The Regional Specialization Trade-off

Lukas Boehnert

January 14, 2026

University of Oxford, Department of Economics

Introduction

Introduction

- Conventional economic wisdom: Specialization is beneficial
  $\rightarrow$ Specialization = Concentration of economic activity across industries

Introduction

- Conventional economic wisdom: Specialization is beneficial
  $\rightarrow$ Specialization = Concentration of economic activity across industries
  - Inter-regional trade gains from comparative advantage
  - Intra-regional productivity gains from knowledge spillovers and agglomeration

Introduction

- Conventional economic wisdom: Specialization is beneficial
  $\rightarrow$ Specialization = Concentration of economic activity across industries
  - Inter-regional trade gains from comparative advantage
  - Intra-regional productivity gains from knowledge spillovers and agglomeration
- Historically: Once-thriving highly specialized hubs often face severe declines

Introduction

- Conventional economic wisdom: Specialization is beneficial
  $\rightarrow$ Specialization = Concentration of economic activity across industries
  - Inter-regional trade gains from comparative advantage
  - Intra-regional productivity gains from knowledge spillovers and agglomeration
- Historically: Once-thriving highly specialized hubs often face severe declines
  - Well-known examples: Rust Belt (US), Rhine-Ruhr area (Germany), Lancashire (UK)

Introduction

- Conventional economic wisdom: Specialization is beneficial
  $\rightarrow$ Specialization = Concentration of economic activity across industries
  - Inter-regional trade gains from comparative advantage
  - Intra-regional productivity gains from knowledge spillovers and agglomeration
- Historically: Once-thriving highly specialized hubs often face severe declines
  - Well-known examples: Rust Belt (US), Rhine-Ruhr area (Germany), Lancashire (UK)
- Were these regions unlucky, or is specializing systematically detrimental?

Introduction

- Conventional economic wisdom: Specialization is beneficial
  $\rightarrow$ Specialization = Concentration of economic activity across industries
  - Inter-regional trade gains from comparative advantage
  - Intra-regional productivity gains from knowledge spillovers and agglomeration
- Historically: Once-thriving highly specialized hubs often face severe declines
  - Well-known examples: Rust Belt (US), Rhine-Ruhr area (Germany), Lancashire (UK)
- Were these regions unlucky, or is specializing systematically detrimental?
- **This paper:** Role of regional specialization in explaining economic fortunes

Introduction

- Conventional economic wisdom: Specialization is beneficial
  $\rightarrow$ Specialization = Concentration of economic activity across industries
  - Inter-regional trade gains from comparative advantage
  - Intra-regional productivity gains from knowledge spillovers and agglomeration
- Historically: Once-thriving highly specialized hubs often face severe declines
  - Well-known examples: Rust Belt (US), Rhine-Ruhr area (Germany), Lancashire (UK)
- Were these regions unlucky, or is specializing systematically detrimental?
- **This paper:** Role of regional specialization in explaining economic fortunes
  1. How does regional specialization affect growth?
  2. What is the optimal regional specialization?

This Paper

This Paper

Empirics: Document novel specialization trade-off in U.S. regional growth since 1950

This Paper

Empirics: Document novel specialization trade-off in U.S. regional growth since 1950

$\Rightarrow$ Highly specialized regions have higher short-run income but lower long-run growth

This Paper

Empirics: Document novel specialization trade-off in U.S. regional growth since 1950

$\Rightarrow$ Highly specialized regions have higher short-run income but lower long-run growth

i) As regions grow, they become more specialized

This Paper

Empirics: Document novel specialization trade-off in U.S. regional growth since 1950

$\Rightarrow$ Highly specialized regions have higher short-run income but lower long-run growth

i) As regions grow, they become more specialized

ii) At the region-industry level, specialization is highly persistent

This Paper

Empirics: Document novel specialization trade-off in U.S. regional growth since 1950

$\Rightarrow$ Highly specialized regions have higher short-run income but lower long-run growth

i) As regions grow, they become more specialized

ii) At the region-industry level, specialization is highly persistent

Theory: Link specialization to growth

This Paper

Empirics: Document novel specialization trade-off in U.S. regional growth since 1950

$\Rightarrow$ Highly specialized regions have higher short-run income but lower long-run growth

i) As regions grow, they become more specialized

ii) At the region-industry level, specialization is highly persistent

Theory: Link specialization to growth

- Benefits: Productivity & income $\uparrow$ *(agglomeration)*

This Paper

Empirics: Document novel specialization trade-off in U.S. regional growth since 1950

$\Rightarrow$ Highly specialized regions have higher short-run income but lower long-run growth

i) As regions grow, they become more specialized

ii) At the region-industry level, specialization is highly persistent

Theory: Link specialization to growth

- Benefits: Productivity & income $\uparrow$ *(agglomeration)*
- Costs: Exposure to sectoral shocks $\uparrow$

This Paper

Empirics: Document novel specialization trade-off in U.S. regional growth since 1950

$\Rightarrow$ Highly specialized regions have higher short-run income but lower long-run growth

i) As regions grow, they become more specialized

ii) At the region-industry level, specialization is highly persistent

Theory: Link specialization to growth

- Benefits: Productivity & income $\uparrow$ *(agglomeration)*
- Costs: Exposure to sectoral shocks $\uparrow$ *(factor adjustment costs)* + *(financial friction)*

This Paper

Empirics: Document novel specialization trade-off in U.S. regional growth since 1950

$\Rightarrow$ Highly specialized regions have higher short-run income but lower long-run growth

i) As regions grow, they become more specialized

ii) At the region-industry level, specialization is highly persistent

Theory: Link specialization to growth

- Benefits: Productivity & income $\uparrow$ *(agglomeration)*
- Costs: Exposure to sectoral shocks $\uparrow$ *(factor adjustment costs)* + *(financial friction)*
- Optimal specialization: Regional planner balances agglomeration & frictions

This Paper

Empirics: Document novel specialization trade-off in U.S. regional growth since 1950

$\Rightarrow$ Highly specialized regions have higher short-run income but lower long-run growth

i) As regions grow, they become more specialized

ii) At the region-industry level, specialization is highly persistent

Theory: Link specialization to growth

- Benefits: Productivity & income $\uparrow$ *(agglomeration)*
- Costs: Exposure to sectoral shocks $\uparrow$ *(factor adjustment costs)* + *(financial friction)*
- Optimal specialization: Regional planner balances agglomeration & frictions

Quantification:

This Paper

Empirics: Document novel specialization trade-off in U.S. regional growth since 1950

$\Rightarrow$ Highly specialized regions have higher short-run income but lower long-run growth

i) As regions grow, they become more specialized

ii) At the region-industry level, specialization is highly persistent

Theory: Link specialization to growth

- Benefits: Productivity & income $\uparrow$ *(agglomeration)*
- Costs: Exposure to sectoral shocks $\uparrow$ *(factor adjustment costs)* + *(financial friction)*
- Optimal specialization: Regional planner balances agglomeration & frictions

Quantification:

- Model captures half of observed trade-off

This Paper

Empirics: Document novel specialization trade-off in U.S. regional growth since 1950

$\Rightarrow$ Highly specialized regions have higher short-run income but lower long-run growth

i) As regions grow, they become more specialized

ii) At the region-industry level, specialization is highly persistent

Theory: Link specialization to growth

- Benefits: Productivity & income $\uparrow$ *(agglomeration)*
- Costs: Exposure to sectoral shocks $\uparrow$ *(factor adjustment costs)* + *(financial friction)*
- Optimal specialization: Regional planner balances agglomeration & frictions

Quantification:

- Model captures half of observed trade-off $\rightarrow$ financial friction accounts for 56% of it

This Paper

Empirics: Document novel specialization trade-off in U.S. regional growth since 1950

$\Rightarrow$ Highly specialized regions have higher short-run income but lower long-run growth

i) As regions grow, they become more specialized

ii) At the region-industry level, specialization is highly persistent

Theory: Link specialization to growth

- Benefits: Productivity & income $\uparrow$ *(agglomeration)*
- Costs: Exposure to sectoral shocks $\uparrow$ *(factor adjustment costs)* + *(financial friction)*
- Optimal specialization: Regional planner balances agglomeration & frictions

Quantification:

- Model captures half of observed trade-off $\rightarrow$ financial friction accounts for 56% of it
- Efficient regional specialization in 1950 raises welfare by 1.2-2.2%

The contribution of this paper

The contribution of this paper

1. **Regional growth:**

   [Solow (1956), Baumol (1986), Barro and Sala-i-Martin (1991), Autor & Dorn (2013), Giannone (2022), Eckert & Peters (2023), Comin et al (2021), Gaubert et al (2020), Caselli et al (2016)]

   Contribution: Document specialization trade-off in U.S. regional growth since 1950

The contribution of this paper

1. **Regional growth:**

   [Solow (1956), Baumol (1986), Barro and Sala-i-Martin (1991), Autor & Dorn (2013), Giannone (2022), Eckert & Peters (2023), Comin et al (2021), Gaubert et al (2020), Caselli et al (2016)]

   Contribution: Document specialization trade-off in U.S. regional growth since 1950

2. **Industrial Specialization:**

   [Jacobs (1961, 1970), Imbs & Waczarg (2003), Gaubert et al (2018), Glaeser (2019), Caselli et al (2020), Nagy (2023), Walsh (2023), Bartelme et al (2024), Heblich et al (2025)]

   Contribution: Endogenize costs of specialization + derive optimal specialization

The contribution of this paper

1. **Regional growth:**

   [Solow (1956), Baumol (1986), Barro and Sala-i-Martin (1991), Autor & Dorn (2013), Giannone (2022), Eckert & Peters (2023), Comin et al (2021), Gaubert et al (2020), Caselli et al (2016)]

   Contribution: Document specialization trade-off in U.S. regional growth since 1950

2. **Industrial Specialization:**

   [Jacobs (1961, 1970), Imbs & Waczarg (2003), Gaubert et al (2018), Glaeser (2019), Caselli et al (2020), Nagy (2023), Walsh (2023), Bartelme et al (2024), Heblich et al (2025)]

   Contribution: Endogenize costs of specialization + derive optimal specialization

3. **Long-run implications of financial frictions:**

   [Kiyotaki & Moore (1997), Bernanke, Gertler & Gilchrist (1999), Mendoza (2010), Gertler & Karadi (2012), Bianchi (2011), Bianchi & Mendoza (2019), Bonciani et al (2023)]

   Contribution: Derive financial friction in multi-industry setting + long-run effects

Roadmap

Roadmap

1. Empirical results:

Roadmap

1. Empirical results:

   $\Rightarrow$ Highly specialized regions have higher income in the short run but lower long-run growth

   i) As regions grow, they become more specialized

   ii) At the region-industry level, specialization is highly persistent

Roadmap

1. Empirical results:

   $\Rightarrow$ Highly specialized regions have higher income in the short run but lower long-run growth

   i) As regions grow, they become more specialized
   ii) At the region-industry level, specialization is highly persistent

2. Theory: Formalize benefits & costs of specialization

Roadmap

1. Empirical results:

   $\Rightarrow$ Highly specialized regions have higher income in the short run but lower long-run growth

   i) As regions grow, they become more specialized

   ii) At the region-industry level, specialization is highly persistent

2. Theory: Formalize benefits & costs of specialization

3. Quantitative Analysis:

   - Quantify relevance of specialization channels for growth
   - Rationalize U.S. regional growth since 1950

Roadmap

1. Empirical results:
   - $\Rightarrow$ Highly specialized regions have higher income in the short run but lower long-run growth
     - i) As regions grow, they become more specialized
     - ii) At the region-industry level, specialization is highly persistent
2. Theory: Formalize benefits & costs of specialization
3. Quantitative Analysis:
   - Quantify relevance of specialization channels for growth
   - Rationalize U.S. regional growth since 1950
4. Efficiency & Welfare: Constrained-efficient specialization

Roadmap

1. Empirical results:
   - $\Rightarrow$ Highly specialized regions have higher income in the short run but lower long-run growth
     - i) As regions grow, they become more specialized
     - ii) At the region-industry level, specialization is highly persistent

2. Theory: Formalize benefits & costs of specialization

3. Quantitative Analysis:
   - Quantify relevance of specialization channels for growth
   - Rationalize U.S. regional growth since 1950

4. Efficiency & Welfare: Constrained-efficient specialization

5. Conclusion

Empirical results

Data

Data

- US labor markets (722 Commuting Zones; Dorn, 2009): 1950-2020

Data

- US labor markets (722 Commuting Zones; Dorn, 2009): 1950-2020
- Three data sources:

Data

- US labor markets (722 Commuting Zones; Dorn, 2009): 1950-2020
- Three data sources:
  1. US Population Census (1950-2020):
     - Decennial representative sample of income, work, industry, demography and location
     - Baseline sample: Earnings of employed individuals, 15-60 years old [Heathcote et al (2023)]

Data

- US labor markets (722 Commuting Zones; Dorn, 2009): 1950-2020
- Three data sources:
  1. US Population Census (1950-2020):
     - Decennial representative sample of income, work, industry, demography and location
     - Baseline sample: Earnings of employed individuals, 15-60 years old [Heathcote et al (2023)]
  2. County Business Patterns (1950-2020):
     - County-industry aggregates: population, employment, income, output

Data

- US labor markets (722 Commuting Zones; Dorn, 2009): 1950-2020
- Three data sources:
  1. US Population Census (1950-2020):
     - Decennial representative sample of income, work, industry, demography and location
     - Baseline sample: Earnings of employed individuals, 15-60 years old [Heathcote et al (2023)]
  2. County Business Patterns (1950-2020):
     - County-industry aggregates: population, employment, income, output
  3. US Housing Census (1970-2020):
     - County-level decennial sample of housing & land units, types & value

Data

- US labor markets (722 Commuting Zones; Dorn, 2009): 1950-2020
- Three data sources:
  1. US Population Census (1950-2020):
     - Decennial representative sample of income, work, industry, demography and location
     - Baseline sample: Earnings of employed individuals, 15-60 years old [Heathcote et al (2023)]
  2. County Business Patterns (1950-2020):
     - County-industry aggregates: population, employment, income, output
  3. US Housing Census (1970-2020):
     - County-level decennial sample of housing & land units, types & value
- Measuring Specialization = concentration of economic activity across industries

Data

- US labor markets (722 Commuting Zones; Dorn, 2009): 1950-2020
- Three data sources:
  1. US Population Census (1950-2020):
     - Decennial representative sample of income, work, industry, demography and location
     - Baseline sample: Earnings of employed individuals, 15-60 years old [Heathcote et al (2023)]
  2. County Business Patterns (1950-2020):
     - County-industry aggregates: population, employment, income, output
  3. US Housing Census (1970-2020):
     - County-level decennial sample of housing & land units, types & value
- Measuring Specialization = concentration of economic activity across industries
  - Baseline: Gini on county-level income shares by 3-digit industry [Imbs & Wacziarg (2003)]

Data

- US labor markets (722 Commuting Zones; Dorn, 2009): 1950-2020
- Three data sources:
  1. US Population Census (1950-2020):
     - Decennial representative sample of income, work, industry, demography and location
     - Baseline sample: Earnings of employed individuals, 15-60 years old [Heathcote et al (2023)]
  2. County Business Patterns (1950-2020):
     - County-industry aggregates: population, employment, income, output
  3. US Housing Census (1970-2020):
     - County-level decennial sample of housing & land units, types & value
- Measuring Specialization = concentration of economic activity across industries
  - Baseline: Gini on county-level income shares by 3-digit industry [Imbs & Wacziarg (2003)]
    $\rightarrow$ Gini = 1: maximal specialization (all income generated in one industry)

Data

- US labor markets (722 Commuting Zones; Dorn, 2009): 1950-2020
- Three data sources:
  1. US Population Census (1950-2020):
     - Decennial representative sample of income, work, industry, demography and location
     - Baseline sample: Earnings of employed individuals, 15-60 years old [Heathcote et al (2023)]
  2. County Business Patterns (1950-2020):
     - County-industry aggregates: population, employment, income, output
  3. US Housing Census (1970-2020):
     - County-level decennial sample of housing & land units, types & value
- Measuring Specialization = concentration of economic activity across industries
  - Baseline: Gini on county-level income shares by 3-digit industry [Imbs & Wacziarg (2003)]
    $\rightarrow$ Gini = 1: maximal specialization (all income generated in one industry)
  - Robustness: other measures (HHI, max share), other variables (employment, value added)

▸ Topcoding ▸ Further Details

Fact 1: The Specialization Trade-off

Fact 1: The Specialization Trade-off

- Define
  - r for commuting zone $r = \{1, ..., 722\}$
  - Y_r as dependent variable
  - $Gini_{r,1950}$ as 1950 Gini on income p.c. by 3-digit industry

$$Y_r = \alpha + \beta \cdot Gini_{r,1950} \qquad\qquad + \epsilon_r$$

Fact 1: The Specialization Trade-off

- Define
  - r for commuting zone $r = \{1, ..., 722\}$
  - Y_r as dependent variable
  - $Gini_{r,1950}$ as 1950 Gini on income p.c. by 3-digit industry

$$Y_r = \alpha + \beta \cdot Gini_{r,1950} + \gamma' \cdot Z_r \qquad + \epsilon_r$$

  - Z_r including a set of control variables:
    - 1950 log income p.c. [Barro & Sala-i-Martin (1992)]
    - 1950 population [Eckert, Ganapati & Walsh (2024)]
    - 1950 share of high-skilled workers [Autor & Dorn (2013)]
    - 1950 old-age dependency ratio [Autor, Dorn & Hanson (2019)]
    - 1950 share of female workers [Fosso, Bergholt, Furlanetto (2025)]

Fact 1: The Specialization Trade-off

- Define
  - r for commuting zone $r = \{1, ..., 722\}$
  - Y_r as dependent variable
  - $Gini_{r,1950}$ as 1950 Gini on income p.c. by 3-digit industry

$$Y_r = \alpha + \beta \cdot Gini_{r,1950} + \gamma' \cdot Z_r + \delta \cdot \hat{g}_r + \epsilon_r$$

  - Z_r including a set of control variables
  - $\hat{g}_r$ as shift-share predicted growth from structural change [Borusyak et al (2025)]

$$\hat{g}_r = \sum_{i=1}^{I} s_{i,r,1950} \cdot g_i^{US}$$

  with
    - $s_{i,r,1950}$ as 1950 income share in industry i
    - g_i^{US} as 1950-2020 US growth in industry i

Fact 1: The Specialization Trade-off after controls

Highly specialized regions are richer in the short-run and have lower long-run growth.

Fact 1: The Specialization Trade-off after controls

Highly specialized regions are richer in the short-run and have lower long-run growth.

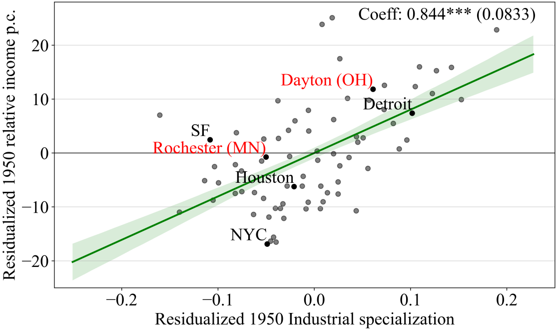


Figure 1: 1950 Income level

Fact 1: The Specialization Trade-off after controls

Highly specialized regions are richer in the short-run and have lower long-run growth.

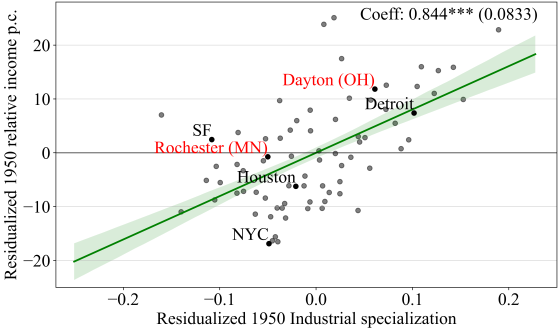


Figure 1: 1950 Income level

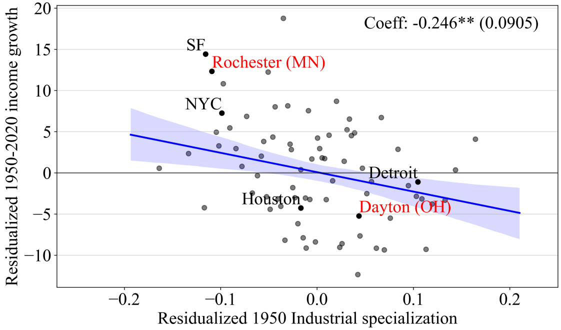


Figure 2: 1950-2020 Growth

▸ Regression table

Fact 2: As regions grow, they become more specialized

Fact 2: As regions grow, they become more specialized

- Goals:
  1. Characterize dynamic relationship between specialization and income
  2. Observe how regions move in distribution

Fact 2: As regions grow, they become more specialized

- Goals:
  1. Characterize dynamic relationship between specialization and income
  2. Observe how regions move in distribution

- Key point: dynamics can be highly non-linear [Imbs & Wacziarg (2003)]

Fact 2: As regions grow, they become more specialized

- Goals:
  1. Characterize dynamic relationship between specialization and income
  2. Observe how regions move in distribution

- Key point: dynamics can be highly non-linear [Imbs & Wacziarg (2003)]

- Define non-parametric locally weighted regression:
  - i as single observation: Commuting Zone $\times$ Year
  - y_i as normalized specialization (Gini)
  - x_i as normalized per capita income

$$y_i = \alpha(x_i) + \beta(x_i)x_i + \epsilon_i$$

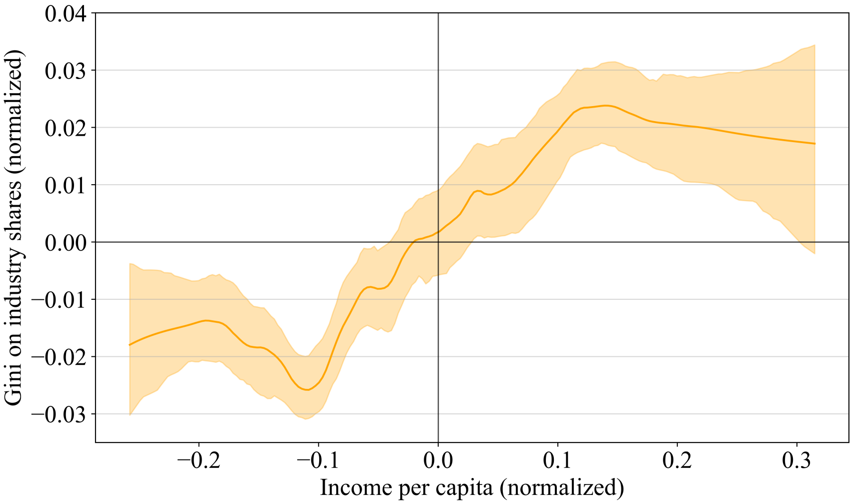
with

- $(\hat{\alpha}(x_i), \hat{\beta}(x_i)) = \arg\min_{\alpha,\beta} \sum_j w_j(x_i)(y_i - (\alpha + \beta x_j))^2$

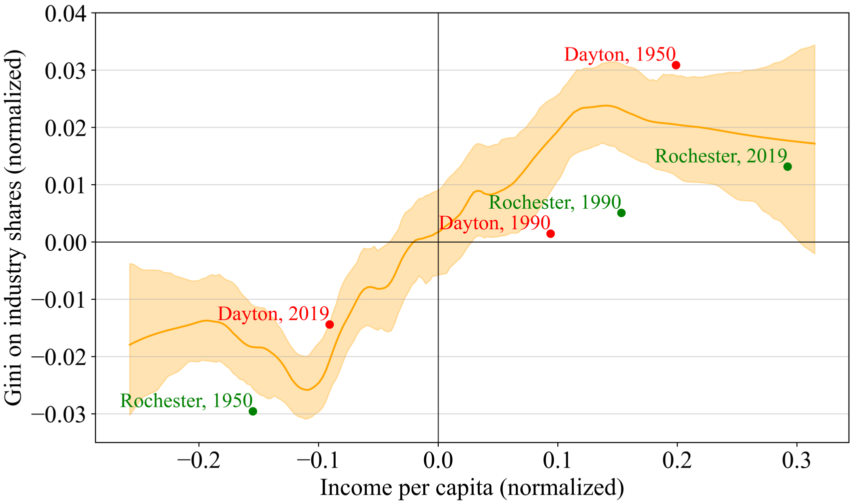
Further details

Fact 2: As regions grow, they become more specialized

Fact 2: As regions grow, they become more specialized



Fact 2: As regions grow, they become more specialized



▸ Further details

Checkpoint

Checkpoint

- **Key take-aways:**

Checkpoint

- **Key take-aways**:
  - $\Rightarrow$ Highly specialized regions are richer initially and have lower long-run growth

Checkpoint

- **Key take-aways**:

  $\Rightarrow$ Highly specialized regions are richer initially and have lower long-run growth

  i) As regions grow, they become more specialized

Checkpoint

- **Key take-aways:**
  - $\Rightarrow$ Highly specialized regions are richer initially and have lower long-run growth
    - i) As regions grow, they become more specialized
    - ii) At the region-industry level, specialization is highly persistent ▸ Fact 3

Checkpoint

- **Key take-aways:**
  - ⇒ Highly specialized regions are richer initially and have lower long-run growth
    - i) As regions grow, they become more specialized
    - ii) At the region-industry level, specialization is highly persistent ‣ Fact 3

- Extensions and Robustness: ‣ Role of tradability ‣ Horizons ‣ Industries ‣ Persistence ‣ Measures

Checkpoint

- **Key take-aways**:
  - ⇒ Highly specialized regions are richer initially and have lower long-run growth
    - i) As regions grow, they become more specialized
    - ii) At the region-industry level, specialization is highly persistent ▸ Fact 3
- Extensions and Robustness: ▸ Role of tradability ▸ Horizons ▸ Industries ▸ Persistence ▸ Measures
- Next: Formalize specialization trade-off theoretically
  1. Rationalize U.S. regional growth since 1950
  2. Assess welfare under optimal specialization

Model

Model environment

Model environment

- Focus on single region (small open economy)

Model environment

- Focus on single region (small open economy)
- Continuum of identical individuals produce using capital k

Model environment

- Focus on single region (small open economy)
- Continuum of identical individuals produce using capital k
- Multiple industries i producing single final good c

Model environment

- Focus on single region (small open economy)
- Continuum of identical individuals produce using capital k
- Multiple industries i producing single final good c
    - Stochastic productivity: $\bar{z}_{i,t}$

Model environment

- Focus on single region (small open economy)
- Continuum of identical individuals produce using capital k
- Multiple industries i producing single final good c
  - Stochastic productivity: $\bar{z}_{i,t}$
  - Intra-industry agglomeration: $z_i = \bar{z}_i \cdot k_i^{\xi_i}$ with $\xi_i \geq 0$

Model environment

- Focus on single region (small open economy)
- Continuum of identical individuals produce using capital k
- Multiple industries i producing single final good c
  - Stochastic productivity: $\bar{z}_{i,t}$
  - Intra-industry agglomeration: $z_i = \bar{z}_i \cdot k_i^{\xi_i}$ with $\xi_i \geq 0$
  - Convex capital adjustment costs: $\Phi_i(k_{i,t}, k_{i,t+1})$

Model environment

- Focus on single region (small open economy)
- Continuum of identical individuals produce using capital k
- Multiple industries i producing single final good c
  - Stochastic productivity: $\bar{z}_{i,t}$
  - Intra-industry agglomeration: $z_i = \bar{z}_i \cdot k_i^{\xi_i}$ with $\xi_i \geq 0$
  - Convex capital adjustment costs: $\Phi_i(k_{i,t}, k_{i,t+1})$
- Financial friction: Occasionally binding collateral constraint

Model environment

- Focus on single region (small open economy)
- Continuum of identical individuals produce using capital k
- Multiple industries i producing single final good c
    - Stochastic productivity: $\bar{z}_{i,t}$
    - Intra-industry agglomeration: $z_i = \bar{z}_i \cdot k_i^{\xi_i}$ with $\xi_i \geq 0$
    - Convex capital adjustment costs: $\Phi_i(k_{i,t}, k_{i,t+1})$
- Financial friction: Occasionally binding collateral constraint
    - Investment is debt-financed [Kiyotaki & Moore (1997), Bianchi & Mendoza (2018)]

Model environment

- Focus on single region (small open economy)
- Continuum of identical individuals produce using capital k
- Multiple industries i producing single final good c
  - Stochastic productivity: $\bar{z}_{i,t}$
  - Intra-industry agglomeration: $z_i = \bar{z}_i \cdot k_i^{\xi_i}$ with $\xi_i \geq 0$
  - Convex capital adjustment costs: $\Phi_i(k_{i,t}, k_{i,t+1})$
- Financial friction: Occasionally binding collateral constraint
  - Investment is debt-financed [Kiyotaki & Moore (1997), Bianchi & Mendoza (2018)]
  - Borrowing against collateral: market value of productive capital stock [Gan (2007), Lustig et al. (2010), Chaney et al. (2012)]

Individual problem

Individual problem

- Individuals solve

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t)$$

subject to

$$c_t + \frac{b_{t+1}}{R_t} + q_t \sum_i^I k_{i,t+1} = \sum_i^I \Big[\underbrace{z_{i,t} f(k_{i,t}) - \Phi_i(k_{i,t}, k_{i,t+1})}_{\text{Industry } i \text{ net output}} + q_t k_{i,t} \Big] + b_t$$

$$-\frac{b_{t+1}}{R_t} \leq \underbrace{\theta q_t \sum_i^I k_{i,t}}_{\text{Collateral value}}$$

Individual problem

- Individuals solve

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t)$$

subject to

$$c_t + \frac{b_{t+1}}{R_t} + q_t \sum\nolimits_i^I k_{i,t+1} = \sum\nolimits_i^I \Big[\underbrace{z_{i,t} f(k_{i,t}) - \Phi_i(k_{i,t}, k_{i,t+1})}_{\text{Industry } i \text{ net output}} + q_t k_{i,t} \Big] + b_t$$

$$-\frac{b_{t+1}}{R_t} \leq \underbrace{\theta q_t \sum\nolimits_i^I k_{i,t}}_{\text{Collateral value}}$$

- **Two decisions:**

Individual problem

- Individuals solve

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t)$$

  subject to

$$c_t + \frac{b_{t+1}}{R_t} + q_t \sum_i^I k_{i,t+1} = \sum_i^I \Big[\underbrace{z_{i,t} f(k_{i,t}) - \Phi_i(k_{i,t}, k_{i,t+1})}_{\text{Industry } i \text{ net output}} + q_t k_{i,t} \Big] + b_t$$

$$-\frac{b_{t+1}}{R_t} \leq \underbrace{\theta q_t \sum_i^I k_{i,t}}_{\text{Collateral value}}$$

- **Two decisions:**
  1. Portfolio allocation: Allocate capital k across industries $i \in \{1, ..., I\}$

Individual problem

- Individuals solve

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t)$$

subject to

$$c_t + \frac{b_{t+1}}{R_t} + q_t \sum\nolimits_i^I k_{i,t+1} = \sum\nolimits_i^I \Big[\underbrace{z_{i,t} f(k_{i,t}) - \Phi_i(k_{i,t}, k_{i,t+1})}_{\text{Industry } i \text{ net output}} + q_t k_{i,t} \Big] + b_t$$

$$-\frac{b_{t+1}}{R_t} \leq \underbrace{\theta q_t \sum\nolimits_i^I k_{i,t}}_{\text{Collateral value}}$$

- **Two decisions:**
  1. Portfolio allocation: Allocate capital k across industries $i \in \{1, ..., I\}$
  2. Consumption vs saving: Borrow to invest in k

Key optimality conditions (Competitive Equilibrium)

Key optimality conditions (Competitive Equilibrium)

- Define:
  - $\tilde{q}_{i,t} = q_t - \phi_2(k_{i,t}, k_{i,t+1})$ as marginal capital price (net of adjustment costs)
  - $\eta_t \geq 0$ as Lagrange multiplier on the collateral constraint

Key optimality conditions (Competitive Equilibrium)

- Define:
  - $\tilde{q}_{i,t} = q_t - \phi_2(k_{i,t}, k_{i,t+1})$ as marginal capital price (net of adjustment costs)
  - $\eta_t \geq 0$ as Lagrange multiplier on the collateral constraint

Portfolio allocation: $\underbrace{\tilde{q}_{i,t} u'(c_t)}_{\text{MC}} = \beta \, \mathbb{E}_t \Big[\underbrace{u'(c_{t+1}) \big(\tilde{q}_{i,t+1} + z_{i,t+1} f'(k_{i,t+1}) \big)}_{\text{Expected MB of capital}} + \underbrace{\theta q_{t+1} \eta_{t+1}}_{\text{Collateral value}} \Big] \, \forall \, i$

Key optimality conditions (Competitive Equilibrium)

- Define:
  - $\tilde{q}_{i,t} = q_t - \phi_2(k_{i,t}, k_{i,t+1})$ as marginal capital price (net of adjustment costs)
  - $\eta_t \geq 0$ as Lagrange multiplier on the collateral constraint

Portfolio allocation: $\underbrace{\tilde{q}_{i,t} u'(c_t)}_{\text{MC}} = \beta \, \mathbb{E}_t \Big[\underbrace{u'(c_{t+1}) \big(\tilde{q}_{i,t+1} + z_{i,t+1} f'(k_{i,t+1}) \big)}_{\text{Expected MB of capital}} + \underbrace{\theta q_{t+1} \eta_{t+1}}_{\text{Collateral value}} \Big] \, \forall \, i$

Consumption-savings: $u'(c_t) = \beta R_t \, \mathbb{E}_t \big[u'(c_{t+1}) \big] + \eta_t$

Recursive Unregulated Competitive Equilibrium

A **Recursive Unregulated Competitive Equilibrium** is a set $\{V, c, b', k_i', q, \Gamma\}$ such that:

Recursive Unregulated Competitive Equilibrium

A **Recursive Unregulated Competitive Equilibrium** is a set $\{V, c, b', k_i', q, \Gamma\}$ such that:

1. **Individual optimization:** Given $(B, b, \mathcal{K}, \mathcal{Z})$, agents solve

$$V(B, b, \mathcal{K}, \mathcal{Z}) = \max_{c, b', k_i'} u(c) + \beta \mathbb{E} V(B', b', \mathcal{K}', \mathcal{Z}')$$

   subject to budget and collateral constraints.

Recursive Unregulated Competitive Equilibrium

A **Recursive Unregulated Competitive Equilibrium** is a set $\{V, c, b', k_i', q, \Gamma\}$ such that:

1. **Individual optimization:** Given $(B, b, \mathcal{K}, \mathcal{Z})$, agents solve

$$V(B, b, \mathcal{K}, \mathcal{Z}) = \max_{c, b', k_i'} u(c) + \beta \mathbb{E} V(B', b', \mathcal{K}', \mathcal{Z}')$$

   subject to budget and collateral constraints.

2. **Market clearing:**
   - Capital market: $\sum_i^I k_i = K$
   - Goods market: $\sum_i^I [z_i f(k_i) - \Phi_i(k_i, k_i')] = c$

Recursive Unregulated Competitive Equilibrium

A **Recursive Unregulated Competitive Equilibrium** is a set $\{V, c, b', k_i', q, \Gamma\}$ such that:

1. **Individual optimization:** Given $(B, b, \mathcal{K}, \mathcal{Z})$, agents solve
$$V(B, b, \mathcal{K}, \mathcal{Z}) = \max_{c, b', k_i'} u(c) + \beta \mathbb{E} V(B', b', \mathcal{K}', \mathcal{Z}')$$
subject to budget and collateral constraints.

2. **Market clearing:**
   - Capital market: $\sum_i^I k_i = K$
   - Goods market: $\sum_i^I [z_i f(k_i) - \Phi_i(k_i, k_i')] = c$

3. **Consistency:**
   - Law of motion of aggregate bond holdings: $B' = \Gamma(B, \mathcal{K}, \mathcal{Z})$
   - Capital pricing function: $q(B, \mathcal{K}, \mathcal{Z}) = \hat{q}(B, \mathcal{K}, \mathcal{Z})$

The role of specialization: Intuition

- The role of specialization:
  - Benefits: Productivity & income $\uparrow$ *(agglomeration)*
  - Costs: Exposure to sectoral shocks $\uparrow$ *(factor adjustment costs)* + *(financial friction)*

The role of specialization: Intuition

- The role of specialization:
  - Benefits: Productivity & income $\uparrow$ *(agglomeration)*
  - Costs: Exposure to sectoral shocks $\uparrow$ *(factor adjustment costs)* + *(financial friction)*
- Financial friction: Occasionally binding collateral constraint
  - Investment is debt-financed [Kiyotaki & Moore (1997), Bianchi & Mendoza (2018)]
  - Use value of productive capital as collateral [Gan (2007), Lustig et al. (2010)]

The role of specialization: Intuition

- The role of specialization:
  - Benefits: Productivity & income $\uparrow$ *(agglomeration)*
  - Costs: Exposure to sectoral shocks $\uparrow$ *(factor adjustment costs)* + *(financial friction)*

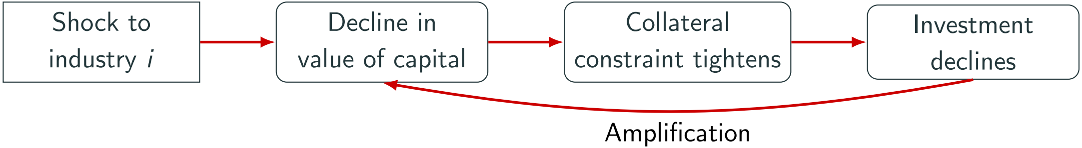
- Financial friction: Occasionally binding collateral constraint
  - Investment is debt-financed [Kiyotaki & Moore (1997), Bianchi & Mendoza (2018)]
  - Use value of productive capital as collateral [Gan (2007), Lustig et al. (2010)]

Shock to industry i → Decline in value of capital → Collateral constraint tightens → Investment declines

The role of specialization: Intuition

- The role of specialization:
    - Benefits: Productivity & income ↑ *(agglomeration)*
    - Costs: Exposure to sectoral shocks ↑ *(factor adjustment costs)* + *(financial friction)*

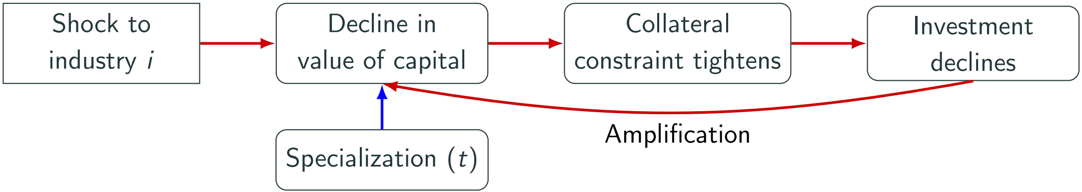
- Financial friction: Occasionally binding collateral constraint
    - Investment is debt-financed [Kiyotaki & Moore (1997), Bianchi & Mendoza (2018)]
    - Use value of productive capital as collateral [Gan (2007), Lustig et al. (2010)]



The role of specialization: Intuition

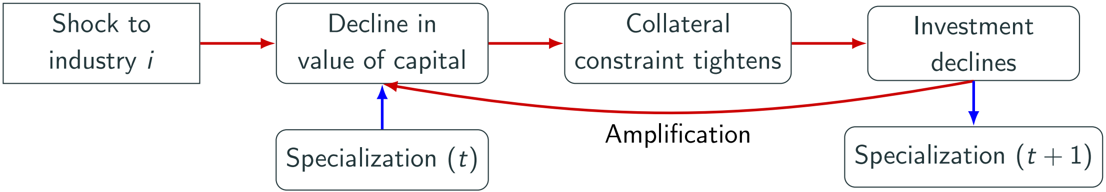
- The role of specialization:
  - Benefits: Productivity & income ↑ *(agglomeration)*
  - Costs: Exposure to sectoral shocks ↑ *(factor adjustment costs)* + *(financial friction)*

- Financial friction: Occasionally binding collateral constraint
  - Investment is debt-financed [Kiyotaki & Moore (1997), Bianchi & Mendoza (2018)]
  - Use value of productive capital as collateral [Gan (2007), Lustig et al. (2010)]



The role of specialization: Intuition

- The role of specialization:
    - Benefits: Productivity & income $\uparrow$ *(agglomeration)*
    - Costs: Exposure to sectoral shocks $\uparrow$ *(factor adjustment costs)* + *(financial friction)*
- Financial friction: Occasionally binding collateral constraint
    - Investment is debt-financed [Kiyotaki & Moore (1997), Bianchi & Mendoza (2018)]
    - Use value of productive capital as collateral [Gan (2007), Lustig et al. (2010)]



Specialization and the value of capital

Specialization and the value of capital

- Re-write pricing condition:

$$q_t = \mathbb{E}_t \sum_{j=0}^{\infty} \underbrace{\left[\prod_{l=0}^{j} \mathbb{E}_{t+j} (\bar{R}^q_{t+1+l})^{-1} \right]}_{\text{Weighted capital return}} \underbrace{\bar{d}_{t+j+1}}_{\substack{\text{Weighted} \\ \text{expected dividends}}} - \underbrace{\bar{\phi}^2_t}_{\substack{\text{Weighted} \\ \text{Adj. costs}}}$$

with weights: $s_{i,t} = \frac{k_{i,t}}{\sum_i^I k_{i,t}}$

Specialization and the value of capital

- Re-write pricing condition:

$$q_t = \mathbb{E}_t \sum_{j=0}^{\infty} \underbrace{\left[\prod_{l=0}^{j} \mathbb{E}_{t+j} (\bar{R}^q_{t+1+l})^{-1} \right]}_{\text{Weighted capital return}} \underbrace{\bar{d}_{t+j+1}}_{\substack{\text{Weighted} \\ \text{expected dividends}}} - \underbrace{\bar{\phi}^2_t}_{\substack{\text{Weighted} \\ \text{Adj. costs}}}$$

with weights: $s_{i,t} = \frac{k_{i,t}}{\sum_i^I k_{i,t}}$

- Specialization **determines response of q_t to** sectoral productivity $z_{i,t}$: $Cov(q, z_i)$

Specialization and the value of capital

- Re-write pricing condition:

$$q_t = \mathbb{E}_t \sum_{j=0}^{\infty} \underbrace{\left[\prod_{l=0}^{j} \mathbb{E}_{t+j}(\bar{R}^q_{t+1+l})^{-1}\right]}_{\text{Weighted capital return}} \quad \underbrace{\bar{d}_{t+j+1}}_{\substack{\text{Weighted}\\ \text{expected dividends}}} \quad - \quad \underbrace{\bar{\phi}^2_t}_{\substack{\text{Weighted}\\ \text{Adj. costs}}}$$

with weights: $s_{i,t} = \frac{k_{i,t}}{\sum_i^I k_{i,t}}$

- Specialization **determines response of q_t to** sectoral productivity $z_{i,t}$: $Cov(q, z_i)$

1. $[I = 1]$: $q = \mathbb{E}_t \sum_{j=0}^{\infty} \frac{z_{t+j+\mathbf{1}} f'(k_{t+j+\mathbf{1}})}{\prod_{s=\mathbf{0}}^{j} R^q_{t+\mathbf{1}+s}}$ $\rightarrow$ **Benchmark model** [Kiyotaki & Moore (1997)]

Specialization and the value of capital

- Re-write pricing condition:

$$q_t = \mathbb{E}_t \sum_{j=0}^{\infty} \underbrace{\left[\prod_{l=0}^{j} \mathbb{E}_{t+j} (\bar{R}^q_{t+1+l})^{-1} \right]}_{\text{Weighted capital return}} \quad \underbrace{\bar{d}_{t+j+1}}_{\substack{\text{Weighted} \\ \text{expected dividends}}} \quad - \quad \underbrace{\bar{\phi}^2_t}_{\substack{\text{Weighted} \\ \text{Adj. costs}}}$$

with weights: $s_{i,t} = \frac{k_{i,t}}{\sum_i^I k_{i,t}}$

- Specialization **determines response of q_t to** sectoral productivity $z_{i,t}$: $Cov(q, z_i)$

  1. $[I = 1]$: $q = \mathbb{E}_t \sum_{j=0}^{\infty} \frac{z_{t+j+\mathbf{1}} f'(k_{t+j+\mathbf{1}})}{\prod_{s=\mathbf{0}}^{j} R^q_{t+\mathbf{1}+s}} \rightarrow$ **Benchmark model** [Kiyotaki & Moore (1997)]
  2. $[I > 1$ and $\Phi = 0]$: $\lim_{I \to \infty} Cov\,(q, z_i) = 0 \rightarrow$ **Full diversification**

Specialization and the value of capital

- Re-write pricing condition:

$$q_t = \mathbb{E}_t \sum_{j=0}^{\infty} \underbrace{\left[\prod_{l=0}^{j} \mathbb{E}_{t+j} (\bar{R}^q_{t+1+l})^{-1} \right]}_{\text{Weighted capital return}} \quad \underbrace{\bar{d}_{t+j+1}}_{\substack{\text{Weighted} \\ \text{expected dividends}}} \quad - \quad \underbrace{\bar{\phi}^2_t}_{\substack{\text{Weighted} \\ \text{Adj. costs}}}$$

with weights: $s_{i,t} = \frac{k_{i,t}}{\sum_i^I k_{i,t}}$

- Specialization **determines response of q_t to** sectoral productivity $z_{i,t}$: $Cov(q, z_i)$

1. $[I = 1]$: $q = \mathbb{E}_t \sum_{j=0}^{\infty} \frac{z_{t+j+\mathbf{1}} f'(k_{t+j+\mathbf{1}})}{\prod_{s=\mathbf{0}}^{j} R^q_{t+\mathbf{1}+s}}$ → **Benchmark model** [Kiyotaki & Moore (1997)]
2. $[I > 1$ and $\Phi = 0]$: $\lim_{I \to \infty} Cov\,(q, z_i) = 0$ → **Full diversification**
3. $[I > 1$ and $\Phi > 0]$: $Cov\,(q, z_i) = F(\sum_i s_i)$ → **Specialization matters for exposure**

Specialization and the collateral constraint

Specialization and the collateral constraint

- Re-write bond Euler condition:

$$\beta R_t \mathbb{E}_t \left[\frac{u'(c_{t+1})}{u'(c_t)} \right] = (1 - \eta_t)$$

with

- $\eta_t = 0$: Unconstrained consumption smoothing
- $\eta_t > 0$: Constrained borrowing ability

Specialization and the collateral constraint

- Re-write bond Euler condition:

$$\beta R_t \mathbb{E}_t \left[\frac{u'(c_{t+1})}{u'(c_t)} \right] = (1 - \eta_t)$$

  with

  - $\eta_t = 0$: Unconstrained consumption smoothing
  - $\eta_t > 0$: Constrained borrowing ability

- Collateral constraint **determines ability to invest**:

Portfolio allocation: $\tilde{q}_{i,t} = \frac{1}{R_t} \mathbb{E}_t \Big[\underbrace{(1 - \eta_t)}_{\text{Tightness of constraint}} \underbrace{\big(\tilde{q}_{i,t+1} + z_{i,t+1} f'(k_{i,t+1})\big)}_{\text{Expected MB of capital}} + \frac{\theta q_{t+1} \eta_{t+1}}{u'(c_t)} \Big] \forall i$

Quantitative Analysis

Calibration

Calibration

- Functional forms:
  - Utility: u(c) $= \frac{c^{(\mathbf{1}-\gamma)}-1}{(1-\gamma)}$
  - Production function: $f(k_i) = k_i^{\alpha}$
  - Adjustment costs: $\phi(k, k') = \frac{\phi}{2}(\frac{k'}{k} - 1)^2 k$

Calibration

- Functional forms:
  - Utility: u(c) $= \frac{c^{(\mathbf{1}-\gamma)}-1}{(1-\gamma)}$
  - Production function: $f(k_i) = k_i^{\alpha}$
  - Adjustment costs: $\phi(k, k') = \frac{\phi}{2}(\frac{k'}{k} - 1)^2 k$
- Key parameters set independently:

Calibration

- Functional forms:
  - Utility: u(c) $= \frac{c^{(1-\gamma)}-1}{(1-\gamma)}$
  - Production function: $f(k_i) = k_i^\alpha$
  - Adjustment costs: $\phi(k, k') = \frac{\phi}{2}(\frac{k'}{k} - 1)^2 k$

- Key parameters set independently:
  1. Industry-specific agglomeration: [Bartelme et al (2024)]
  2. Industry-specific adj. costs: [Hall (2004) and Groth & Khan (2010)]
  3. Tightness of collateral constraint (loan-to-value ratio): [Graham et al (2015)]

Calibration

- Functional forms:
  - Utility: u(c) $= \frac{c^{(\mathbf{1}-\gamma)}-1}{(1-\gamma)}$
  - Production function: $f(k_i) = k_i^{\alpha}$
  - Adjustment costs: $\phi(k, k') = \frac{\phi}{2}(\frac{k'}{k} - 1)^2 k$

- Key parameters set independently:
  1. Industry-specific agglomeration: [Bartelme et al (2024)]
  2. Industry-specific adj. costs: [Hall (2004) and Groth & Khan (2010)]
  3. Tightness of collateral constraint (loan-to-value ratio): [Graham et al (2015)]

- Key parameters set internally:

Calibration

- Functional forms:
  - Utility: $u(c) = \frac{c^{(1-\gamma)}-1}{(1-\gamma)}$
  - Production function: $f(k_i) = k_i^{\alpha}$
  - Adjustment costs: $\phi(k, k') = \frac{\phi}{2}(\frac{k'}{k} - 1)^2 k$

- Key parameters set independently:
  1. Industry-specific agglomeration: [Bartelme et al (2024)]
  2. Industry-specific adj. costs: [Hall (2004) and Groth & Khan (2010)]
  3. Tightness of collateral constraint (loan-to-value ratio): [Graham et al (2015)]

- Key parameters set internally:
  1. 1950 fixed capital stock: Matching 1950 income shares
  2. Discount factor: Matching U.S. NFA position

Calibration

Parameter	Value	Source/ Target
Parameters set independently		
Risk Aversion	$\gamma = 5$	Average value in literature
Capital Share	$\alpha = 0.3$	Avg. US capital income share
Adjustment Costs	$\Phi_i \in [0, 3.26]$	Hall (2004); Groth & Khan (2010)
Agglomeration	$\xi_i \in [0.1, 0.29]$	Bartelme et al. (2024)
Collateral regime	$\theta \in [0.35, 0.53]$	Historical LTV ratio (Graham et al, 2015)
Interest Rate	$\bar{R} = 1.3\%, \rho_R = 0.01$	U.S. 90-day T-Bills
	$\sigma_R = 0.0186$	
TFP Process	$\rho_i \in [0.71, 0.9]$	Std. and autoc. of U.S. industry TFP
	$\sigma_i \in [0.013, 0.027]$	
Parameters set internally		
1950 capital stock	$k_{i,1950} \in [0.1, 0.29]$	Matching income shares
Discount Factor	$\beta = 0.95$	Avg. NFA position

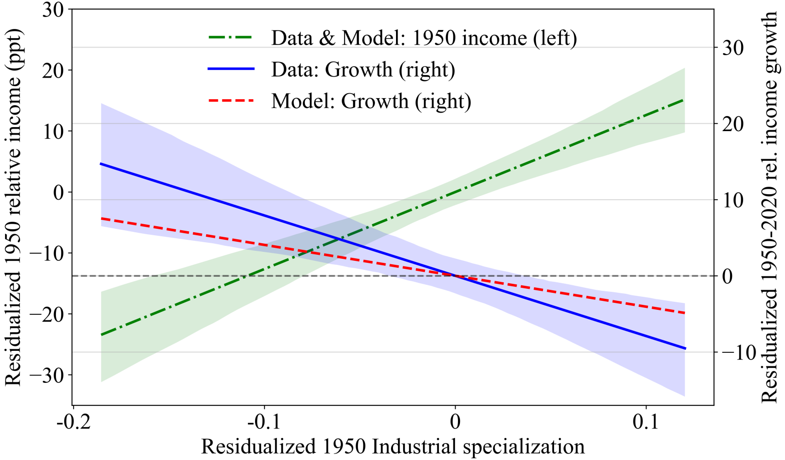
The Regional Specialization Trade-off: Data vs. Model

The Regional Specialization Trade-off: Data vs. Model

- Experiment: Match 1950 specialization (722 CZs) + simulate using realized TFP process

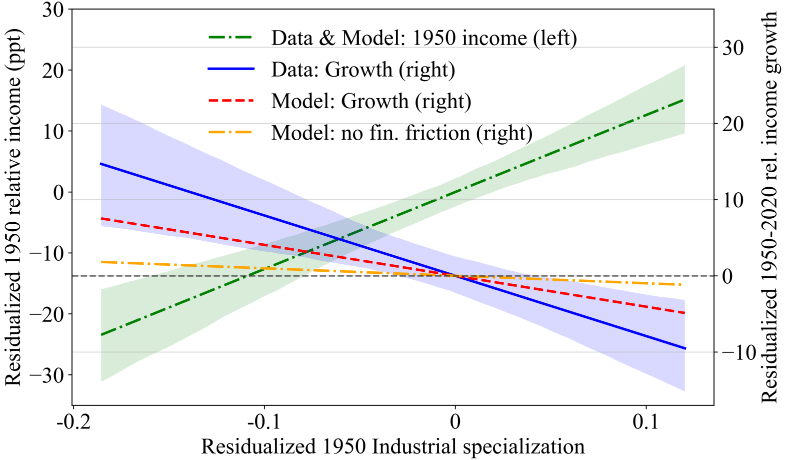
The Regional Specialization Trade-off: Data vs. Model

- Experiment: Match 1950 specialization (722 CZs) + simulate using realized TFP process



The Regional Specialization Trade-off: Data vs. Model

- Experiment: Match 1950 specialization (722 CZs) + simulate using realized TFP process



⇒ Financial friction captures 56% of adverse specialization effect on growth! ‣ IRF

Efficiency & Welfare

Constrained Efficiency

Constrained Efficiency

- Best feasible allocation taking market incompleteness as given

Constrained Efficiency

- Best feasible allocation taking market incompleteness as given
- Constrained-efficient planner s.t. identical collateral constraint

Constrained Efficiency

- Best feasible allocation taking market incompleteness as given

- Constrained-efficient planner s.t. identical collateral constraint
  - $\Rightarrow$ Internalize externalities
  - $\Rightarrow$ Instructs agents to deviate from private optimality conditions

Constrained Efficiency

- Best feasible allocation taking market incompleteness as given

- Constrained-efficient planner s.t. identical collateral constraint
  - $\Rightarrow$ Internalize externalities
  - $\Rightarrow$ Instructs agents to deviate from private optimality conditions

- Two sources of inefficiency:

Constrained Efficiency

- Best feasible allocation taking market incompleteness as given
- Constrained-efficient planner s.t. identical collateral constraint
  - $\Rightarrow$ Internalize externalities
  - $\Rightarrow$ Instructs agents to deviate from private optimality conditions
- Two sources of inefficiency:
  1. Agglomeration externality: Productivity = function of aggregate capital in industry i

Constrained Efficiency

- Best feasible allocation taking market incompleteness as given

- Constrained-efficient planner s.t. identical collateral constraint
  - $\Rightarrow$ Internalize externalities
  - $\Rightarrow$ Instructs agents to deviate from private optimality conditions

- Two sources of inefficiency:
  1. Agglomeration externality: Productivity = function of aggregate capital in industry i
  2. Pecuniary externality: Price of capital = function of capital portfolio + bond position

Constrained Efficiency

- Best feasible allocation taking market incompleteness as given
- Constrained-efficient planner s.t. identical collateral constraint
  - $\Rightarrow$ Internalize externalities
  - $\Rightarrow$ Instructs agents to deviate from private optimality conditions
- Two sources of inefficiency:
  1. Agglomeration externality: Productivity = function of aggregate capital in industry i

     $\Rightarrow$ Increase specialization
  2. Pecuniary externality: Price of capital = function of capital portfolio + bond position

     $\Rightarrow$ Increase diversification

Constrained-efficient Planner

- Planner maximizes

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t)$$

subject to

$$c_t + \frac{b_{t+1}}{R_t} = \sum_i^I [z_{i,t} f(k_{i,t}) - \Phi_i(k_{i,t}, k_{i,t+1})] + b_t$$

$$-\frac{b_{t+1}}{R_t} \leq \theta q_t$$

$$\sum_i^I k_{i,t} = \bar{K} \quad \forall\, t$$

$$\boxed{z_{i,t} = \bar{z}_{i,t} \cdot k_{i,t}^{\xi_i} \quad \forall\, i}$$

$$\boxed{\tilde{q}_{i,t} u'(c_t) = \beta\, \mathbb{E}_t \Big[u'(c_{t+1}) \big(\tilde{q}_{i,t+1} + z_{i,t+1} f'(k_{i,t+1}) \big) + \theta q_{t+1} \eta_{t+1} \Big] \,\forall\, i}$$

Key optimality conditions (Planner Equilibrium)

Key optimality conditions (Planner Equilibrium)

- Define:
    - $\eta_t^* \geq 0$ as Lagrange multiplier on the collateral constraint
    - δ_i as Lagrange multiplier on implementability constraint
    - $\lambda_t = u'(c_t) - \frac{u''(c_t)}{u'(c_t)}\theta\eta_t q_t - u''(c_t)\sum_i^I \delta_{i,t}\phi_{i,t}$ as shadow value of wealth

Key optimality conditions (Planner Equilibrium)

- Define:
  - $\eta_t^* \geq 0$ as Lagrange multiplier on the collateral constraint
  - δ_i as Lagrange multiplier on implementability constraint
  - $\lambda_t = u'(c_t) - \frac{u''(c_t)}{u'(c_t)}\theta\eta_t q_t - u''(c_t)\sum_i^I \delta_{i,t}\phi_{i,t}$ as shadow value of wealth
  - Ω_i collecting all cross-derivatives from implementability constraints

Portfolio all.: $$\underbrace{\lambda_t\phi_{i,t}}_{\text{MC}} = \beta\mathbb{E}_t\Big[\underbrace{\lambda_{t+1}\big(\bar{z}_{i,t+1}(\xi_i+\alpha)k_{i,t+1}^{\xi_i+\alpha-1} - \phi_{i,t+1}\big)}_{\text{Social net MPK}} + \underbrace{\sum_i^I \delta_{i,t}\Omega_{i,t+1}^K}_{\text{GE effect on price}}\Big] + \underbrace{\Xi}_{\text{Market Clearing}}$$

Key optimality conditions (Planner Equilibrium)

- Define:
  - $\eta_t^* \geq 0$ as Lagrange multiplier on the collateral constraint
  - δ_i as Lagrange multiplier on implementability constraint
  - $\lambda_t = u'(c_t) - \frac{u''(c_t)}{u'(c_t)}\theta\eta_t q_t - u''(c_t)\sum_i^I \delta_{i,t}\phi_{i,t}$ as shadow value of wealth
  - Ω_i collecting all cross-derivatives from implementability constraints

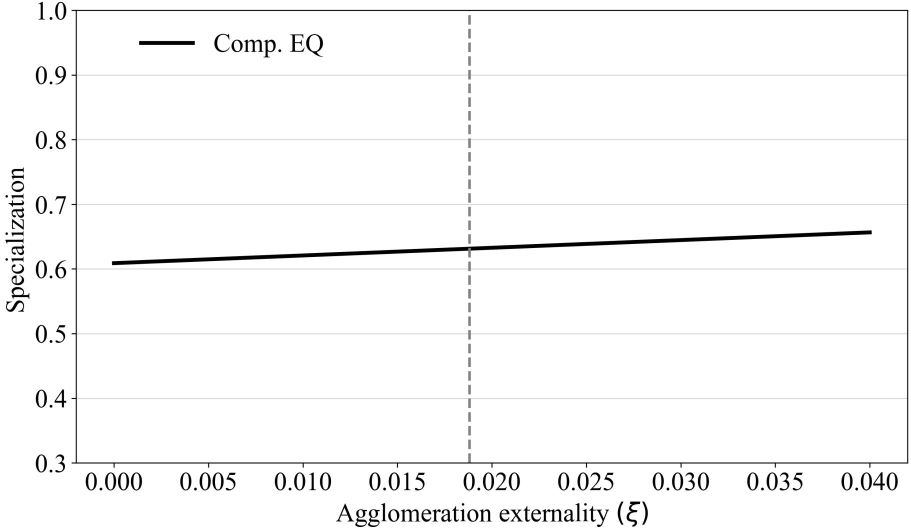
Portfolio all.: $$\underbrace{\lambda_t\phi_{i,t}}_{\text{MC}} = \beta\mathbb{E}_t\Big[\underbrace{\lambda_{t+1}\big(\bar{z}_{i,t+1}(\xi_i+\alpha)k_{i,t+1}^{\xi_i+\alpha-1} - \phi_{i,t+1}\big)}_{\text{Social net MPK}} + \underbrace{\sum\nolimits_i^I \delta_{i,t}\Omega_{i,t+1}^K}_{\text{GE effect on price}}\Big] + \underbrace{\Xi}_{\text{Market Clearing}}$$

Cons.-savings: $$\lambda_t = \beta R_t\,\mathbb{E}_t\Big[\lambda_{t+1} + \underbrace{\sum\nolimits_i^I \delta_{i,t}\Omega_{i,t+1}^B}_{\text{GE effect on price}}\Big] + \eta_t^*$$

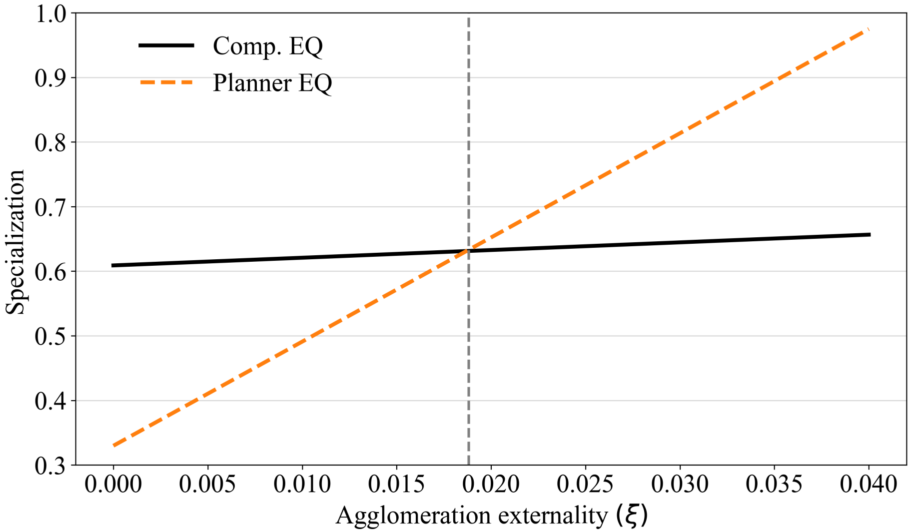
‣ Further details ‣ Equilibrium definition ‣ Planner implementation

The Specialization Trade-off: Individual vs. Planner

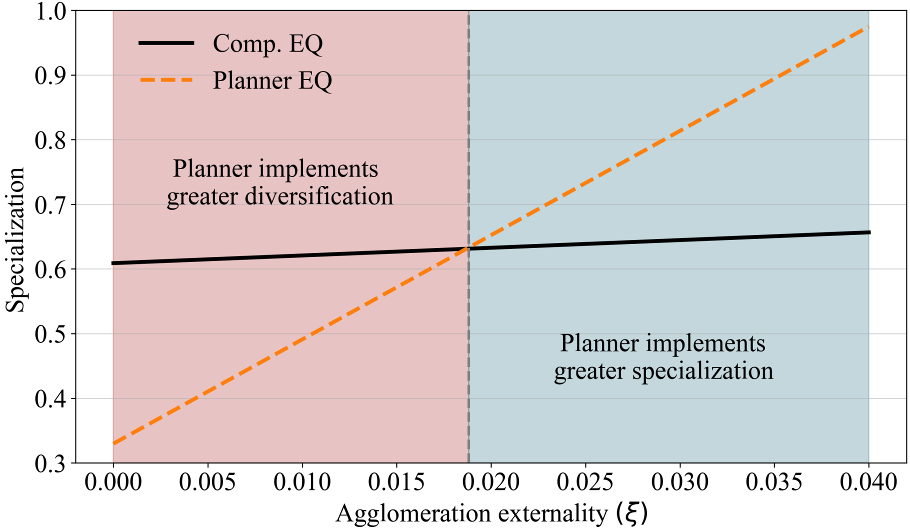
The Specialization Trade-off: Individual vs. Planner



The Specialization Trade-off: Individual vs. Planner

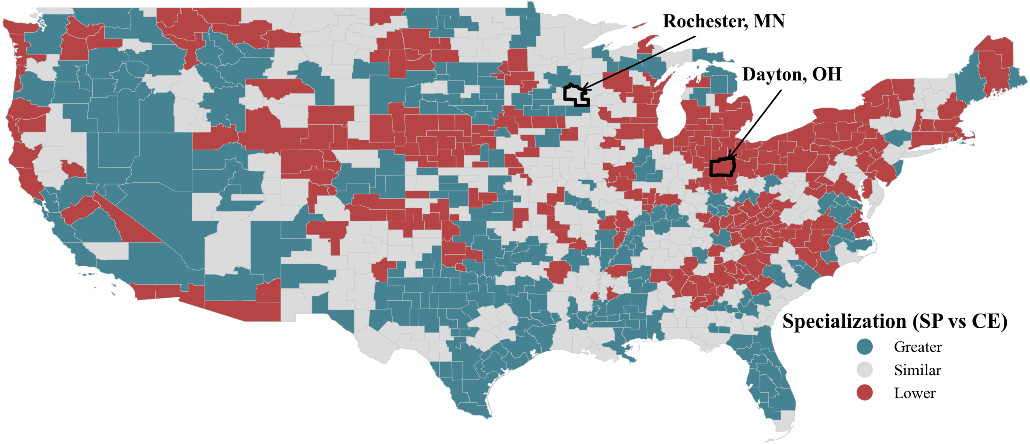


The Specialization Trade-off: Individual vs. Planner



Constrained-efficient regional specialization in 1950

Constrained-efficient regional specialization in 1950



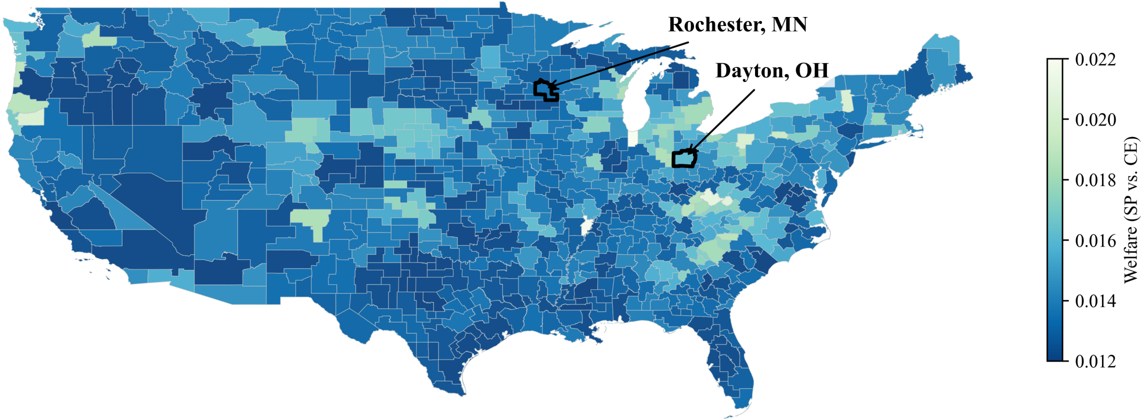
Constrained-efficient welfare gains in 1950

Constrained-efficient welfare gains in 1950

- Define welfare: $\Lambda = \left(\frac{V_{SP}}{V_{CE}}\right)^{\frac{1}{1-\gamma}} - 1$

Constrained-efficient welfare gains in 1950

- Define welfare: $\Lambda = \left(\frac{V_{SP}}{V_{CE}}\right)^{\frac{1}{1-\gamma}} - 1$



Conclusion

Conclusion

- **Empirical take-away**: The Regional Specialization Trade-off
  - $\Rightarrow$ Highly specialized regions are richer initially and have lower long-run growth

Conclusion

- **Empirical take-away**: The Regional Specialization Trade-off
  - $\Rightarrow$ Highly specialized regions are richer initially and have lower long-run growth
- **Theoretical take-away**:
  - $\Rightarrow$ Specialization: productivity $\uparrow$ + exposure to sectoral shock $\uparrow$
  - $\Rightarrow$ Frictions make reallocation costly & long-lasting

Conclusion

- **Empirical take-away**: The Regional Specialization Trade-off
  - $\Rightarrow$ Highly specialized regions are richer initially and have lower long-run growth
- **Theoretical take-away**:
  - $\Rightarrow$ Specialization: productivity $\uparrow$ + exposure to sectoral shock $\uparrow$
  - $\Rightarrow$ Frictions make reallocation costly & long-lasting
- **Quantitative take-away**:
  - $\Rightarrow$ Financial frictions play key role in generating adverse specialization effect on growth
  - $\Rightarrow$ Efficient degree of specialization implies sizable welfare gains

Conclusion

- **Empirical take-away**: The Regional Specialization Trade-off
  - $\Rightarrow$ Highly specialized regions are richer initially and have lower long-run growth
- **Theoretical take-away**:
  - $\Rightarrow$ Specialization: productivity $\uparrow$ + exposure to sectoral shock $\uparrow$
  - $\Rightarrow$ Frictions make reallocation costly & long-lasting
- **Quantitative take-away**:
  - $\Rightarrow$ Financial frictions play key role in generating adverse specialization effect on growth
  - $\Rightarrow$ Efficient degree of specialization implies sizable welfare gains
- **Future Research**:

Conclusion

- **Empirical take-away**: The Regional Specialization Trade-off
  - $\Rightarrow$ Highly specialized regions are richer initially and have lower long-run growth
- **Theoretical take-away**:
  - $\Rightarrow$ Specialization: productivity $\uparrow$ + exposure to sectoral shock $\uparrow$
  - $\Rightarrow$ Frictions make reallocation costly & long-lasting
- **Quantitative take-away**:
  - $\Rightarrow$ Financial frictions play key role in generating adverse specialization effect on growth
  - $\Rightarrow$ Efficient degree of specialization implies sizable welfare gains
- **Future Research**:
  - Regional vs. National Planner (introduce migration frictions + place-based insurance)

Conclusion

- **Empirical take-away**: The Regional Specialization Trade-off
  - $\Rightarrow$ Highly specialized regions are richer initially and have lower long-run growth
- **Theoretical take-away**:
  - $\Rightarrow$ Specialization: productivity $\uparrow$ + exposure to sectoral shock $\uparrow$
  - $\Rightarrow$ Frictions make reallocation costly & long-lasting
- **Quantitative take-away**:
  - $\Rightarrow$ Financial frictions play key role in generating adverse specialization effect on growth
  - $\Rightarrow$ Efficient degree of specialization implies sizable welfare gains
- **Future Research**:
  - Regional vs. National Planner (introduce migration frictions + place-based insurance)
  - Heterogeneously specialized countries in a currency union [w. de Ferra, Mitman & Romei]

Thank you very much!

lukas.boehnert@economics.ox.ac.uk

Appendix

Topcoding income

- Topcoding: Recode/ cut income above certain threshold
  - In individual-level income survey
  - Prevent identification of individuals in sample

- Problem: manipulates income distribution for high earners

- Regression approach (following Heathcote et al, 2023):
  - Assume underlying distribution of income is Pareto
  - Forecast the mean top-coded income by extrapolating Pareto density fitted to upper end of non-top-coded income
  - Following algorithm by David Domeij

▸ Return

Industry details

	Industry	1950	1990	2020	Tradable
1	Agriculture	20.71	3.61	3.46	Yes
2	Business Services	2.96	4.43	7.61	Yes
3	Communication	0.61	1.52	1.36	No
4	Construction	8.75	9.98	11.91	No
5	Durable	13.53	15.88	10.77	Yes
6	Entertainment	0.66	1.06	1.28	No
7	Finance	2.20	4.47	4.79	No
8	Mining	3.99	1.90	1.82	Yes
9	Nondurable	9.48	8.64	5.77	Yes
10	Personal Services	2.37	1.39	1.60	No
11	Routine Prof. Serv.	4.39	11.26	13.19	No
12	Non-routine Prof. Serv.	0.37	2.02	3.33	Yes
13	Public	4.67	7.96	6.98	No
14	Retail	11.84	11.15	13.26	No
15	Transportation	8.09	6.61	6.91	Yes
16	Utilities	1.80	2.53	2.34	No
17	Wholesale	3.59	5.60	3.63	Yes

Return

Fact 1: Controls

Fact 1: Controls

	1950-2020 Growth		1950 Income p.c.	
	(1)	(2)	(3)	(4)
Specialization	-0.233*		0.844***	
	(0.0901)		(0.084)	
Tradable		-0.151***		0.110**
		(0.0388)		(0.0423)
Non-tradable		0.632		-0.43
		(0.294)		(0.456)
1950 measures:				
$\hat{g}$	-0.180***	-0.133*	-0.187**	-0.319***
	(0.0471)	(0.0521)	(0.058)	(0.0631)
log income p.c.	-0.868***	-0.885***		
	(0.0339)	(0.0323)		
High-skill labor share	1.435***	1.618***	6.042***	5.692***
	(0.41)	(0.418)	(0.402)	(0.431)
Old-age dependency ratio	0.0145**	0.0120*	-0.0187***	-0.0230***
	(0.00532)	(0.00553)	(0.00484)	(0.00526)
Female labor share	0.984***	0.965***	0.0754	0.283
	(0.167)	(0.184)	(0.164)	(0.187)
Population	170.6***	163.0***	136.8***	152.0***
	(35.55)	(33.46)	(25.75)	(31.66)
N	722	722	722	722
adj. R-sq	0.538	0.544	0.41	0.344

Return Return

Regional specialization in the U.S.

Regional specialization in the U.S.

The US **labor markets become more specialized** over time.

Year	Gini on income shares			Gini on employment shares		
	Mean	CV	p90/p10	Mean	CV	p90/p10
1950	0.46	0.162	1.55	0.45	0.152	1.50
1970	0.48	0.123	1.35	0.47	0.116	1.35
1990	0.47	0.089	1.23	0.46	0.082	1.26
2010	0.53	0.089	1.29	0.50	0.073	1.20
2020	0.53	0.089	1.24	0.51	0.068	1.20

Table 1: U.S. Regional specialization over time

Return

Fact 3: Specialization at the region-industry level is highly persistent

Fact 3: Specialization at the region-industry level is highly persistent

- Define
  - Revealed Comparative Advantage (RCA): $RCA_{irt} = \frac{Y_{irt}}{Y_{rt}} / \frac{Y_{it}^{US}}{Y_{t}^{US}}$
    $\rightarrow$ Measure how much a region is relatively specialized in one industry i

Fact 3: Specialization at the region-industry level is highly persistent

- Define
  - Revealed Comparative Advantage (RCA): $RCA_{irt} = \frac{Y_{irt}}{Y_{rt}} / \frac{Y_{it}^{US}}{Y_{t}^{US}}$
    $\rightarrow$ Measure how much a region is relatively specialized in one industry i
  - RankRCA_{irt}: Rank region-industries by RCA

Fact 3: Specialization at the region-industry level is highly persistent

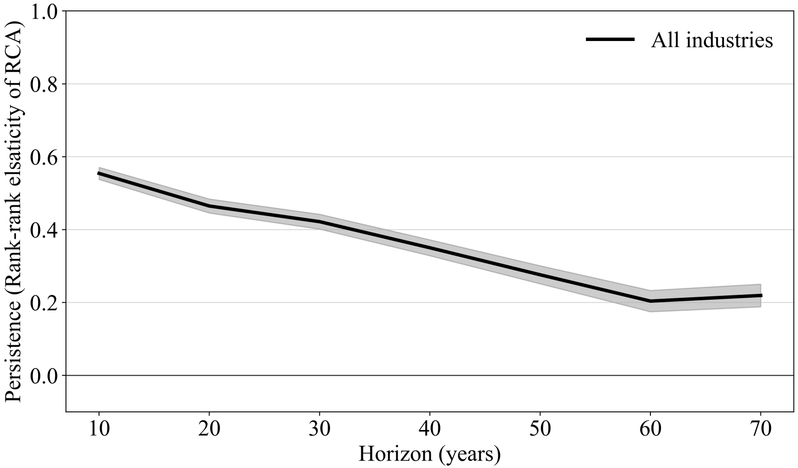
- Define
  - Revealed Comparative Advantage (RCA): $RCA_{irt} = \frac{Y_{irt}}{Y_{rt}} / \frac{Y_{it}^{US}}{Y_{t}^{US}}$
    $\rightarrow$ Measure how much a region is relatively specialized in one industry i
  - RankRCA_{irt}: Rank region-industries by RCA
  - $\delta_{r,t}$ as region-year FE
  - $\gamma_{i,t}$ as industry-year FE
  - h as horizon

$$\text{logRankRCA}_{i,r,t} = \alpha + \beta_h \cdot \text{logRankRCA}_{i,r,t-h} + \delta_{r,t} + \gamma_{i,t} + \epsilon_{i,r,t}$$

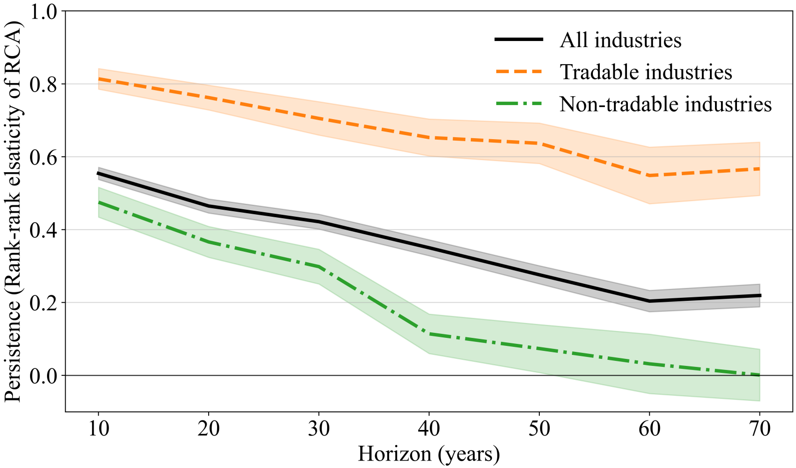
- Coefficent β_h: Rank-rank elasticity of RCA (persistence measure)

▸ Further details ▸ Return

Fact 3: Specialization at the region-industry level is highly persistent



Fact 3: Specialization at the region-industry level is highly persistent



Further details Return

Specialization Trade-off at different horizons

	Income pc growth						
	10-year (1)	20-year (2)	30-year (3)	40-year (4)	50-year (5)	60-year (6)	70-year (7)
Trad. Specialization (t-10)	0.00152						
	(-0.025)						
Trad. Specialization (t-20)		-0.0747***					
		(-0.0209)					
Trad. Specialization (t-30)			-0.106***				
			(-0.0254)				
Trad. Specialization (t-40)				-0.162***			
				(-0.0293)			
Trad. Specialization (t-50)					-0.1420**		
					(-0.0147)		
Trad. Specialization (t-60)						-0.152**	
						(-0.0347)	
Trad. Specialization (t-70)							-0.154***
							(-0.04)
N	3528	3563	2842	2123	1403	1007	700
adj. R-sq	0.101	0.113	0.152	0.219	0.308	0.403	0.549

Return

Specialization Trade-off across different industries

	1950-2020 Growth	1950 Income level
	(1)	(2)
Specialization in		
Manufacturing	-1.086**	2.296***
	(0.373)	(0.488)
Services	1.441	-5.386**
	(1.201)	(1.776)
Agriculture	-0.0653	0.35
	(0.191)	(0.241)
Transportation	0.397	2.071*
	(0.912)	(0.894)
Wholesale	-2.356***	2.992**
	(0.698)	(0.994)
Retail	-0.747	3.404***
	(0.764)	(0.64)
N	722	722
adj. R-sq	0.54	0.399

Return

Specialization Trade-off with Herfindahl Index

	1950-2020 Growth	1950 Income level
	(1)	(2)
Specialization (HHI)	-0.212*	0.933***
	(0.122)	(0.134)
$\hat{g}$	-0.169***	-0.233**
	(0.0470)	(0.064)
log income	-0.886***	
	(0.0328)	
High-skill share	1.482***	6.351***
	(0.424)	(0.436)
Old-age dependency	0.0149**	-0.0213***
	(0.00532)	(0.00512)
Female share	1.04***	-0.172
	(0.167)	(0.179)
Population	172.7***	136.7***
	(35.77)	(25.67)
N	722	722
adj. R-sq	0.535	0.375

Return

Production and agglomeration

Production and agglomeration

- Multiple industries $i \in \{i, \ldots, I\}$ produce single tradable good c
- Productivity processes (AR1):

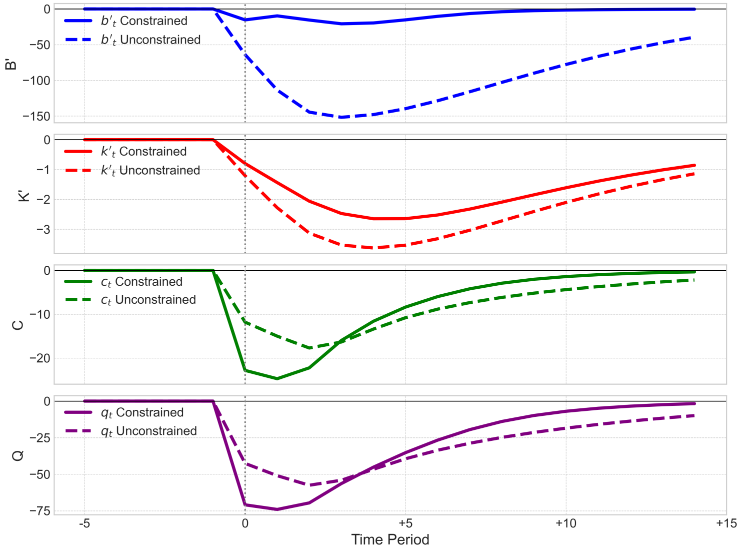
$$\bar{z}_{i,t} = \tilde{z}_i + g_{i,t} t + \rho u_{i,t-1} + \epsilon_{i,t} \quad \text{with } \epsilon_{i,t} \sim \mathcal{N}(0, \sigma_i^2)$$

- Agglomeration:

$$z_{i,t} = \bar{z}_{i,t} \cdot k_{i,t}^{\xi_i}$$

with intra-industry agglomeration $\xi_i \geq 0$ [Bartelme et al (2024)]

IRF to a 2SD adverse productivity shock to one industry



Return

Planner FOCs: Cross-derivatives

$$\Omega_i^B = \frac{1}{R}\Big[\frac{\partial u'(\mathcal{C}(b',\mathcal{K}',\mathcal{Z}'))}{\partial b'}(\mathcal{Q}(b',\mathcal{K}',\mathcal{Z}') + \alpha z_i' k_i'^{\xi_i+\alpha-1} - \phi_{1i}) + u'(\mathcal{C}(b',\mathcal{K}',\mathcal{Z}'))\Big(\frac{\partial \mathcal{Q}(b',\mathcal{K}',\mathcal{Z}')}{\partial b'} - \frac{\partial \phi_{1i}}{\partial b'}\Big) + \theta\Big(\frac{\partial q'}{\partial b'}\eta' - \frac{\partial \eta'}{\partial b'}\mathcal{Q}(b',\mathcal{K}',\mathcal{Z}')\Big)\Big] \tag{1}$$

$$\Omega_i^K = -u'(c)\phi_{22,i} + \frac{1}{R}\Big[\frac{\partial u'(\mathcal{C}(b',\mathcal{K}',\mathcal{Z}'))}{\partial k_i'}(\mathcal{Q}(b',\mathcal{K}',\mathcal{Z}') + \alpha z_i' k_i'^{\xi_i+\alpha-1} - \phi_{1i}) + u'(\mathcal{C}(b',\mathcal{K}',\mathcal{Z}'))\Big(\frac{\partial \mathcal{Q}(b',\mathcal{K}',\mathcal{Z}')}{\partial k_i'} + (\xi_i+\alpha-1)\alpha z_i' k_i'^{\xi_i+\alpha-2} - \phi_{11,i} - \phi_{12,i}\frac{\partial k_i''}{\partial k_i'}\Big) + \theta\Big(\frac{\partial q'}{\partial k_i'}\eta' - \frac{\partial \eta'}{\partial k_i'}\mathcal{Q}(b',\mathcal{K}',\mathcal{Z}')\Big)\Big] \tag{2}$$

▸ Return

Recursive Constrained-Efficient Equilibrium

A **Recursive Constrained-Efficient Equilibrium** is a set $\{V, c, b', k_i', q\}$ such that:

1. **Planner optimization:** Given $(b, \mathcal{K}, \mathcal{Z})$, agents solve

$$V(b, \mathcal{K}, \mathcal{Z}) = \max_{c, b', k_i'} u(c) + \beta \mathbb{E} V(b', \mathcal{K}', \mathcal{Z}')$$

subject to budget, collateral constraint, market clearing and implementability constraints.

Return

Planner Implementation: Constrained-efficient Decentralization

- Define:
    - τ_t^K state-contingent industry-specific tax or subsidy
    - τ_t^B state-contingent tax on debt

$\forall i$

Return

Planner Implementation: Constrained-efficient Decentralization

- Define:
  - τ_t^K state-contingent industry-specific tax or subsidy
  - τ_t^B state-contingent tax on debt

$\forall i$

Return

Planner Implementation: Constrained-efficient Decentralization

- Define:
  - τ_t^K state-contingent industry-specific tax or subsidy
  - τ_t^B state-contingent tax on debt

Portfolio all.: $\tilde{q}_t u'(c_t) = \beta \mathbb{E}_t \left[u'(c_{t+1}) \big(\tilde{q}_{t+1} + (1 + \tau_{i,t+1}^K) z_{i,t+1} f'(k_{i,t+1}) \big) + \theta_{t+1} q_{t+1} \eta_{t+1} \right] \forall i$

Return

Planner Implementation: Constrained-efficient Decentralization

- Define:
  - τ_t^K state-contingent industry-specific tax or subsidy
  - τ_t^B state-contingent tax on debt

Portfolio all.: $\tilde{q}_t u'(c_t) = \beta \mathbb{E}_t \left[u'(c_{t+1}) \big(\tilde{q}_{t+1} + (1 + \tau_{i,t+1}^K) z_{i,t+1} f'(k_{i,t+1}) \big) + \theta_{t+1} q_{t+1} \eta_{t+1} \right] \forall i$

Cons.-sav.: $u'(c_t) = \beta R_t (1 + \tau_t^B) \mathbb{E}_t \left[u'(c_{t+1}) \right] + \eta_t$

▸ Return