Unpacking Aggregate Welfare in a Spatial Economy

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Motivation

- How do spatially disaggregated shocks affect aggregate welfare?
- Recent developments in quantitative spatial equilibrium models
  - Highly complex and parameterized
  - Obscuring sources of welfare gains/losses
- Alternative: first-order approximation (Hulten, 1978; Fogel, 1964)
  - Frictionless representative agent economy $\Rightarrow$ revenue is a sufficient stat
- Unclear whether or how this approach extends to spatial economy

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  (ii) MU dispersion
  (iii) Fiscal externality
  (iv) Technological externality
  (v) Redistribution

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  1. Non-parametric optimal spatial transfer formula
  2. Hulten in the presence of optimal spatial transfers
- Conclude with application(s) to the US economy

Model

Environment

- Many locations indexed by i, j
- Many households types indexed by θ with mass ℓ^{θ}
  - endowed with a unit of labor
  - decides where to live
  - endowed with shares on fixed factors $\{h_j\}$
- Many tradable intermediate goods indexed by k

Households

- Utility from living in location j:

$$u_j^\theta(C_j^\theta) + \epsilon_j^\theta$$

  - Preference shocks are additively separable (come back later)
  - The case with $\epsilon_j^\theta = 0$ corresponds to Rosen-Roback

- Budget constraint:

$$P_j^\theta C_j^\theta = w_j^\theta + T_j^\theta + \Pi^\theta$$

- Households choose living locations j that maximize utility

- Let μ_j^θ be choice probability and $l_j^\theta = \ell^\theta \mu_j^\theta$ be population size of type θ

- Transfers satisfy government budget, $\sum_\theta \sum_j T_j^\theta l_j^\theta = 0$

Firms

- Intermediate goods k produced in i and sold in j:

$$y_{ij,k} = \mathscr{A}_{ij,k} f_{ij,k}\left(\{l^{\theta}_{ij,k}\}_{\theta}, h_{ij,k}, \{x^{l,m}_{ij,k}\}_{l,m} \right)$$

  - $\mathscr{A}_{ij,k}$: TFP (includes trade costs)

- Final goods in location j: $\mathscr{C}^{\theta}_{j}(\{c^{\theta}_{ij,k}\}_{i,k})$

- TFP is subject to agglomeration externality: $\mathscr{A}_{ij,k} = A_{ij,k} g_{ij,k}(\{l^{\theta}_{i}\}_{\theta})$

$$\gamma^{\theta}_{ij,k} \equiv \frac{\partial \ln g_{ij,k}(\{l^{\theta}_{i}\}_{i}}{\partial \ln l^{\theta}_{i}}$$

- Non-labor income is $\Pi^{\theta} = \alpha^{\theta} \sum_{j} r_j \bar{h}_j$

Aggregate Welfare

- Competitive equilibrium: households and firms optimize and markets clear

- Define aggregate welfare as

$$W = \mathscr{W}(\{W^\theta\}_\theta), \qquad W^\theta = \mathbb{E}\left[\max_j \{u_j(C_j^\theta) + \epsilon_j\}\right]$$

- Local welfare weights attached to θ:

$$\Lambda^\theta \equiv \frac{\partial \mathscr{W}(\{W^\theta\}_\theta)}{\partial W^\theta} \frac{1}{l^\theta}$$

Main Results

Suboptimality of Spatial Equilibria

- **First best:** $\max W$ subject to resource constraints
- Spatial equilibrium does not solve first-best
  1. Agglomeration externality (well understood)
  2. Spatial dispersion in marginal utility of income (Mirleese, 1972)
     - Incomplete market to insure against uncertainty in location choice
     - Lack of redistribution for households with differing location choices
- Suboptimality arises even without preference shocks or externality
- Implication: Hulten's theorem does not apply

Experiment

- Cross-sectional moments across j conditional on θ

$$\mathbb{E}_{j|\theta}[X_j^\theta] \equiv \sum_j \mu_j^\theta X_j^\theta, \qquad \mathrm{Cov}_{j|\theta}\left(X_j^\theta, Y_j^\theta\right) \equiv \mathbb{E}_{j|\theta}[X_j^\theta Y_j^\theta] - \mathbb{E}_{j|\theta}[X_j^\theta]\mathbb{E}_{j|\theta}[Y_j^\theta]$$

- Cross-sectional moments across θ

$$\mathbb{E}_\theta[X^\theta] \equiv \sum_\theta \ell^\theta X^\theta, \qquad \mathrm{Cov}_\theta\left(X^\theta, Y^\theta\right) \equiv \mathbb{E}_\theta[X^\theta Y^\theta] - \mathbb{E}_\theta[X^\theta]\mathbb{E}_\theta[Y^\theta]$$

- Consider arbitrary shocks to $\{d\ln A_{ij,k}\}$ and/or $\{dT_j^\theta\}$
- How does aggregate welfare W respond?

Main Result

$$dW = \underbrace{\sum_{i,j,k} p_{ij,k} y_{ij,k} d\ln A_{ij,k}}_{\text{(i) Technology } (\Omega_T)} + \underbrace{\mathbb{E}_\theta \left[\mathrm{Cov}_{j|\theta} \left(-\frac{P_j^\theta}{u_j^{\theta\prime}(C_j^\theta)}, u_j^{\theta\prime}(C_j^\theta) \right) dC_j^\theta \right]}_{\text{(ii) MU dispersion } (\Omega_{MU})}$$

$$+ \underbrace{\mathbb{E}_\theta \left[\mathrm{Cov}_{j|\theta} \left(-T_j^\theta, d\ln l_j^\theta \right) \right]}_{\text{(iii) Fiscal externality } (\Omega_{FE})} + \underbrace{\mathbb{E}_\theta \left[\mathrm{Cov}_{j|\theta} \left(\frac{1}{l_j^\theta} \sum_{l,k} p_{jl,k} y_{jl,k} \times \gamma_{jl,k}^\theta, d\ln l_j^\theta \right) \right]}_{\text{(iv) Technological externality } (\Omega_{TE})}$$

$$+ \underbrace{\mathrm{Cov}_\theta \left(\Lambda^\theta - \mathbb{E}_{j|\theta} \left[\frac{P_j^\theta}{u_j^{\theta\prime}(C_j^\theta)} \right], \mathbb{E}_{j|\theta} \left[u_j^{\theta\prime}(C_j^\theta) dC_j^\theta \right] \right)}_{\text{(v) Redistribution } (\Omega_R)}$$

Main Result

$$dW = \underbrace{\sum_{i,j,k} p_{ij,k} y_{ij,k} d \ln A_{ij,k}}_{\text{(i) Technology } (\Omega_T)} + \cdots$$

Direct impact absent reallocation

(Hulten)

$$+ \underbrace{\mathbb{E}_\theta \left[\text{Cov}_{j|\theta} \left(-T_j^\theta, d \ln l_j^\theta \right) \right]}_{\text{(iii) Fiscal externality } (\Omega_{FE})} + \underbrace{\mathbb{E}_\theta \left[\text{Cov}_{j|\theta} \left(\frac{1}{l_j^\theta} \sum_{l,k} p_{jl,k} y_{jl,k} \times \gamma_{jl,k}^\theta, d \ln l_j^\theta \right) \right]}_{\text{(iv) Technological externality } (\Omega_{TE})}$$

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$$\ldots \, \mathrm{n}\, l_j^\theta \Bigg) \Bigg] \quad (\Omega_{TE})$$

Changes in MU dispersion

- Positive if $dC_j \uparrow$ in places with high $u_j^{\theta\prime}(C_j^\theta)/P_j^\theta$
- Absent if
  1. $u_j^\theta(C) = C$ and $P_j^\theta = P^\theta$
  2. $u_j^\theta(C) = \log C$ and $w_j^\theta + T_j^\theta = I^\theta$
  3. No preference shocks

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Changes in government budget

Positive if $d\ln l_j^\theta \uparrow$ in places with low T_j^θ

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Main Result

Positive if $d\ln l_j^\theta \uparrow$ in places with high $\gamma_{jl,k}^\theta$

Constant elasticity γ does not imply $\Omega_{TE} = 0$

$$\ldots {}^{\theta\prime}(C_j^\theta)\Big) dC_j^\theta \Big]$$

n (Ω_{MU})

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(Ω_{MU})

Redistribution

Positive if $dC_j^\theta \uparrow$ for types with high Λ^θ

$$+ \quad \underbrace{\mathbb{E}_\theta \left[\mathrm{Cov}_{j|\theta} \left(\ldots \right) \right]}_{\text{(iii) Fiscal externality } (\Omega_{FE})} \quad + \quad \underbrace{\mathbb{E}_\theta \left[\mathrm{Cov}_{j|\theta} \left(\ldots \frac{\ldots}{l_j^\theta} \sum_{l,k} p_{jl,k} y_{jl,k} \times \gamma_{jl,k}^\theta, d \ln l_j^\theta \right) \right]}_{\text{(iv) Technological externality } (\Omega_{TE})}$$

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Second-Best Spatial Transfer Formula

- Optimal $T_j \Rightarrow dW = 0$ with respect to perturbations $\{dT_j\}$
- Rearranging, we obtain non-parametric **second-best** spatial transfer formula:

$$\mu_j^\theta \left[\Lambda^\theta u_j^{\theta\prime}(C_j^\theta) - P_j^\theta\right] = \sum_i \frac{\partial \mu_i^\theta}{\partial C_j^\theta} \left[T_i^\theta - \frac{1}{l_i^\theta} \sum_{l,k} p_{il,k} y_{il,k} \gamma_{il,k}^\theta\right]$$

  - **LHS**: marginal benefit of transferring to location j
    - equalize MU
  - **RHS**: marginal cost of transferring to location j
    - fiscal and technological externalities
- Strict generalization of Fajgelbaum-Gaubert (2020)
- Tight link to Bailey-Chetty optimal UI formula

Hulten in a Spatial Economy

- Suppose optimal spatial transfers are implemented, then

$$dW = \underbrace{\sum_{i,j,k} p_{ij,k} y_{ij,k} d \ln A_{ij,k}}_{\text{(i) Technology } (\Omega_T)}$$

- Hulten's characterization holds despite the economy being second-best
- This is precisely because transfers are set so that $\Omega_{MU} + \Omega_{FE} + \Omega_{TE} + \Omega_R = 0$

Identification of Marginal Utility

- Marginal utility across space, $u_j^{\theta\prime}(C_j^\theta)$, is a key statistic in welfare evaluation
- Can it be non-parametrically identified from the location choice data?
  $\Rightarrow$ Yes, as long as ϵ_j^θ is additive separable (Allen-Rehbeck, 2019)
- What if ϵ_j^θ is not additive?
- **Result:** If utility is $\tilde{\epsilon}_j^\theta \tilde{u}_j^\theta(C_j^\theta)$ and $\{\tilde{\epsilon}_j^\theta\}$ follows Frechet with arbitrary correlation (GEV)
  $\Rightarrow$ positive *and* normative predictions isomorphic to $\log \tilde{u}_j^\theta(C_j^\theta) + \log \tilde{\epsilon}_j^\theta$
- Without multiplicative Frechet, identification is not possible…
  … but GEV approximates arbitrary discrete choice system
- Welfare changes can be non-parametrically identified in a broad class of models

Application:
“Ex-post” Welfare Evaluation

"Ex-Post" Welfare Evaluation

- Study welfare changes in the US 2010-2019
  - 214 MSAs
  - Two skill types (college, non-college)
- Obtain l_j^θ and $C_j^\theta \equiv (w_j^\theta + T_j^\theta)/P_j^\theta$ from the data
- Take values of $\{\gamma_{ij,k}^\theta\}$ from Fajgelbaum-Gaubert (2020)
- Estimate utility function, $u(C) = \frac{C^{1-\rho_\theta}}{1-\rho_\theta}$ using shift-share IV and GMM
  - Our estimates: $\rho_\theta = 1.52$ for low-skill and $\rho_\theta = 1.29$ for high-skill
- Obtain $\Omega_T = \sum_{i,j,k} p_{ij,k} y_{ij,k} d \ln A_{ij,k}$ as Solow residual (adjusted for agglomeration)
- Assume utilitarian $\Lambda^\theta = 1$

Ex-Post Evaluation in the US

	dW	Ω_T	Ω_{MU}	Ω_{FE}	Ω_{TE}	Ω_R
2010-2015	2.247%	2.043%	0.136%	0.022%	0.014%	0.033%
2015-2019	1.843%	1.354%	-0.003%	0.009%	-0.073%	0.556%

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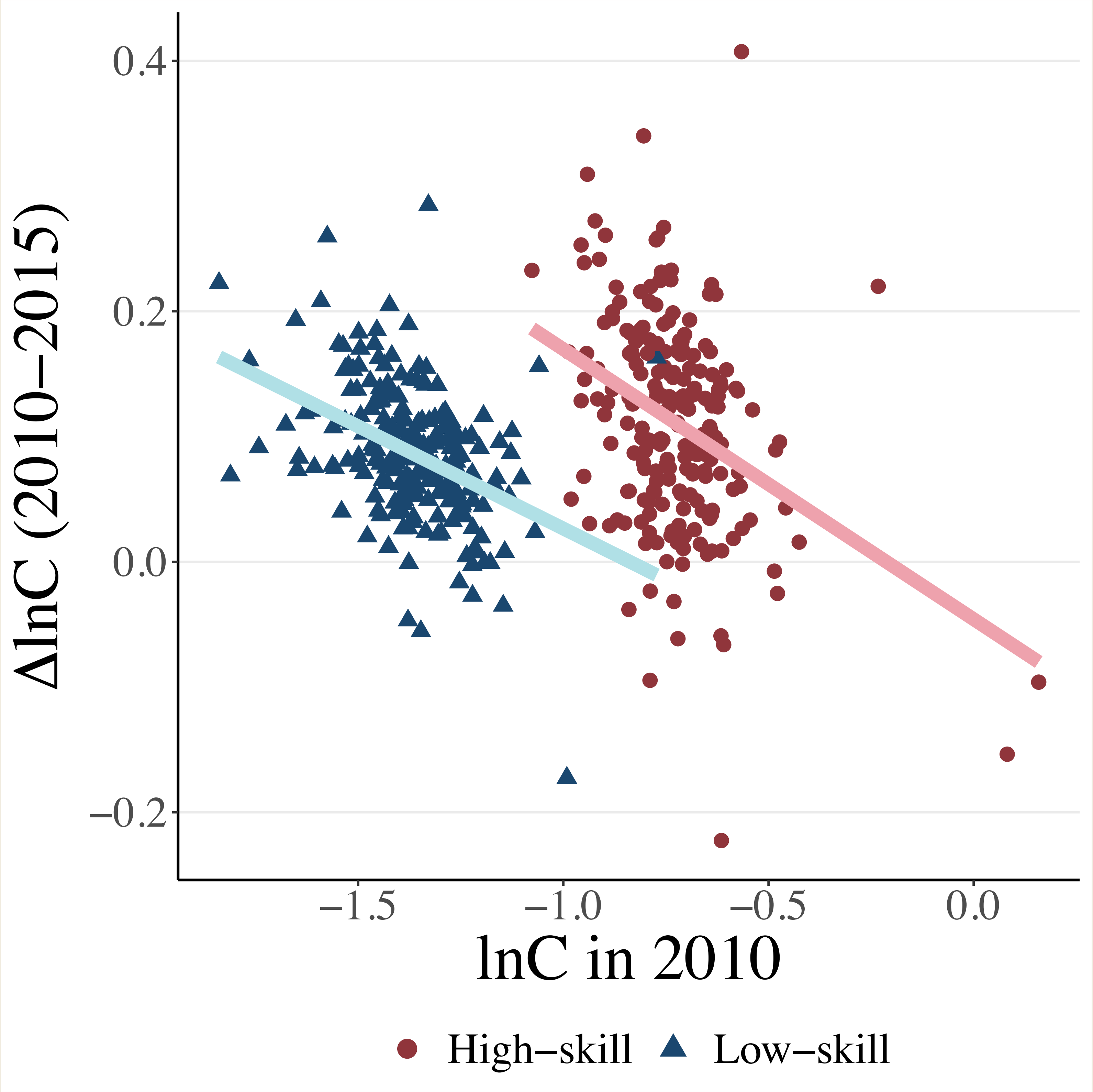

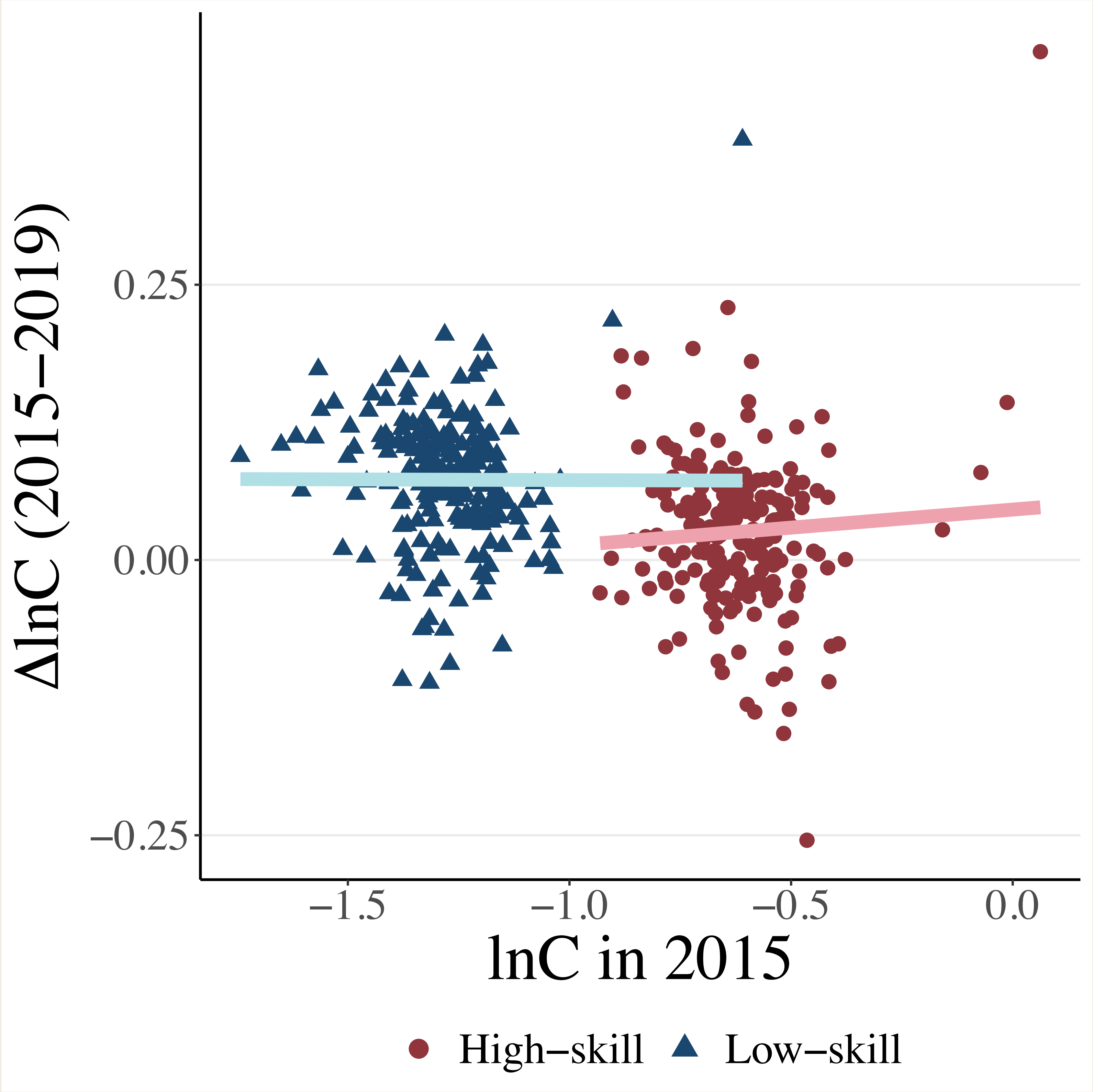

Summary

Theory to unpack source of welfare gains/losses in a spatial economy

- Exact decomposition of welfare changes into five terms
- Non-parametric optimal spatial transfer formula
- Hulten is recovered when optimal spatial transfer policy is in place
- Non-parametric identification of welfare changes

Application:
“Ex-ante” Welfare Evaluation

“Ex-Ante” Welfare Evaluation

- Study welfare changes in response to shocks using Allen-Arkoakis (2022) model
  - One-type
  - log-utility and Armington
  - Route choice and congestion in shipments
  - No spatial transfers
- 228 MSAs and 704 links in the U.S.
- Two experiments:
  1. reduce exogenous component of trade cost by 1%
  2. reduce productivity by 1%

Ex-Ante Welfare Evaluation

	Dependent Variable:				
	Ω_T	Ω_{MU}	$\Omega_{TE,S}$	$\Omega_{TE,A}$	Ω_{Resid}
PANEL A. TRANSPORTATION INFRASTRUCTURE IMPROVEMENTS					
ΔW	2.04	-0.03	-1.03	0.01	0.02
R-squared	0.767	0.004	0.479	0.004	0.657
PANEL B. PRODUCTIVITY SHOCKS					
ΔW	1.08	-0.30	0.10	0.10	0.02
R-squared	0.990	0.653	0.773	0.653	0.998