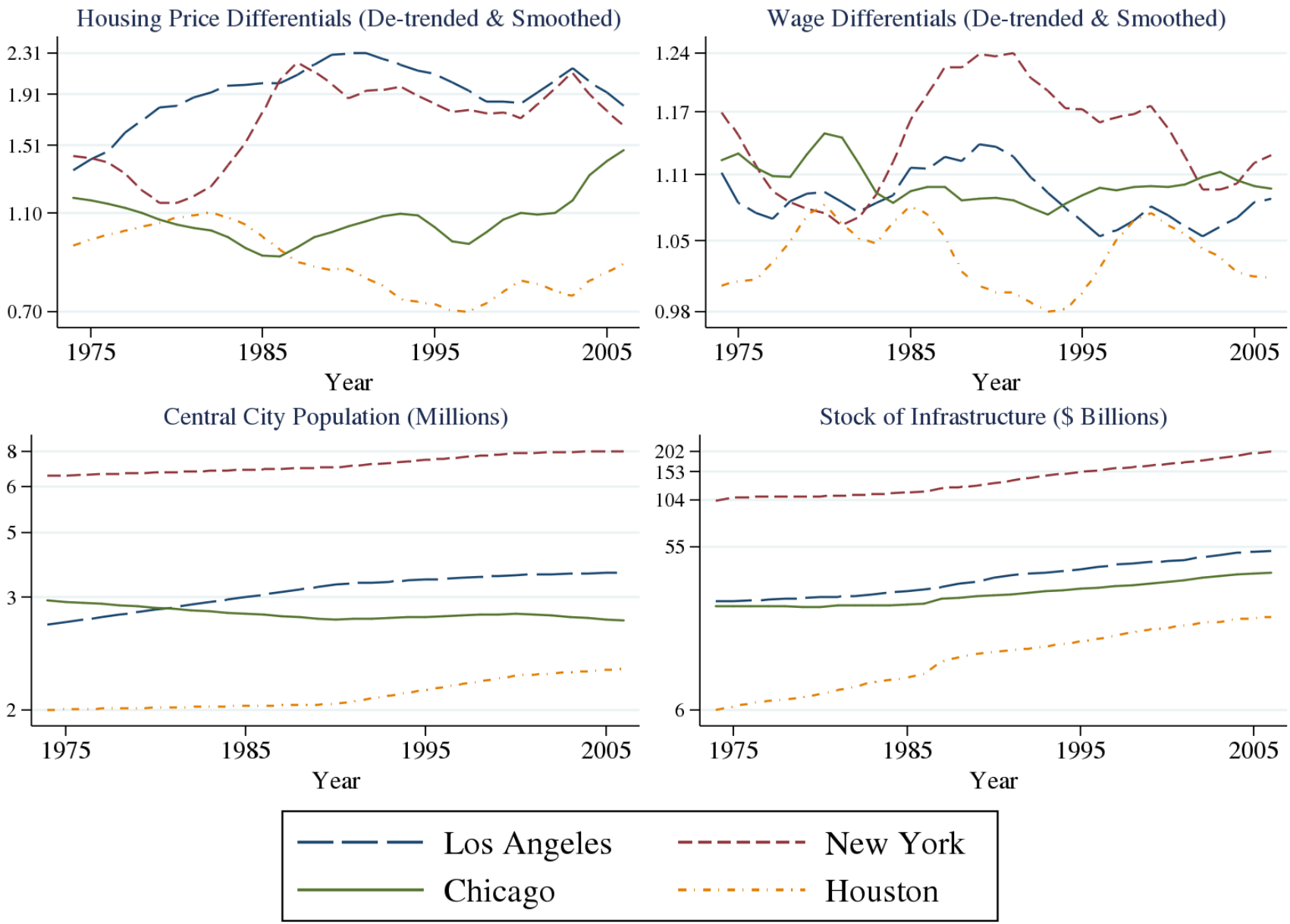
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- For 33 cities from 1971 to 1992.
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Econometric specifications at higher city level

1. Pooled OLS: controls for tax rates, climate and time-varying controls.
2. City and Year Fixed Effects: crime & teacher/student ratio.

Figure: Trends across Selected Major Cities



Reinterpreting Haughwout's Original Estimates

Effect of a 1 Std. Dev. Increase in Public Infrastructure on Log			Value per Dollar of Infrastructure			
			Household	Firm	Total	Federal
Housing Cost	Wages	Valuation	QOL	Tr. Prod.	Value	Revenue
(1)	(2)	Procedure	(3)	(4)	(5)	(6)
Panel A: Pooled Estimates with Controls						
		Haughwout	0.39	0.21	0.60	
0.23	0.003		(0.06)	(0.04)	(0.07)	
(0.02)	(0.002)					
		Revised	1.09	0.26	1.35	-0.11
			(0.18)	(0.04)	(0.18)	(0.02)
Panel B: Panel Estimates with City and Year Effects						
		Haughwout	0.39	-0.09	0.30	
0.12	-0.016		(0.10)	(0.10)	(0.15)	
(0.05)	(0.009)					
		Revised	0.70	0.00	0.70	-0.13
			(0.31)	(0.21)	(0.29)	(0.06)

Housing-cost and wage estimates taken from rows 2 and 4 of Table 4 in Haughwout (2002). Per-dollar values obtained by multiplying values by 14.93, the ratio of the present value of income flows to the valued infrastructure (with a std. dev of $ 4,640 million in 1997$).

- Revisions suggest much higher infrastructure values

New Estimates of the Impact of Public Infrastructure

Our contribution to these estimates

1. Longer Panel: extend end date from 1992 to 2006 (18 to 34 years)
2. Wider Panel: 36 to 55 cities, including NYC.
3. Deeper Panel: Current Population Survey; Decennial Census and ACS
4. Population effects estimates
5. Standard Errors corrected for clustering by city and year

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6. Instrumental Variables... tried many, nothing relevant!
7. Metropolitan Level... working on it!

New Estimates of Wages and Housing Price Impacts

Effect of a 1 Std. Dev. Increase in Public Infrastructure on Log			Value per Dollar of Infrastructure			
			Household	Firm	Total	Federal
Housing Cost	Wages	Valuation	QOL	Tr. Prod.	Value	Revenue
(1)	(2)	Procedure	(3)	(4)	(5)	(6)
Panel A: Pooled OLS Estimates with Controls						
0.12	0.021	Revised	0.44	0.28	0.73	0.02
(0.03)	(0.007)		(0.17)	(0.06)	(0.19)	(0.03)
Panel B: Panel Estimates with City and Year Effects						
0.11	0.077	Revised	-0.07	0.69	0.69	0.27
(0.06)	(0.023)		(0.32)	(0.18)	(0.33)	(0.10)

Housing-cost and wage estimates estimated using long panel. Clustered city & year

- Housing estimates smaller overall: total values under $1
- Larger wage estimates in fixed effects: bigger fiscal externality
- Value more in the form of a trade productivity effect.

Incorporating Population Estimates to Value Infrastructure

Effect of a 1 Std. Dev. Increase in Public Infrastructure on Log				Value per Dollar of Infrastructure			
Housing Cost	Wages	Population	Mobility	Househ. QOL	Firm Tr Pr.	Firm Home Pr.	Total Value
(1)	(2)	(3)		(4)	(5)	(6)	(7)
Panel A: Pooled OLS Estimates with Controls							
			Perfect	0.44	0.42	0.71	1.58
0.12	0.021	0.72	$\psi = 0.00$	(0.17)	(0.06)	(0.18)	(0.08)
(0.03)	(0.007)	(0.04)					
			Imperfect	1.20	0.42	0.71	2.34
			$\psi = 0.07$	(0.17)	(0.06)	(0.18)	(0.09)
Panel B: Panel Estimates with City and Year Effects							
			Perfect	-0.07	0.77	0.46	1.17
0.11	0.077	0.39	$\psi = 0.00$	(0.32)	(0.19)	(0.31)	(0.15)
(0.06)	(0.023)	(0.04)					
			Imperfect	0.34	0.77	0.46	1.58
			$\psi = 0.05$	(0.34)	(0.21)	(0.33)	(0.20)

Housing-cost and wage estimates estimated using long panel. Clustered metro & year.

- Population gains suggest large gains from home prod & QOL if $\psi > 0$

Conclusions

1. Common (over-)simplifying shortcuts can change valuations
   - Parametrizations (esp. mobility) should be treated carefully!
2. Housing or land values insufficient to value public goods
   - Fiscal externalities and moving costs matter
   - Housing costs may reflect QOL & trade-prod. well; not home-prod.
3. Available data sources need to be considered in tandem
   - Population data a substitute for land data
   - Imperfect mobility: prices incomplete
   - Wages and population changes identify most value
4. Evidence now suggests infrastructure has higher value
   - Reinterpreted Haughwout (2002) estimates imply larger values
   - New wage estimates higher; housing prices, lower
   - Pop. estimates imply large home-prod. and QOL effects; larger overall value!