Untangling Trade and Technology: Evidence from Local Labor Markets

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The Bundestag Eagle

Untangling Trade and Technology

Key forces shaping labor markets in industrialized nations?

- Universal hypothesis: "Trade and Technology"

Why are these two terms always used together?

1. Backward induction: "Effects" visible, searching for causes
2. Sense of inevitably: Anything can *either* be automated *or* done in China
3. Hypothesis that "routine" tasks both easier to offshore *and* automate [Blinder '07]

Do "Trade and Technology" have Comparable Effects?

1. **Similar local labor markets affected?**
   - Are locations most exposed to trade also most subject to automation?
2. **Similar employment effects?**
   - Employment, unemployment, labor force non-participation (NILF)
3. **Similar demographic groups affected?**
   - Male/Female, College/Non-College, Younger/Older?
4. **Similar tasks affected – abstract, routine, manual?**
   - Do both trade and technology mostly just replace routine tasks?
5. **Similar sectors affected?**
   - Do both primarily affect manufacturing?

Current literature offers limited evidence on these questions

Untangling Trade and Technology

Empirical Challenges

Measuring concurrent impacts of trade & technology

1. Small N problem
2. Difficulty of measuring trade exposure
3. 'Offshorability' vs. 'automatibility' – What is distinctive in each?
   - Inconsistent definitions of task constructs
4. Offshoring vs. trade in goods
   - Distinctions? Relative magnitudes?
5. Focusing only on employed, excluding unemployed, NILF

Objective: Untangling 'Trade and Technology'

1. **Taking measurement seriously**
   - Measuring technology using robust task measures
   - Measuring *trade in goods* using import shocks
2. **Overcoming small N problem**
   - Outcomes at the Commuting Zone (CZ) level: 722 local labor markets
   - Measuring 'local general equilibrium' effects
3. **Exploring multiple margins of adjustment**
   - Employment status: Employment, unemp, non-participation
   - Demographic breakdown: Sex, age, education
   - Task allocation: Abstract, Routine, Manual occupations
   - Sectoral breakdown: Manufacturing v. non-manufacturing

Recent Work 1: Technological Δ and labor markets

- **Capital-skill complementarity**
  - **Cost share:** Katz & Murphy '92, Berman, Bound, Griliches '94, Autor, Katz & Krueger '98, Machin and Van Reenen '98, Card & Lemieux '01, Carneiro & Lee '11, Lindley & Machin '11
  - **Prod'n f'n:** Krusell, Ohanian, Rios-Rull & Violante '00; Lewis '11; Beaudry, Doms & Lewis '11 and '12
- **Task approach:**
  - Autor, Levy & Murnane '03; Spitz-Oener '06; Autor & Dorn '11; Goos, Manning & Salomons '11; Michaels, Natraj & van Reenen '12; Firpo, Fortin & Lemieux '12
- **Broad consensus of this literature:**
  - Complementarity between IT and educated labor
  - IT associated with displacement of routine occs/tasks
  - Of course, not everyone agrees...

Recent Work 2: Trade and Labor Markets

- **Structural GE approaches:** Models of wage adjustment
  - **Early literature:** Berman-Bound-Machin '98; perfect labor mobility (eg, Feenstra & Hanson '99)
  - **Recent:** Search frictions (eg, Helpman et al. '12)
- **Reduced form approaches:** Firm, industry, regional impacts
  - **Firms** (eg, Bloom Draca & Van Reenen '11)
  - **Industries** (eg, Menezes-Filho & Muendler '11)
  - **Regions** (eg, Topalova '10; Kovak '11; Autor, Dorn & Hanson '12, Dauth, Findeisen & Suedekum, '12)
- **A variety of conclusions**
  - Traditional: Trade too small to matter, does not affect wages
  - Emerging: Trade w/ China, other LDCs $\rightarrow$ Large effects on rich country labor markets

Recent Work 3: Considering Trade + Tech Simultaneously

- **Theoretical models:**
  - Grossman & Rossi-Hansberg '08; Costinot & Vogel '10; Acemoglu & Autor '11
- **Estimating technology, offshoring 'effects' using job tasks:**
  - Blinder '07; Blinder & Krueger '10; Autor & Dorn '11; Goos, Manning & Salomons '11; Michaels, Natraj & van Reenen '12; Firpo, Fortin & Lemieux '12, Oldenski '12
  - *No work studying technology + trade in goods with equal seriousness*
- **Results from this literature: All possibilities confirmed!**
  - Large offshoring effects: Blinder '08, Blinder-Krueger '10, Firpo-Fortin-Lemieux '11, Oldenski '12
  - Small, non-robust offshoring effects: Autor & Dorn '11; Goos, Manning & Salomons '11; Michaels, Natraj & van Reenen '12

Agenda

1. **Measurement**
   - Local labor markets
   - Exposure to computerization/automation
   - Exposure to import shocks
2. Untangling trade and technology
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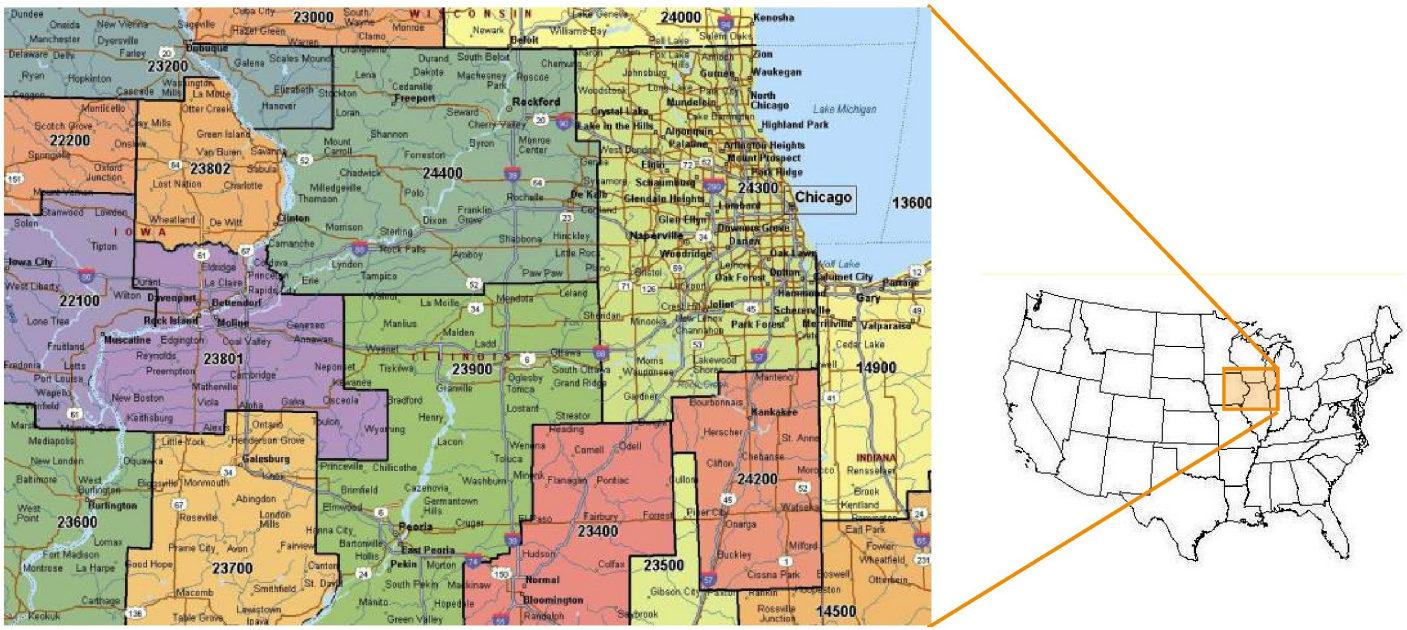
Defining Local Labor Markets: "Commuting Zones"

- **Map $\sim 3,150$ mainland U.S. counties into 722 commuting zones**
  - Strong commuting ties within a CZ, weak commuting ties across CZs
- **Permits analysis of 'Local General Equilibrium' effects**
  - Topolova '10; Autor & Dorn '11; Beaudry, Doms & Lewis '11 & '12; Autor, Dorn, Hanson '12. (Topel '86: Local labor market approach)



Measuring Susceptibility to Automation

- **Autor-Dorn '11 Routine Task Intensity by occupation k**

$$RTI_k = \ln\left(T^R_{k,1980}\right) - \ln\left(T^M_{k,1980}\right) - \ln\left(T^A_{k,1980}\right),$$

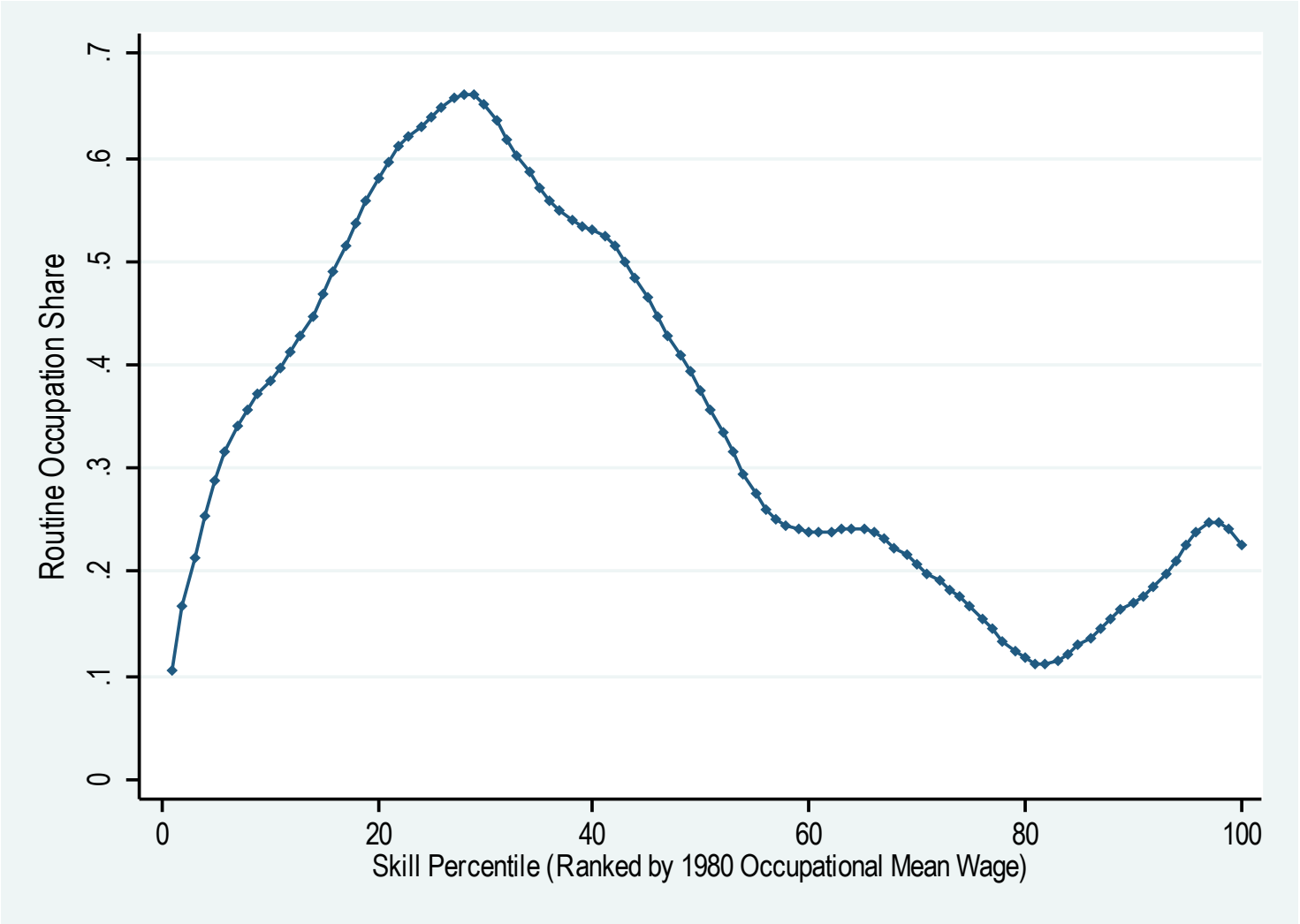
  - T^R_k, T^M_k, T^M_k are Routine, Manual, Abstract task input in occ in 1980
  - Label top-third (weighted by employment) as "Routine Occs"

Task Intensity of Major Occupation Groups

	RTI Index	Abstract Tasks	Routine Tasks	Manual Tasks
Managers/Prof/Tech/Finance/Public Safety	-	+	-	-
Production/Craft	+	+	+	-
Transport/Construct/Mech/Mining/Farm	-	-	+	+
Machine Operators/Assemblers	+	-	+	+
Clerical/Retail Sales	+	-	+	-
Service Occupations	-	-	-	+

The table indicates whether the average task value in occupation group is larger ("+") or smaller ("-") than the task average across all occupations. Shaded fields indicate the largest task value for each occupation group.

Routine Task Share: Non-Monotone in Occ Skill (Wage)



Share of 'Routine' Occupations by Occupational Skill Percentile

Occupations with High v. Low RTI

	A. Occupations with Highest RTI Scores	B. Low-Skill Occupations with Lowest RTI Scores	C. High-Skill Occupations with Lowest RTI Scores
1	Butchers & meat cutters	Bus drivers	Fire fighting, prevention & inspection
2	Secretaries & stenographers	Taxi cab drivers & chauffeurs	Police & detectives, public service
3	Payroll & timekeeping clerks	Waiters & waitresses*	Primary school teachers
4	Bank tellers	Truck, delivery, & tractor drivers	Managers of properties & real estate
5	File clerks	Door-to-door/street sales, news vendors	Secondary school teachers
6	Cashiers	Carpenters	Electrical engineers
7	Typists	Telecom & line installers & repairers	Physicians
8	Pharmacists	Housekeepers, maids, butlers & cleaners*	Computer systems analysts & scientists
9	Bookkeepers, accounding clerks	Health & nursing aides*	Civil engineers
10	Postal clerks, except mail carriers	Electricians	Industrial engineers

Instrumenting Routine Share Measure by CZ

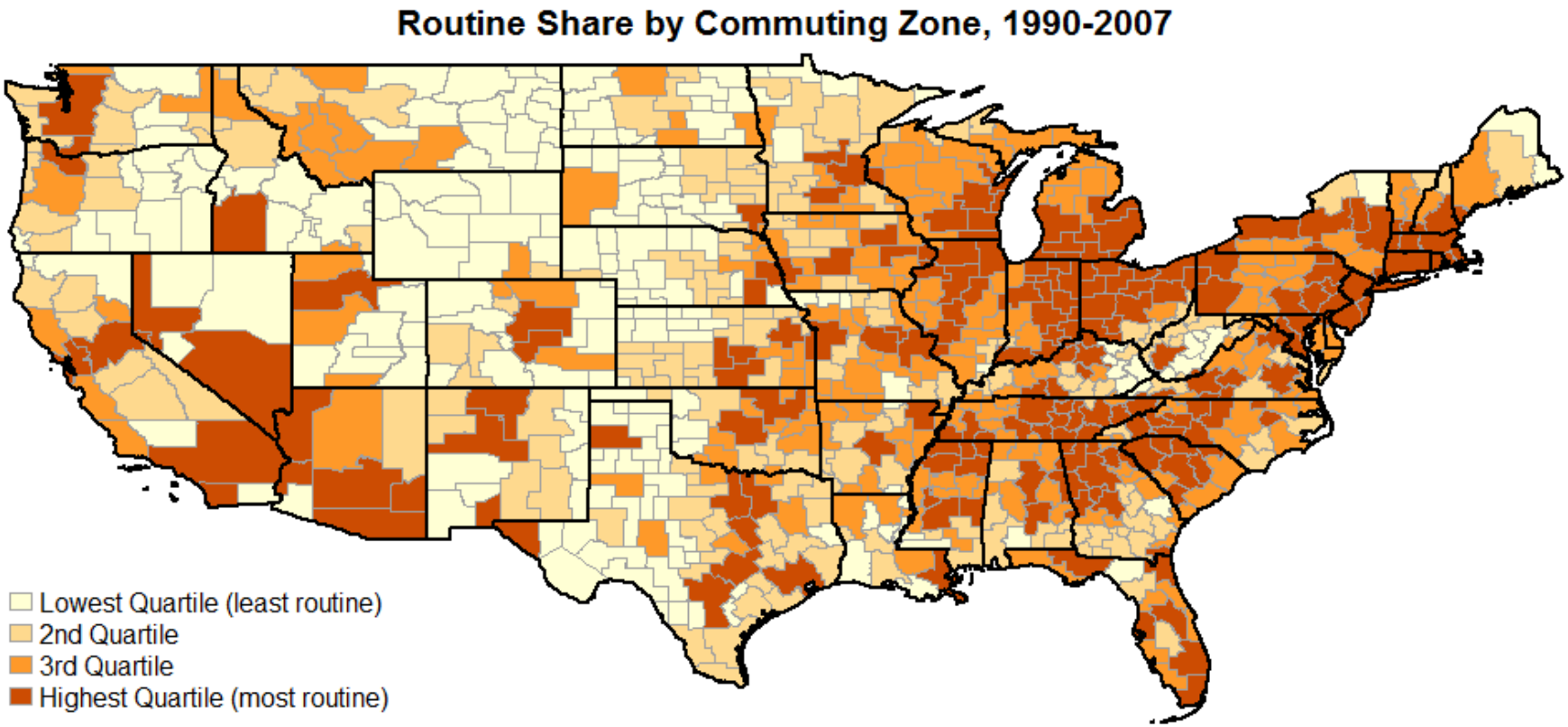
Isolating long-run component of RSH_i^* by CZ

- RSH_i^* is long-run, quasi-fixed industrial structure determining CZ's routine share
- $RSH_{it_0} = RSH_i^* + \nu_{it_0}$ is observed value of RSH at point in time
- ν_{it_0} is unobserved, time-varying factors affecting CZs' routine share

Instrumenting for RSH_j^*

- $E_{ni,1950}$ is employment share of industry $n \in 1, ..., N$ in CZ i in 1950
- $R_{n,1950}$ is routine occ share in industry n in 1950
- $\widetilde{RSH}_i = \sum_{n=1}^{N} E_{n,i,1950} \times R_{n,-i,1950}$, serves as instrument for RSH_i^*

Geography of Routine Task Exposure



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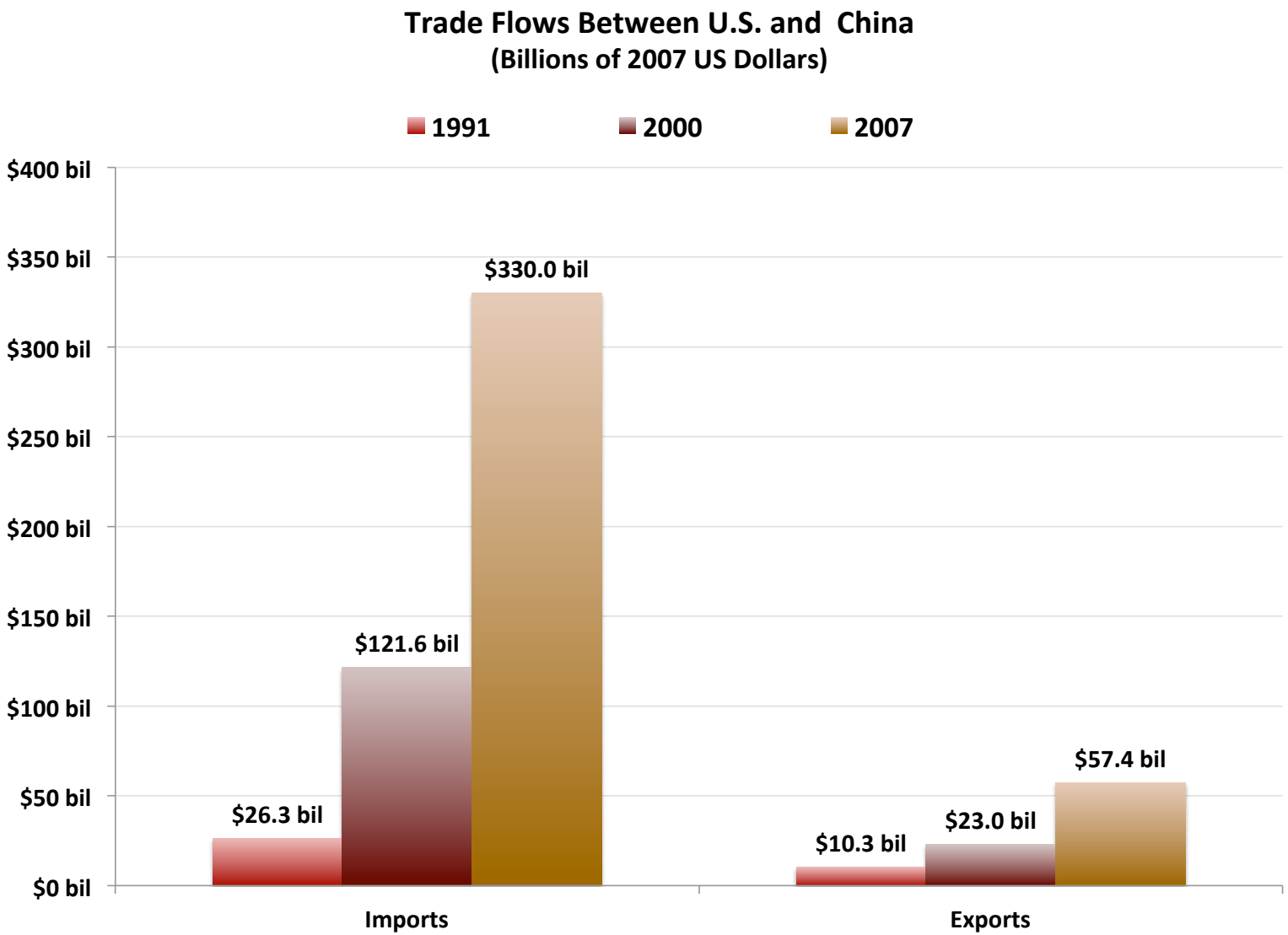
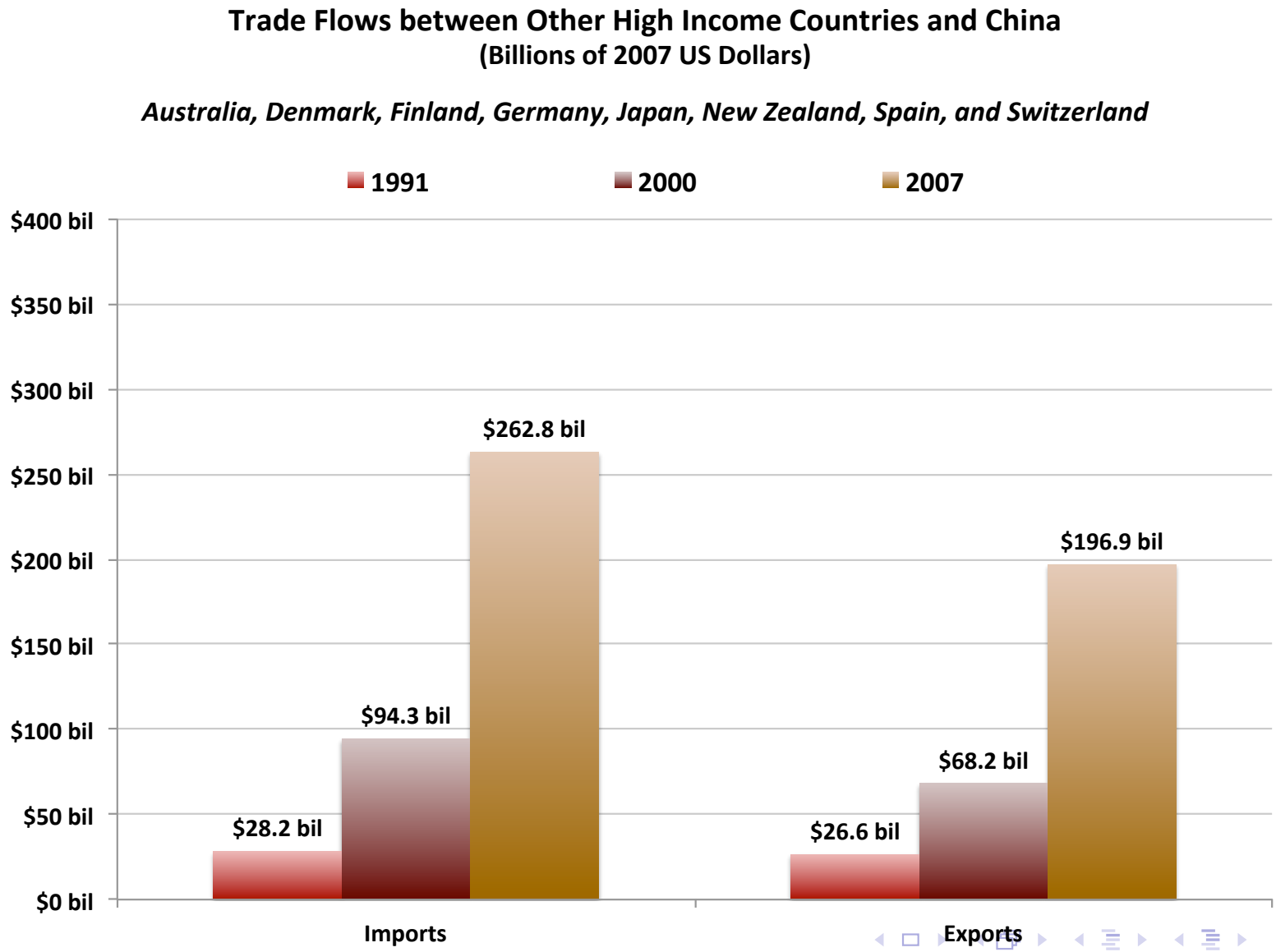
Trade Exposure: Rising Trade between U.S. and China



Rising Trade: Other High Income Countries & China



The rise of China since the early 1990s

Between 1990 and 2007

- China accounted for 75% of growth of Least Developed Country manufacturing value-added
- US **imports** from China increased by 11.5 times
- US **exports** to China are small, below 15% of bilateral trade flows

"Reform and Opening" $\rightarrow$ Surge in Chinese manufacturing

- Opening to trade and Foreign Direction Investment
- Marketization, privatization, easing controls on labor mobility
- Median Chinese manufacturing plant had **15% annual** productivity growth 1992 – 2007

Ratio of Chinese Imports to U.S. Domestic Consumption

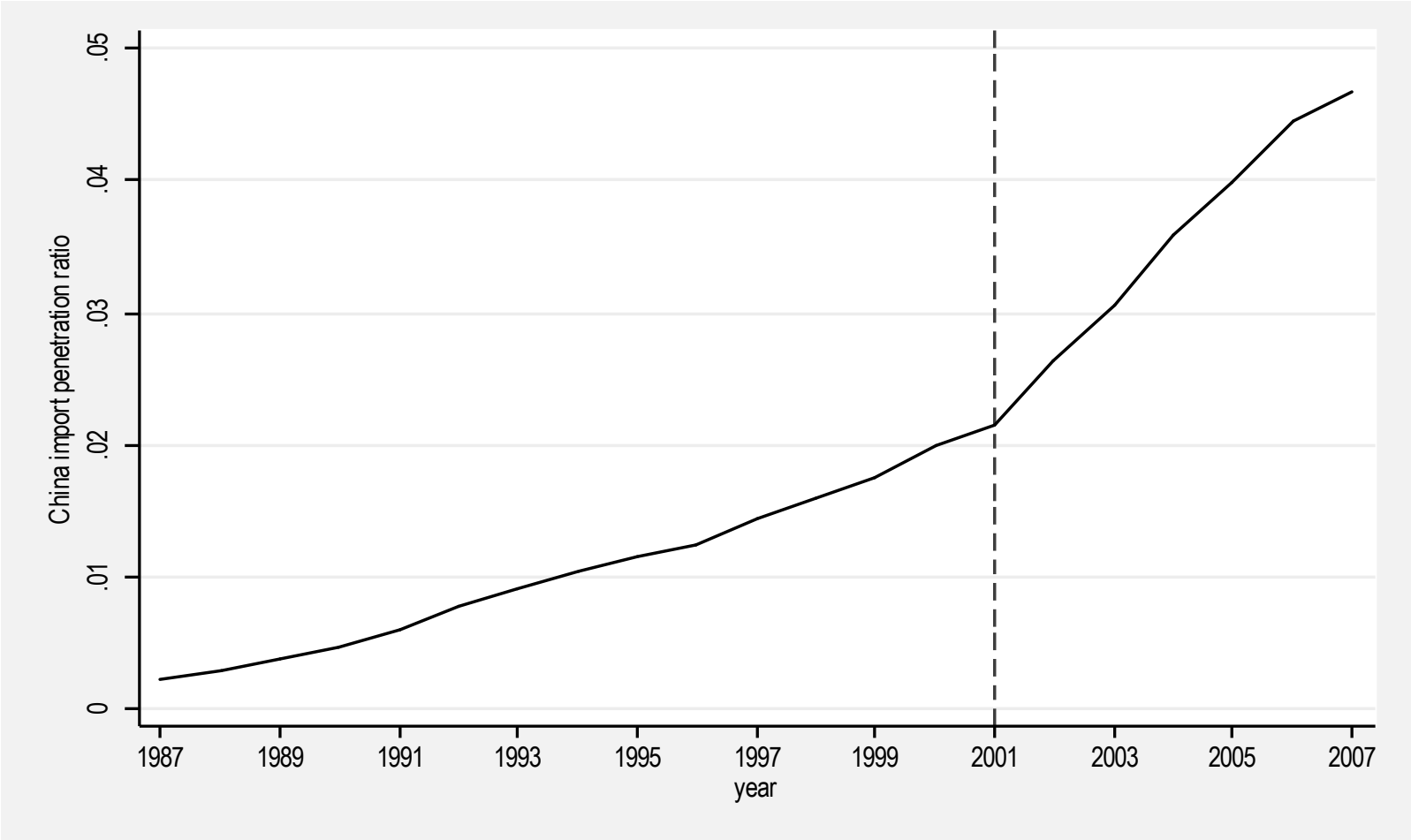
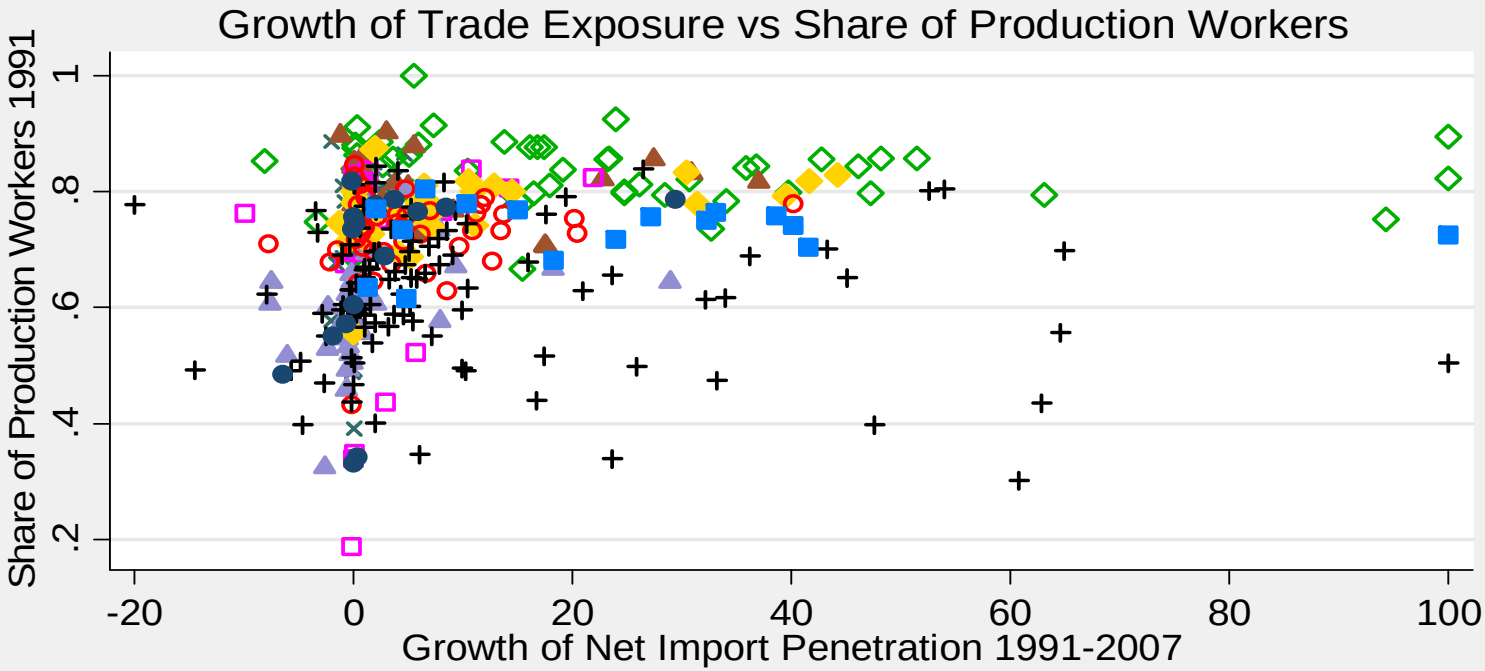


Figure 1.
Import Penetration Ratio for U.S. Imports from China.

But Exposure Varies Within and Across Industries



Measuring Supply-Push Component of Rising China Trade

Why focus on the "supply push?"

- Separate the impact of international competition from consumer demand

China's export growth as supply push: Driven by...

- Rural to urban migration (over 150m migrants moved to cities)
- Opening to foreign investments, technology, imported inputs
- World Trade Organization accession in 2001

This motivates our instrumental variables (IV) strategy

Motivate trade shocks using Eaton and Kortum '02

- CZ i's sales in industry j to destination market n are:

$$X_{nij} = \frac{T_{ij}(w_{ij}\tau_{nij})^{-\theta}}{\Phi_{nj}} X_{nj}, \qquad \Phi_{nj} \equiv \sum_{h} T_{hj}(w_{hj}\tau_{nhj})^{-\theta}$$

  - T_{ij} is productivity of industry j in CZ i
  - w_{ij} is unit production cost of industry j in CZ i
  - τ_{nij} is trade cost between CZ i and market n
  - Φ_{nj} is "toughness" of competition for industry j in market n
  - X_{nj} is total spending on industry j in market n
  - θ is productivity dispersion parameter

Effect of China's ΔTFP or $\Delta\tau$ on CZ's product demand

- Productivity growth in China or a reduction in US trade barriers on Chinese goods increases market toughness facing CZ i
- Derive the log change in demand for goods produced by CZ i due to China's productivity and trade costs (across all industries)

$$\hat{Q}_i = -\sum_j \frac{X_{uij}}{X_{uj}} \times \frac{X_{ucj}(\hat{A}_{cj} - \theta\hat{\tau}_{cj})}{Q_i}$$

  - X_{uij}/X_{uj} is CZ i's sales as a share of US purchases in industry j
  - Q_i is total output in CZ i
  - $X_{ucj}(\hat{A}_{cj} - \theta\hat{\tau}_{cj})$ is growth in US imports from China due to China's productivity growth and change in trade costs facing China

- $\hat{Q}_i$ **is an exposure index:** Allocates exogenous component of ΔChina goods imports to CZ's according to their output of those goods

Proxying for Δ Chinese import exposure at CZ level

Empirical proxy for Δ CZ's import exposure:

$$\Delta IPW_{uit} = \sum_j \frac{E_{ijt}}{E_{jt}} \frac{\Delta M_{ucjt}}{E_{it}}$$

- Allocates to each CZ a share of total national import growth
- Divides this import value by a CZ's total employment
- Yields measure of "import growth per worker" (in $1,000's of USD)
- IPW_{uit} **is trade-induced demand shock for CZ's goods output**

Note two sources of variation in this measure:

1. Overall manufacturing employment *share* in CZ
   - Control for initial manuf emp, ID comes from variation in industry mix
2. Variation in CZ's manufacturing industry *mix*

IV strategy: Exogenous Variation in Chinese Import Shocks

Source of endogeneity

- U.S. imports from China affected by U.S. demand shocks as well as China's growing productivity and falling trade costs

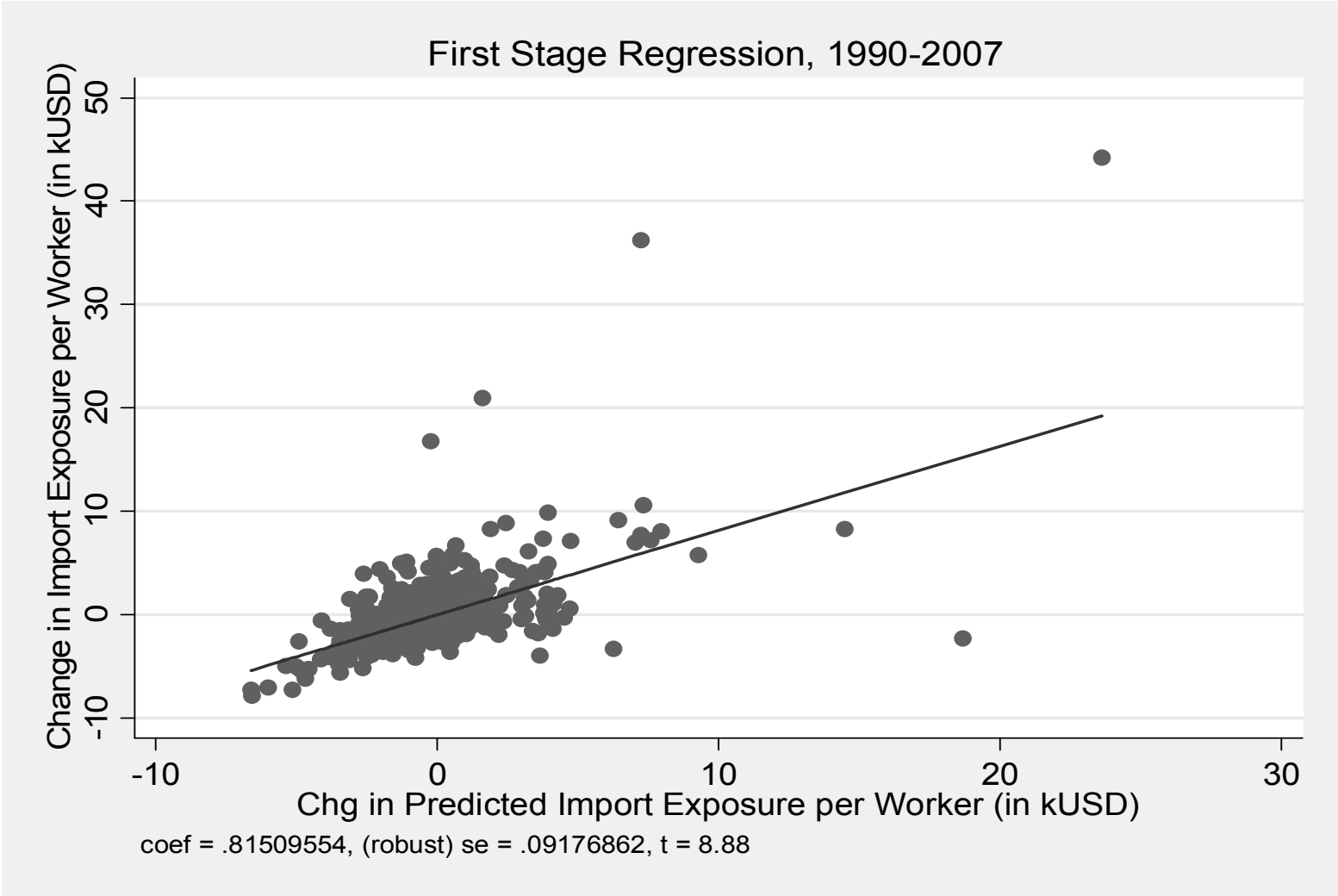
Instrumental variables approach

- Instrument for ΔIPW_{it} using other high-income countries' imports from China (and lagged CZ employment)

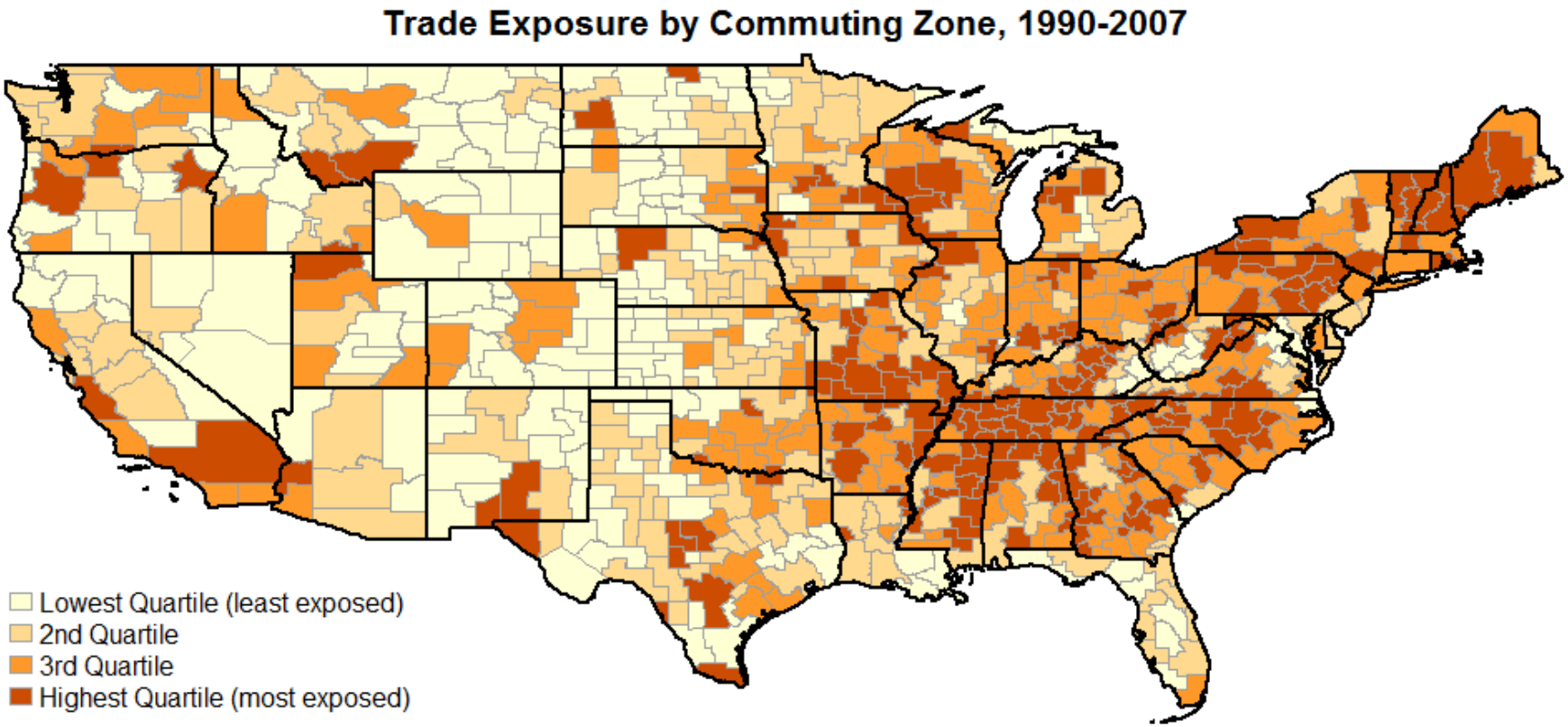
$$\Delta IPW_{oit} = -\sum_j \frac{E_{uijt-10}}{E_{ujt-10}} \left[\frac{\Delta M_{ocjt}}{E_{it-10}} \right]$$

2SLS First Stage

Panel A: 2SLS 1st Stage Regression, Full Sample



Geography of Trade Exposure



Δ China imports per worker (in 1,000s of US$) across CZs

Appendix Table 1. Descriptive Statistics for Growth of Imports Exposure per Worker across C'Zones

I. 1990-2000		II. 2000-2007	
A. Percentiles			
90th percentile	2.05	90th percentile	4.30
75th percentile	1.32	75th percentile	3.11
50th percentile	0.89	50th percentile	2.11
25th percentile	0.62	25th percentile	1.60
10th percentile	0.38	10th percentile	1.03

Over all CZ's:

- 75/25 percentile Δ: $1,510 in 2000-2007 (over 10 yrs)
- 75/25 percentile Δ: $700 in 1990-2000
- Average per decade over 1990-2007: $1,105

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Geography of Technology *and* Trade Exposure

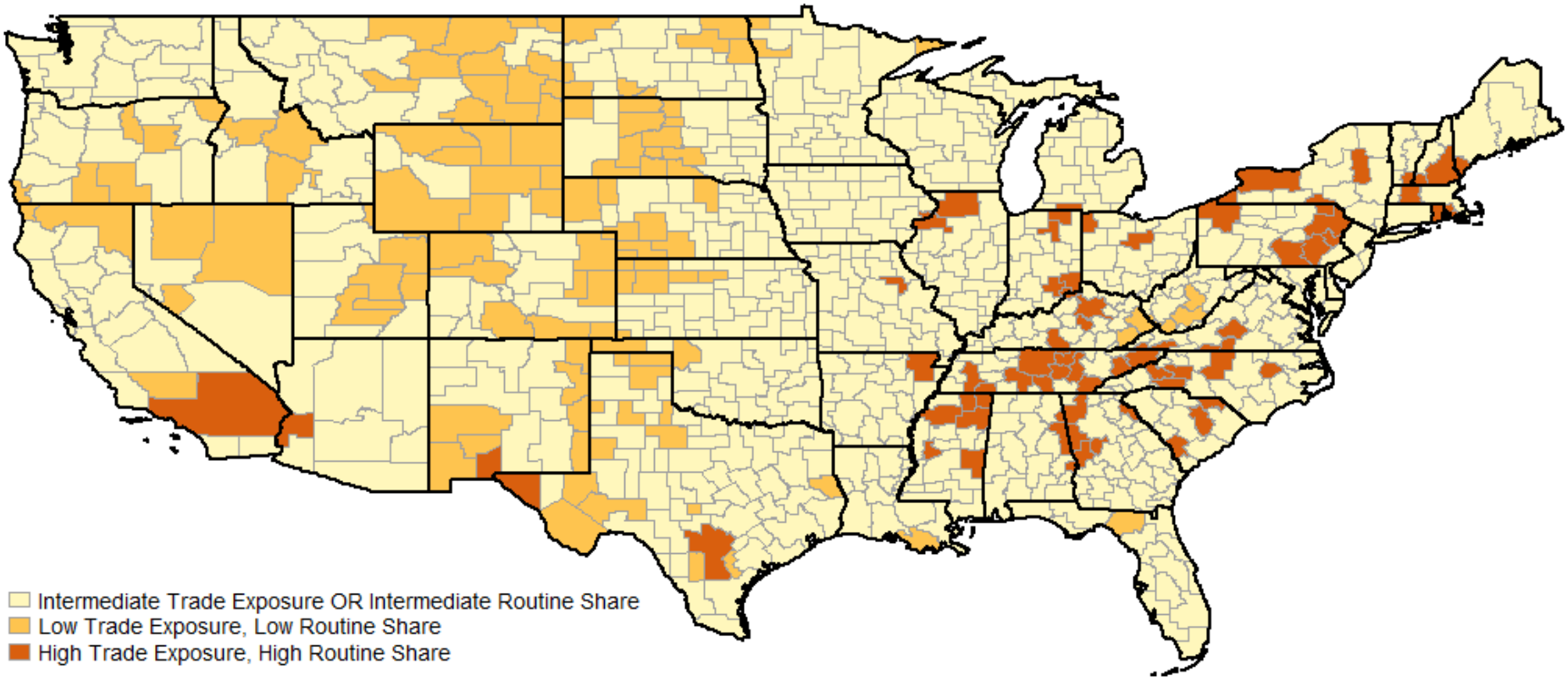
Are same CZs equally exposed to trade and technology?

No: Technology, trade exposure *weakly* correlated across CZs

- $\rho\left(RSH_{j,1990},\ ImpWkr_{j,1990-2000}\right) = -0.02$
- $\rho\left(RSH_{j,2000},\ ImpWkr_{j,2000-2007}\right) = 0.01$

Are Same CZs Exposed to Trade and Technology?

- **Plotting CZs that are *either* high-high *or* low-low on both technology and trade exposure (high, low $= 4^{th}$, 1^{st} quartiles)**



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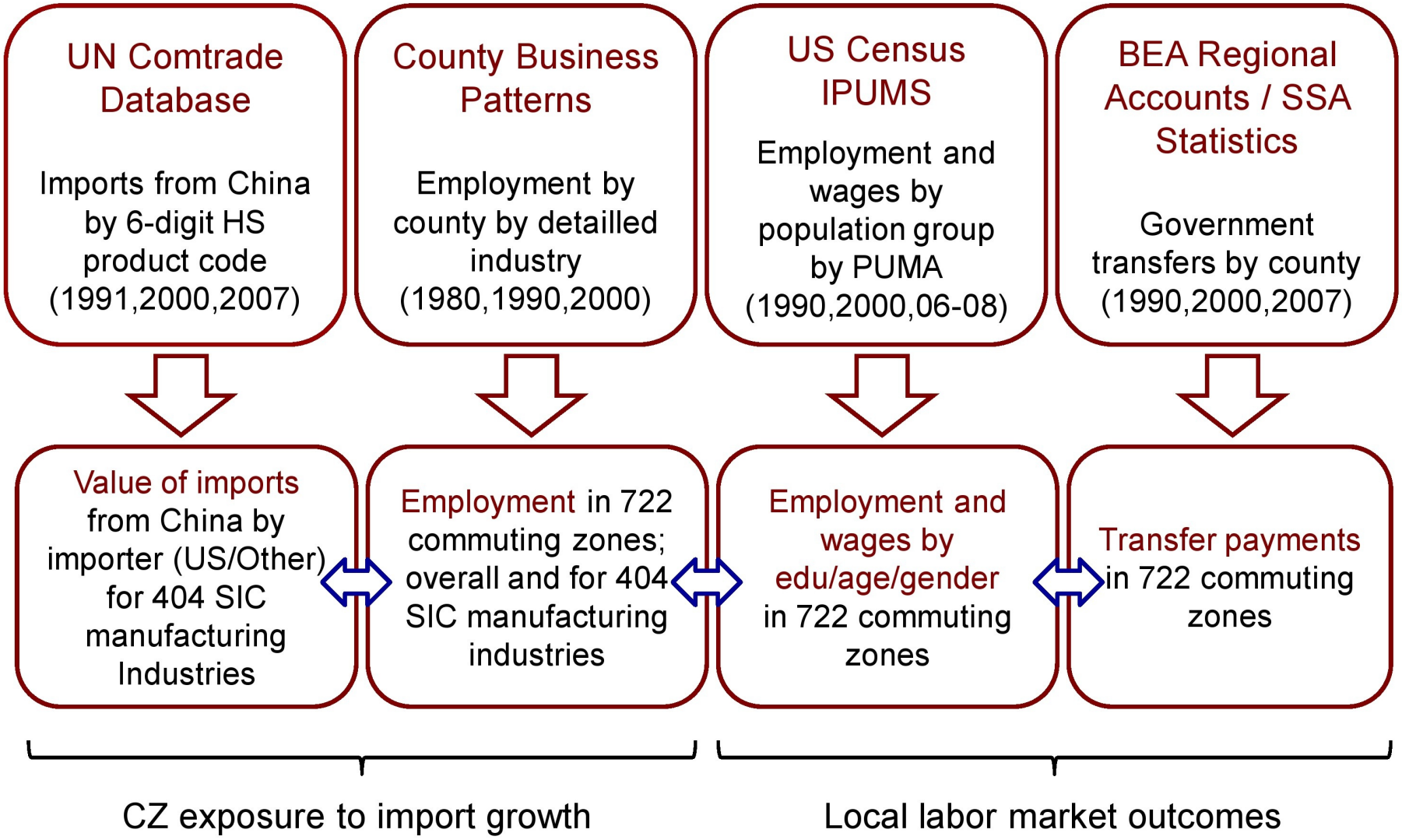
Data Sources: Time Periods 1990-2000, 2000-2007



Estimation

Regression model

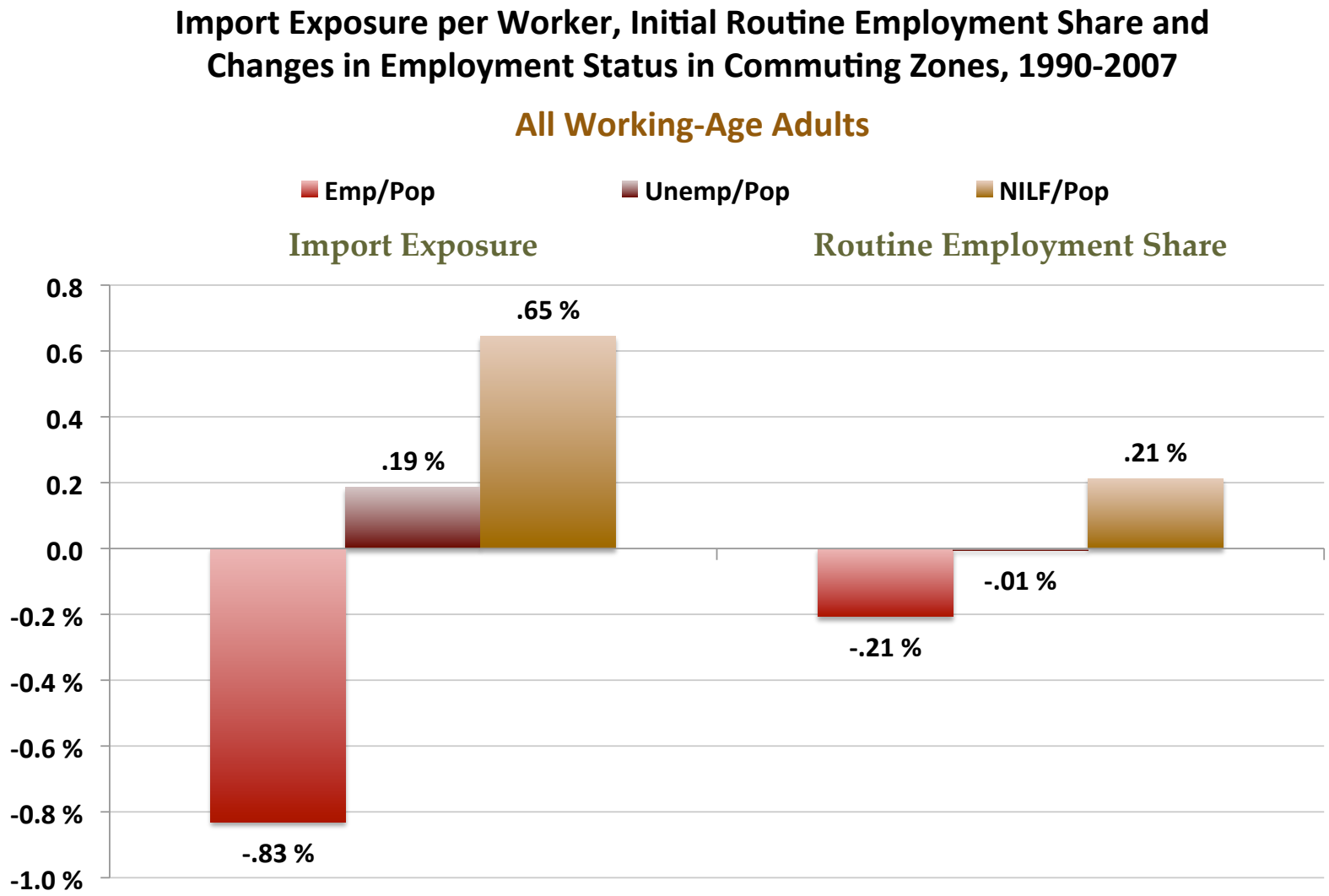
$$\Delta Y_{it} = \gamma_t + \beta_1 \Delta IPW_{uit} + \beta_2 RSH_{it} + X_{it}' \beta_2 + e_{it}$$

- ΔY_{it} is 10-year equivalent change of emp, unemp, tasks/occs
- γ_t is a period effect (time periods 1990–2000, 2000–2007)
- ΔIPW_{uit} is import exposure
- RSH_{it} is routine occupation emp share at the start of period
- X_{it} contains start of period CZ manufacturing share, CZ demographics
- Observations weighted by CZ population; SEs clustered by state

Instrumental variables

- ΔIPW_{uit} is instrumented by ΔIPW_{oit}
- RSH_{it} is instrumented by $\widetilde{RSH}_i$

Overall Employment Impacts



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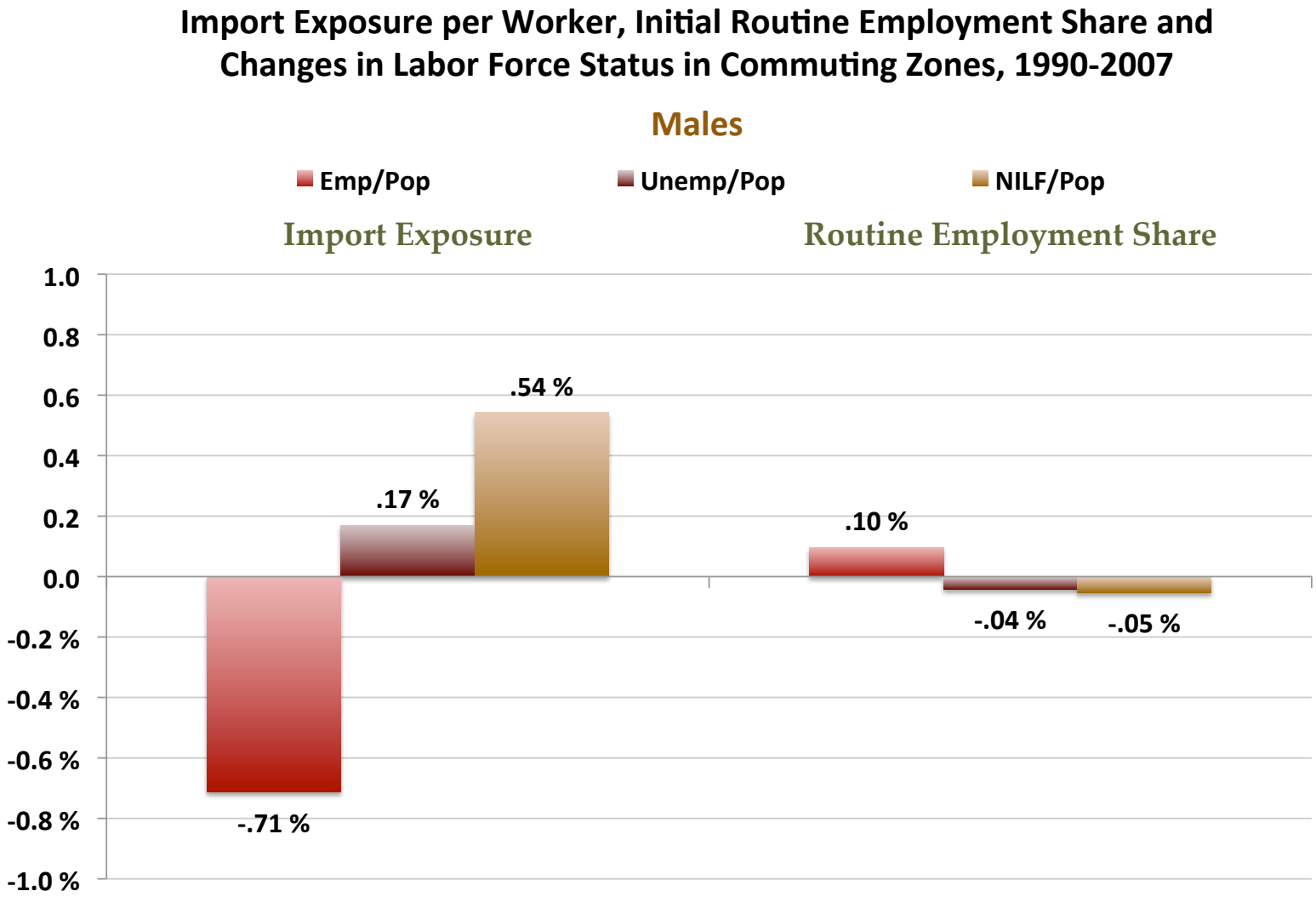
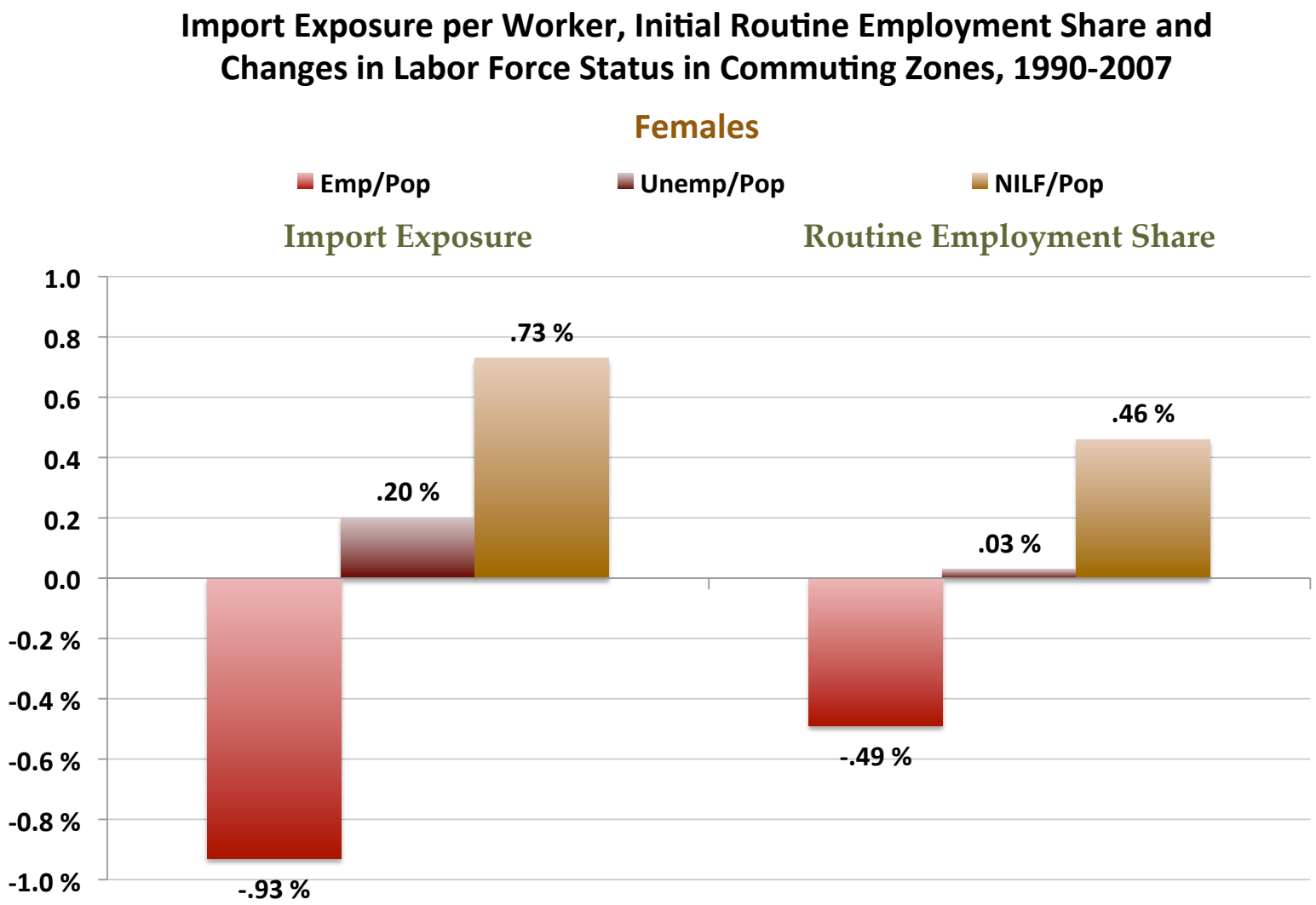
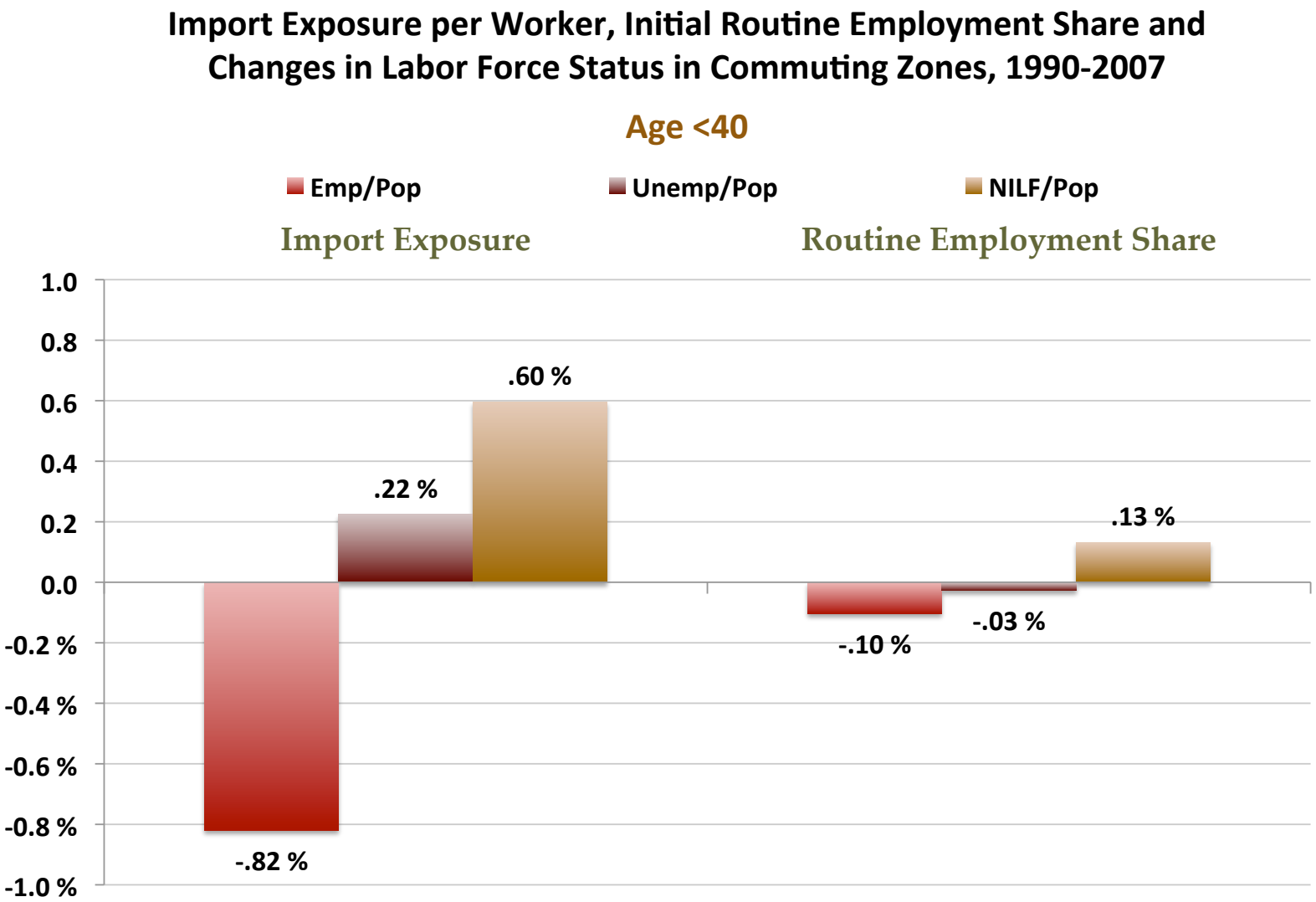
Employment Impacts: Males



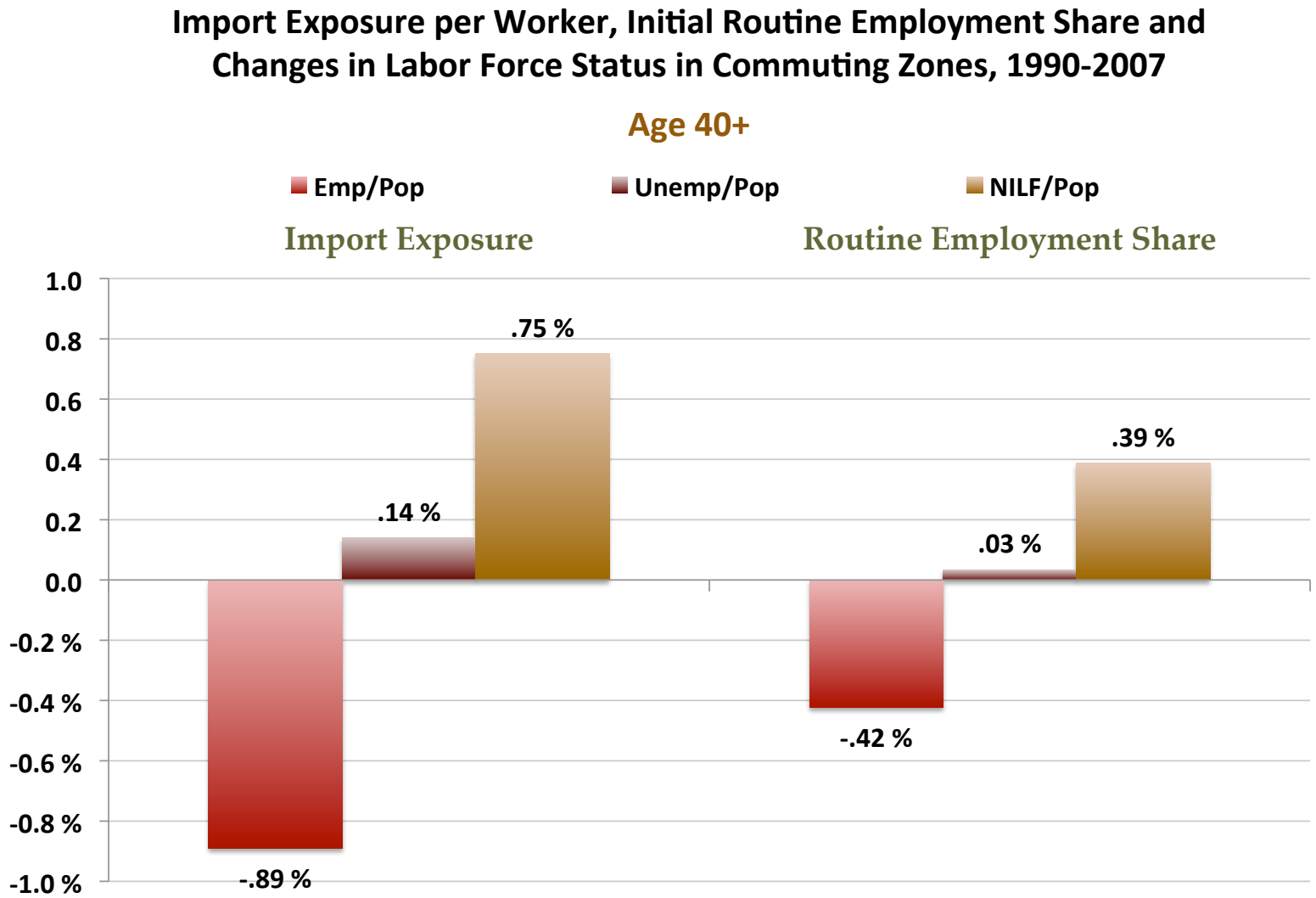
Employment Impacts: Females



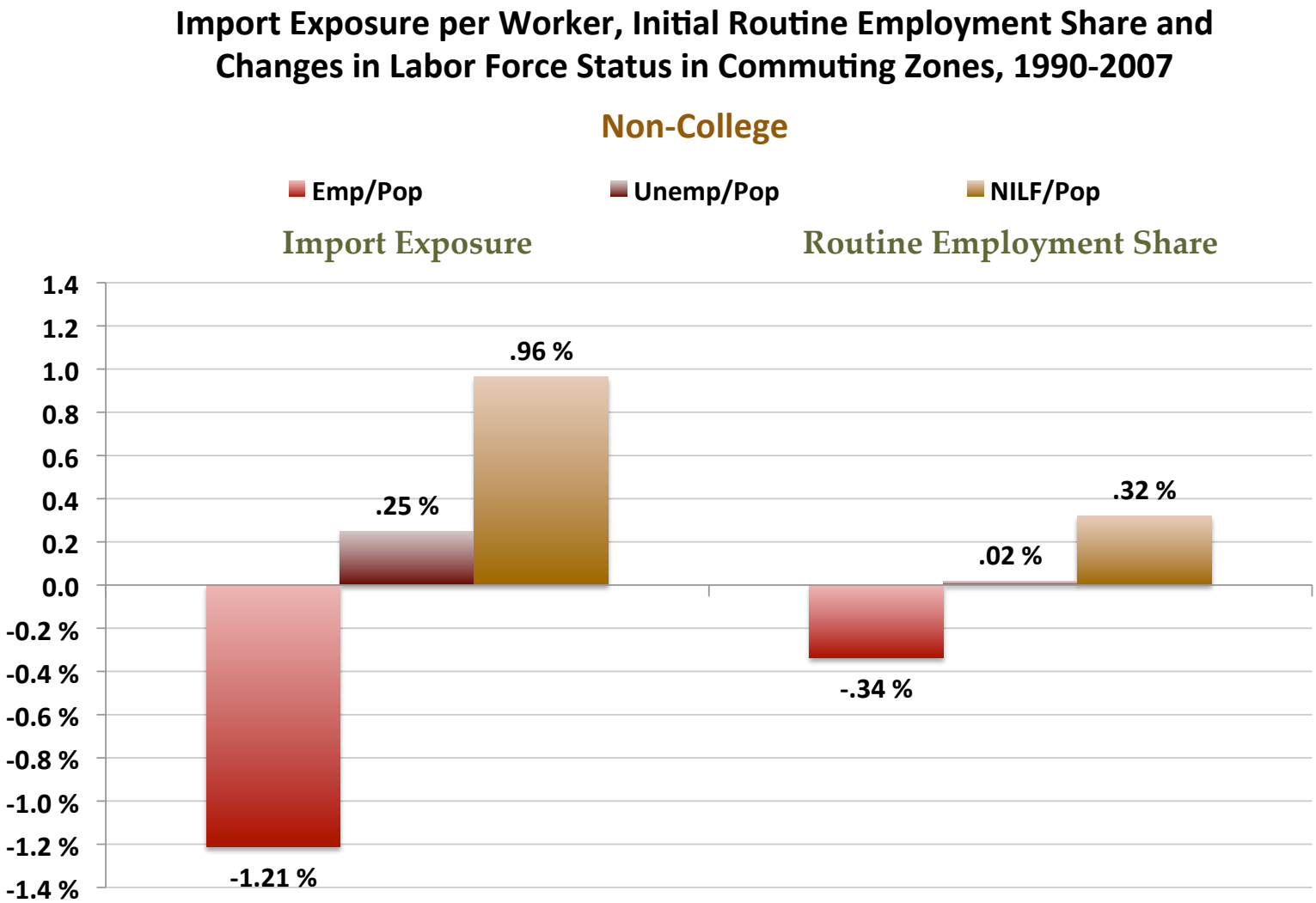
Employment Impacts: Age <40



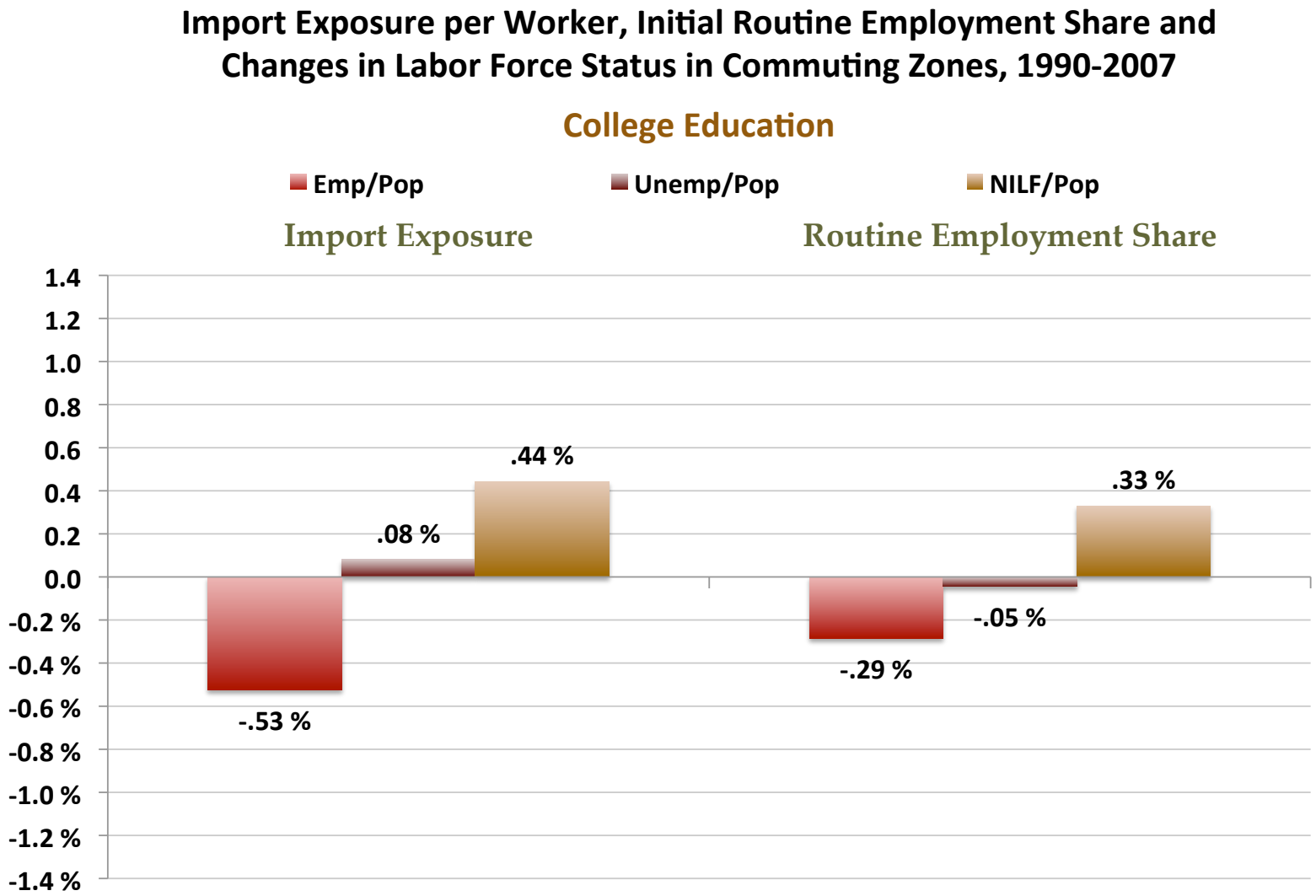
Employment Impacts: Age 40+



Employment Impacts: No College



Employment Impacts: College+



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Measuring Impacts on Task Inputs

Employment by task/occupation

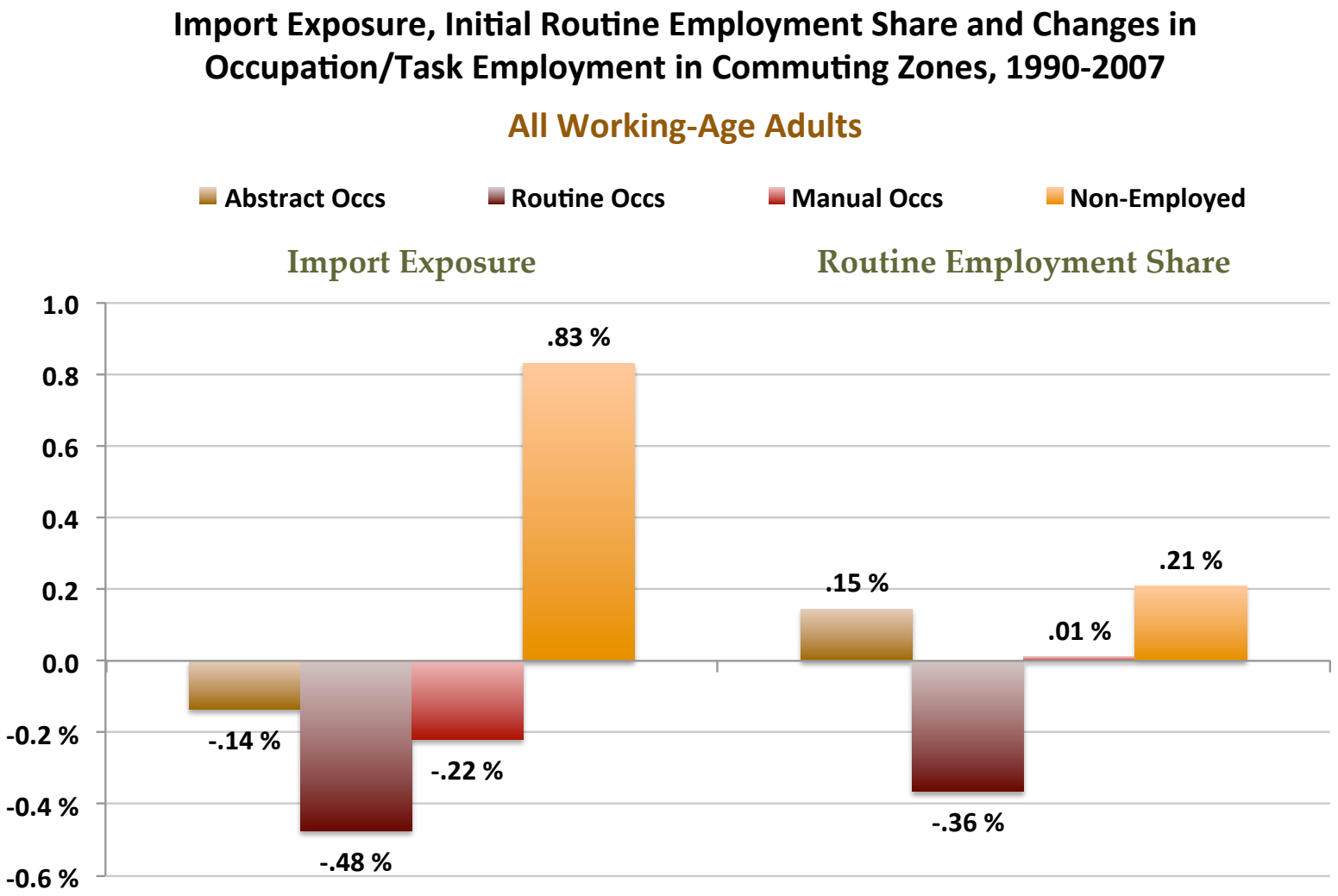
1. Abstract tasks
   - Managerial, Professional and Technical occupations
2. Routine tasks
   - Production, Clerical, Retail, Sales occupations
3. Manual tasks
   - Craft, Mechanics, Agricultural, Service occupations
4. Non-participation
   - Useful to recognize a fourth 'option'

Regression model (2SLS)

$$\Delta Y_{it}^{k} = \gamma_t + \beta_1 \Delta IPW_{uit} + \beta_2 RSH_{it} + X_{it}^{'}\beta_2 + e_{it}$$

- where $k \in \{\text{Abstract Occ, Routine Occ, Manual Occ, NILF}\}$

Overall Impacts of Trade and Technology on Tasks



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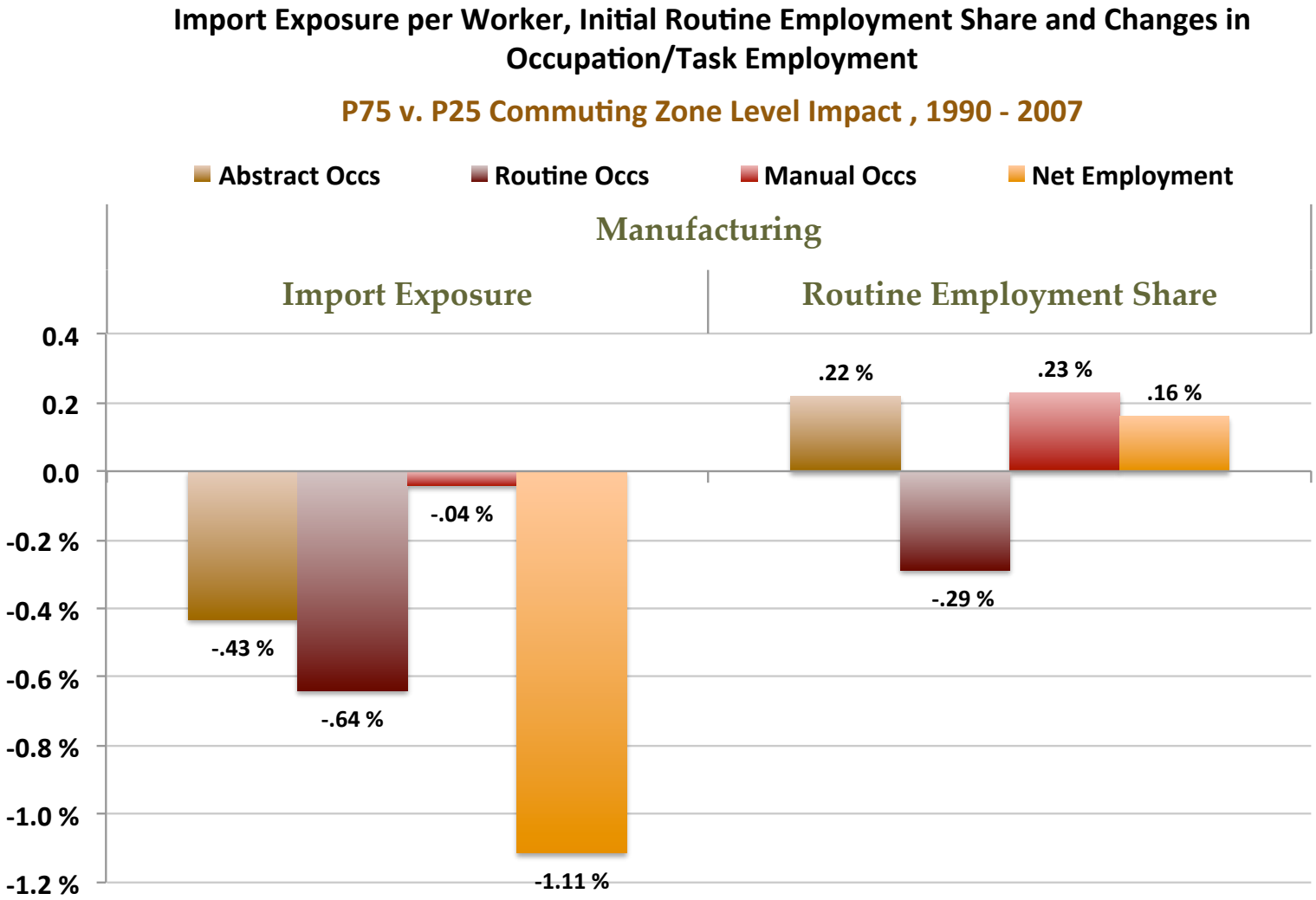
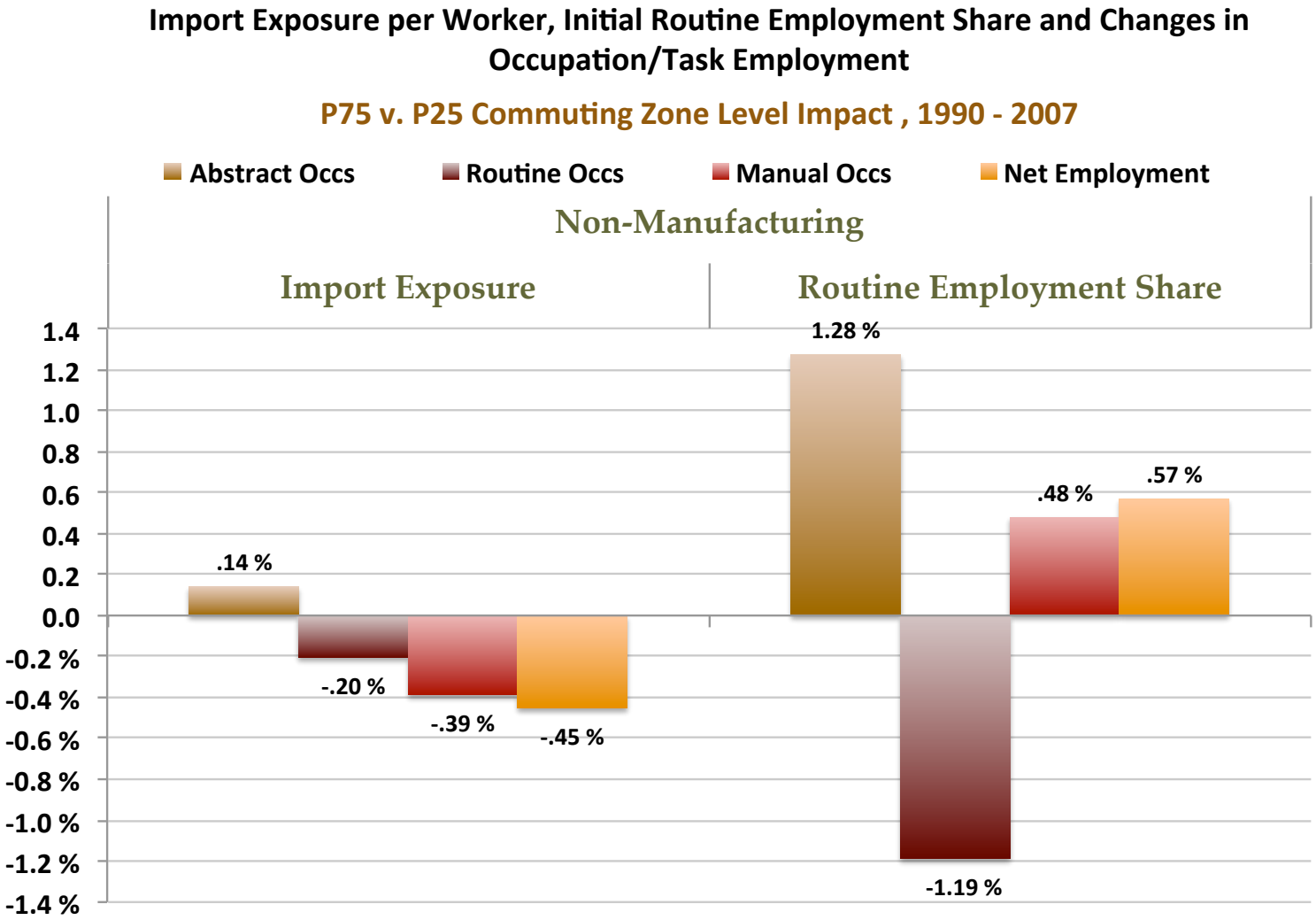
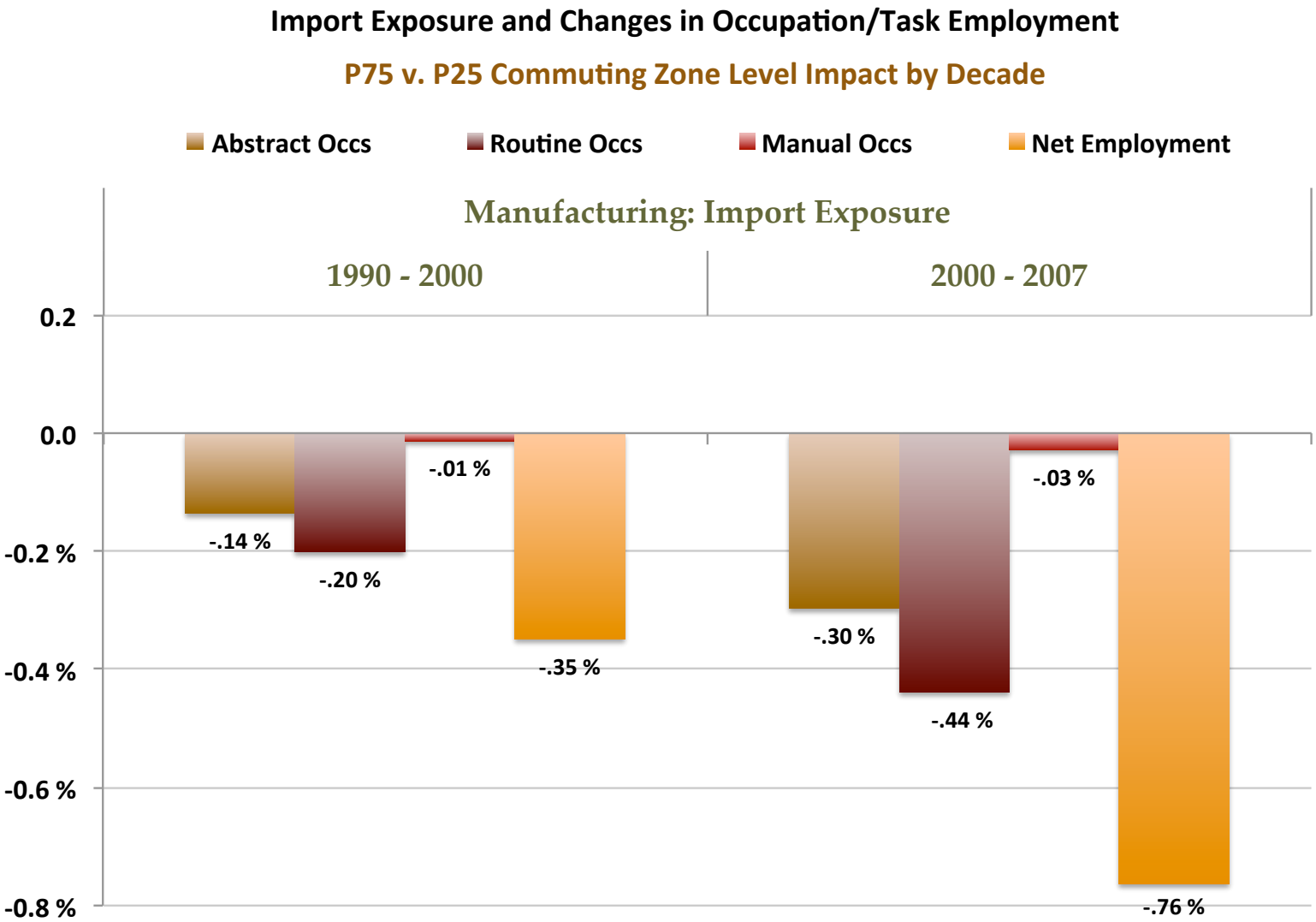
Trade and Tech in Manufacturing: Standardized P75 v. P25 CZ-Level Effects, 1970 - 2007



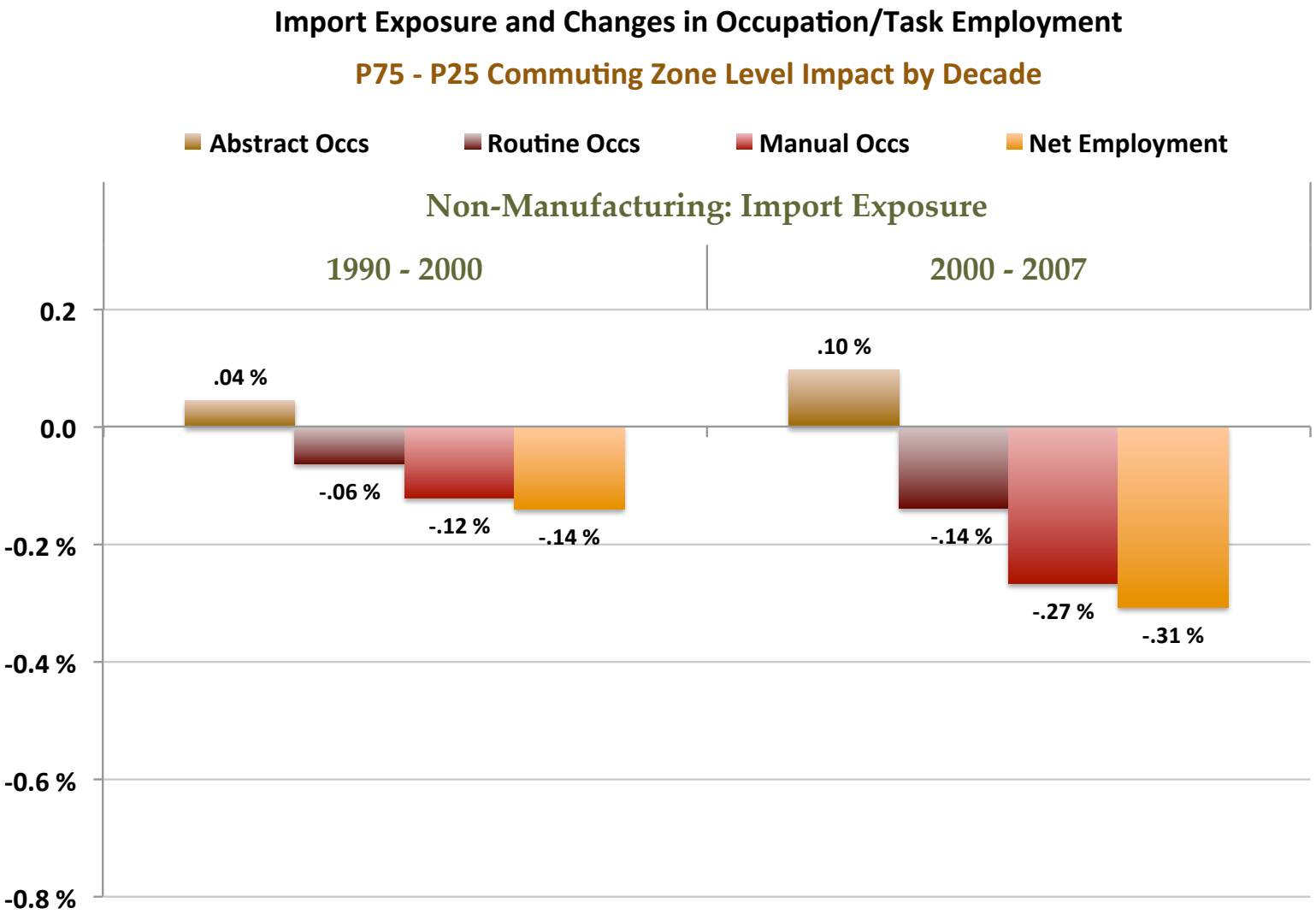
Trade and Tech in Non-Manufacturing: Standardized P75 v. P25 CZ-Level Effects, 1970 - 2007



Trade Effects in Manufacturing by Decade: Standardized P75 v. P25 Impact



Trade Effects in Non-Manufacturing by Decade: Standardized P75 v. P25 Impact



Agenda

1. Measurement
   - Local labor markets
   - Exposure to computerization/automation
   - Exposure to import shocks
2. Untangling trade and technology
   1. Similar local labor markets?
   2. Similar employment impacts?
   3. Similar demographic groups?
   4. Similar tasks affected – abstract, routine, manual?
   5. Similar sectors?
3. **Conclusions and next steps**

Technology & Trade: Same Local Labor Market Impacts?

1. Similar local labor markets?
   - **No**. Different regions. Trade has larger effects in low-education areas
2. Similar employment effects?
   - **No**. Trade exposure reduces epop raises unemp, NILF
   - Routine-displacement has no significant effect on total epop, unemp, NILF
3. Similar worker groups?
   - **Somewhat**. Both disproportionately affect older, less-educated workers
   - But routine-displacement has larger impacts on females
4. Similar tasks?
   - **No**. Trade displaces Manual, Routine and Abstract tasks
   - Routine displacement $\rightarrow$ Rising emp. in Manual and Abstract occs
5. Similar sectors?
   - **No**. Trade impacts concentrated in manufacturing
   - Routine displacement concentrated in non-manufacturing

Conclusions and Next Steps

- **Worker level impacts**
  - How are individual workers affected by rising trade exposure in their industry?
  - Distinct question from "local general equilibrium" effects studied here
  - Distinguishes *direct* effects from spillover/multiplier effects
- **Presentation tomorrow**
  - Autor-Dorn-Hanson, "Trade Adjustment: Worker Level Evidence"
  - Saturday Sept 22, 13:45-15:30, session E13, Room 1.7