Universities and the Rise of Services

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ABFER

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Motivation

- Structural transformation toward high-skill services is highly uneven across locations
- Regions with good universities have seen faster growth of high-skill services
  - Pittsburgh's shift from a Rust Belt city into a "brain belt" hub
  - Silicon Valley
  - Austin
- How do universities shape local structural transformation from manufacturing to high-skill services?

What We Do

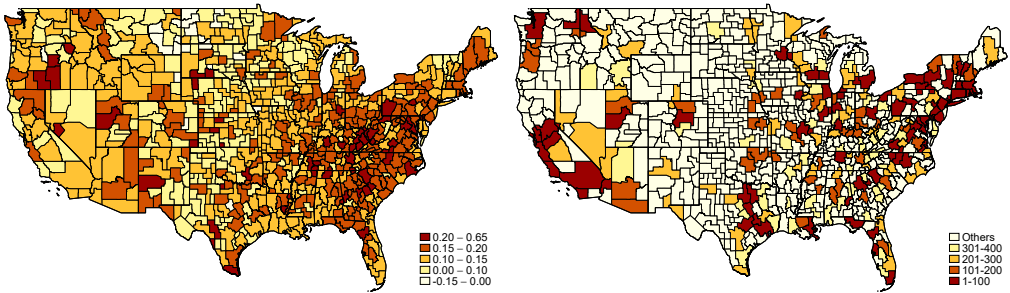
- Document new facts showing that regions with universities experience:
  1. Expansion of high-skill service employment share
  2. Higher college wage premia
  3. Emergence of new tasks

- Develop a novel task-based theory where universities affect local economies through:
  1. **Supply of high-skilled labor**: Universities raise the local stock of skilled workers
  2. **Task creation**: Universities expand the set of adoptable tasks

- Calibrate the quantitative spatial model with the U.S. regional data
  - We validate the cross-regional distribution in task creation
  - We quantify the role of **education** and **technology** in local structural transformation and skill premium

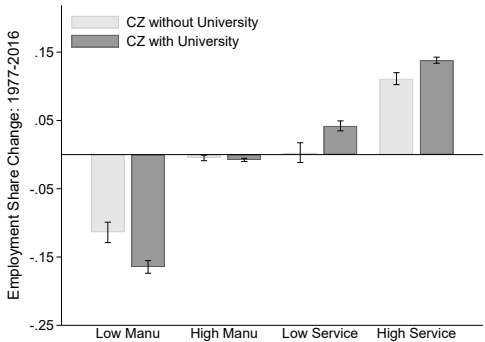
Stylized Facts

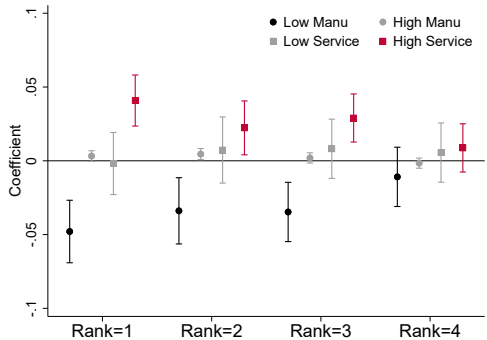
High-Skill Service Employment Growth and US Colleges



- **Left**: Commuting zone level changes in the service employment share 1977–2016
  - The rise of high-skill services (1977–2016) is highly uneven across regions
- **Right**: from dark to light, rank=1; rank=2; rank=3; rank=4; and others
  - Top universities are highly concentrated geographically

Fact #1: Growth of Service Employment Share





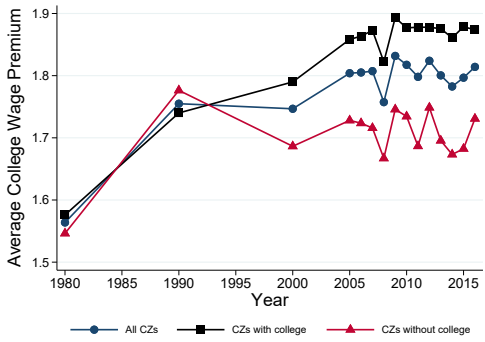
- High-skill services grow significantly more in regions with (top) universities

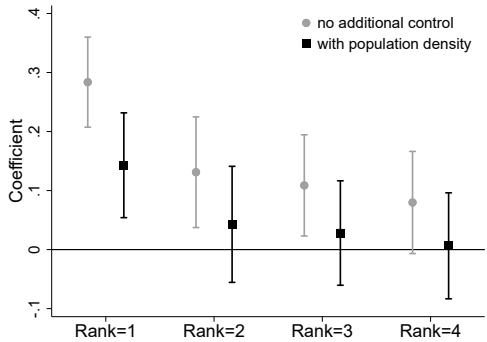
Identification: Winner v.s. Runner-up Counties

- Compare “winner” vs “runner-up” locations of university placement during the 1700s–1950s
- Winners experience more service growth

	Manufacturing		High-Skill Service	
	(1)	(2)	(3)	(4)
Winner County	-.009**	-.021***	.007*	.016*
	(.004)	(.007)	(.004)	(.008)

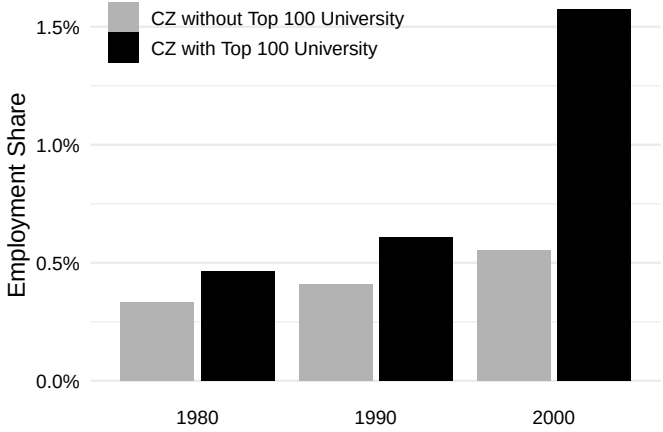
Fact #2: Skill (College Wage) Premium





- Skill premia rise more in university regions, especially those with a top one

Fact #3: New Tasks



- New tasks, such as IT occupations, are much more concentrated in regions with top universities

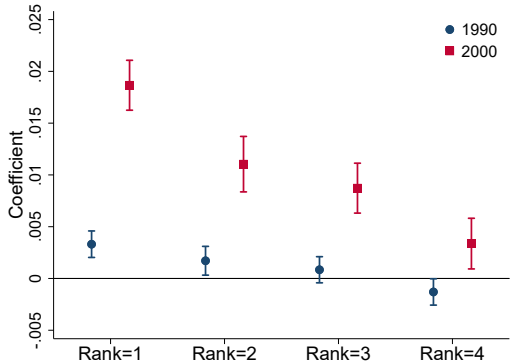
Fact #3: New Tasks

- We construct a "New-Task Index" for each CZ i and period t:

$$\text{New Task}_{it} = \sum_{o \in Occ.} \frac{L_{iot}}{L_{it}} \frac{\#\text{New job titles}_{ot}}{\#\text{Job titles}_{ot}}$$

  where new job titles by occupation is based on Autor et al. (2024)

- CZs with **top universities** have significantly higher New-Task Indexes



Theory

Model Environment

- **Two sectors.** Manufacturing (M) and High-skill Services (S)
  - Manufacturing includes some low-skilled services (e.g., retail)
- **Tasks.** A continuum of horizontally differentiated $j \in [0, J]$
  - J is adopted local frontier of tasks
- **Two types of workers.** College graduate (c) and non-college worker (ℓ)
  - Cobb-Douglas preferences and spend share of $1 - \alpha$ on manufacturing and α on services

Tasks

- Individuals perform tasks j
- Two types $i \in \{\ell, c\}$ differ in productivity of performing tasks z_{ij}
  - Non-college workers are relatively less productive at higher j
- Unit cost of task j performed by worker type i is

$$\gamma_{ij} = \frac{w_i}{z_{ij}}$$

- Minimal cost of task j is: $\gamma_j = \min\{\gamma_{\ell j},\ \gamma_{cj}\}$
- **Cutoff task.** At j^*, the two types are indifferent:

$$\gamma_{\ell j^*} = \gamma_{cj^*} \iff \omega \equiv \frac{w_\ell}{w_c} = \frac{z_{\ell j^*}}{z_{cj^*}}$$

Sectors

- Manufacturing uses tasks $j \in [0, 1]$ with a Cobb-Douglas technology
- High-skill services require all tasks up to the local frontier $j \in [0, J]$:

$$q^S = B(J) \min_{j \in [0,J]} \{\psi_j \tau_j\}$$

  - τ_j denotes input of task j
  - ψ_j is the task-specific productivity in services
  - $B(J)$ is the term for love of variety

- Price of services:

$$p^S = \frac{1}{B(J)} \int_0^J \frac{\gamma_j}{\psi_j} dj$$

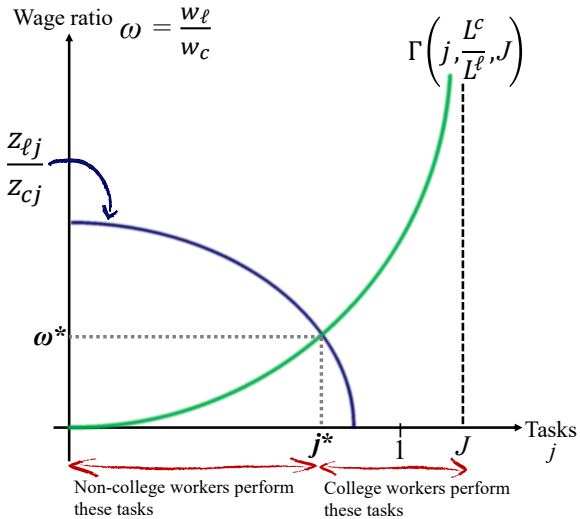
Equilibrium

- Labor market clearing requires that each type is fully employed in performing tasks used by services or manufacturing
- The labor market clearing pins down the relative wage of the two types:

$$\omega \equiv \frac{w_\ell}{w_c} = \frac{\alpha\left[(1-\lambda(j^*,\omega,J)\right] + (1-\alpha)j^*}{\alpha\lambda(j^*,\omega,J) + (1-\alpha)\left(1-j^*\right)} \frac{L_c}{L_\ell} \equiv \Gamma\left(j^*, \frac{L_c}{L_\ell}, J\right)$$

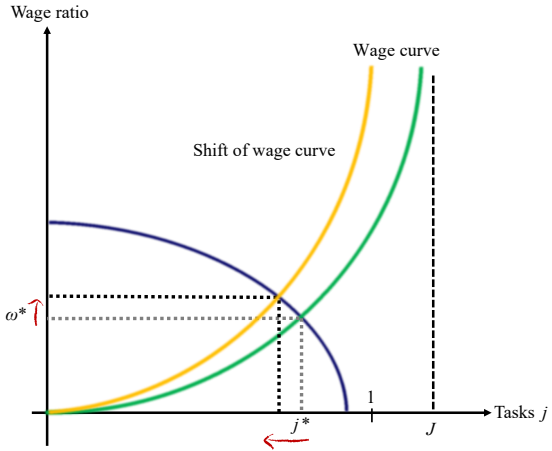
  where $\lambda(j^*,\omega,J)$ is task cost share performed by college graduates in high-skill services
- Given population distribution (L_i) and task set (J), there exists an unique equilibrium characterized by relative wage ω^* and task allocation j^*

Equilibrium



- Relative productivity of non-college workers to college graduates $z_{\ell j}/z_{cj}$ is downward sloping
- Wage curve from the labor market clearing condition is upward sloping

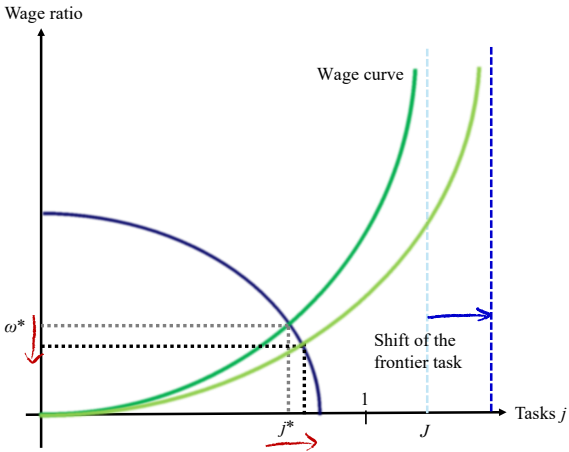
Comparative Statics: More College Graduates



Universities supply college graduates

- Task downgrading for college graduates
- Skill premium falls
- Inconsistent with empirical facts

Comparative Statics: Creating New Tasks



Universities facilitate innovation that creates new tasks

- Expansion of the set of tasks J
- Skill premium rises
- Some tasks are reallocated to non-college workers
- Works like textbook "*skill-biased technical change*", but with different implications for task assignment

University $\rightarrow$ New Tasks $\rightarrow$ Rise of Services

- University creates new tasks (suggested by the data and supported by the quantitative evidence)
- News tasks lead to changes in employment share of high-skill services:

$$\frac{dL^S}{dJ} = \underbrace{\frac{q^S}{B(J)}\frac{1}{\psi_J z_{cJ}}}_{\text{frontier task}} + \underbrace{\frac{q^S}{B(J)}\left(\frac{1}{\psi_{j^*} z_{\ell j^*}} - \frac{1}{\psi_{j^*} z_{cj^*}}\right)\frac{dj^*}{dJ}}_{\text{task reallocation}} + \underbrace{\frac{dq^S}{dJ}\frac{L^S}{q^S}}_{\text{output scale}} - \underbrace{\frac{B'(J)}{B(J)}L^S}_{\text{productivity scale}}$$

- High-skill service employment rises with the frontier task if
  - i) the labor absorbed through task creation
  - ii) task reallocation
  - ii) any induced demand increase

  dominates the productivity gains from expanding the task set

Relationship with Existing Theory

- **Relative productivity**
  - Endogenously determined through task assignment, not exogenously assumed
- **Relative price**
  - caused by J with endogenous task allocation
  - matters in the quantitative analysis
- **Income effects**
  - abstracted here, but non-homotheticity can be a simple extension
- **Skill-biased technical/structural change**
  - microfounded by J with endogenous task allocation
  - different from changes in $z_c(j)/z_\ell(j)$
- A unified theory that nests existing explanations for structural change and rising skill premium, all pointing to the same source: **universities!**

Quantitative Model

Setup

- Multiple regions N, and each region $n \in N$ is characterized by
  - Population of each type, L_{cn}, $L_{\ell n}$
  - Task frontier J_n
  - Wage rate, w_{cn}, $w_{\ell n}$
- CES production functions for the aggregation of complementary tasks:

$$Y_n^{\mathrm{M}} = A_n^{\mathrm{M}} \left[\int_0^1 x_{jn}^{\mathrm{M}} \frac{\varepsilon-1}{\varepsilon} \, dj \right]^{\frac{\varepsilon}{\varepsilon-1}}, \quad Y_n^{\mathrm{S}} = A_n^{\mathrm{S}} J_n^{\phi} \left[\int_0^{J_n} x_{jn}^{\mathrm{S}} \frac{\varepsilon-1}{\varepsilon} \, dj \right]^{\frac{\varepsilon}{\varepsilon-1}}, \quad 0 < \varepsilon < 1$$

- Indirect utility for type $i \in \{\ell, c\}$ in n is:

$$v_{in} = \frac{w_{in} \, b_n}{\left(P_n\right)^{\mu_i} \left(r_n\right)^{1-\mu_i}}$$

  - b_n is amenities
  - P_n is CES composite price index and r_n is floor space rent
- College graduates are mobile, and free mobility implies: $v_{cn} = \bar{v}$ in equilibrium

Calibration Overview

- We set the basic parameters in the model
  - Elasticity of substitution between tasks in production
  - Preference parameters
- Location-specific unobservables are inverted to match the distribution of employment by sector and type (L_{in}^k) and wages by type (w_{in}) across CZs:
  - Task frontier J_{nt}
  - Task threshold j_{nt}^*
  - Skill-biased productivity change $a_{cnt}/a_{\ell nt}$
  - Local amenities b_{nt}
- These estimates are used to:
  1. Validate the model mechanism: Has J_n increased by more in regions with a (good) university?
  2. Quantify the model channels on the effects of a university

Task Frontier and Universities, 1980-2015

	Change in task frontier $(\Delta \ln J_n)$		
	(1)	(2)	(3)
University Rank = 1	.040**	.063***	.088***
	(.016)	(.022)	(.021)
University Rank = 2	.020	.036	.056**
	(.025)	(.027)	(.026)
University Rank = 3	.032	.045**	.042*
	(.022)	(.023)	(.023)
University Rank = 4	.006	.015	.001
	(.016)	(.018)	(.018)
Log Employment in 1980		.027	.049**
		(.021)	(.019)
Log Service Employment in 1980		-.034	.195***
		(.022)	(.031)
Log College Workers in 1980			-.243***
			(.027)

Conclusion

- We document that regions with universities show:
  1. faster growth of high-skill services
  2. higher college wage premia
  3. concentration of new tasks
- Present a task-based model in which universities change two local objects: skilled-labor supply and the adoption of frontier tasks
  - The task-creation role may jointly account for Facts 1 & 2
- Results from a quantitative spatial model further support the “innovation” role of universities
- Policy implications: research funding vs. enrollment expansion

Thank you!