Tradability and the Labor-Market Impact of Immigration: Theory and Evidence from the United States

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Impact of immigration on domestic labor market outcomes

- What is impact of immigration on labor-market outcomes (wages and allocations) of native born?
- Previous research: largely comparisons across regions or broad skill groups
- We start from a more disaggregate level:
  - Occupations differ in exposure to immigration
    - Textile production, housekeeping intensive in immigrants relative to firefighting
  - Occupation tradability shapes adjustment to local labor-market shocks
    - Textile factories can absorb expanded labor supplies by changing exports to other regions in a way that housekeepers cannot

Theory preview

- Three key elements in the model
  (1) allow for *possibility* that immigrant, domestic workers are imperfect substitutes within occupations

- In response to exogenous ↑ immigrants into a region
  (1) at fixed occupation prices, labor reallocates towards immigrant-intensive occupations ("crowding in") — equivalent to Rybczynski

  as output of immigrant-intensive occupations ↑, price ↓
  ⇒ less crowding in (or more "crowding out")
    - ⋆ "crowding in"/"crowding out" depending on a simple comparison of elasticities

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    - ⋆ price responsiveness to local output higher for Nontradable than Tradable
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- Rybczynski generalized to many occupations, producer price ≠ import price, upward sloping labor supply curves, and heterogeneous tradability

Empirics preview

- Exploit variation within and across local labor markets
- Off-the-shelf measures of occupation and industry tradability
- Testing reduced-form predictions on labor allocations
  - more crowding out in N than T occupations
- Testing mechanism underlying labor allocation results using wage bill data
  - adjustment to immigration within T occurs more through Δoutput (vs Δprices) compared to within N
- Testing wage implications
  - use model structure because occupation wages not observed

Quantitative preview

- Model generalizations:
  - Native labor mobility across regions
  - Multiple education groups
  - Full general equilibrium
- Parameterize model using reduced-form results
- Validate wage implications of theory by comparing model-generated and observed aggregated wage data
- Apply the model to two counterfactual exercises
  - Large within region effects of immigration
  - Immigrants raise utility of most natives, except those in very exposed non-tradable occupations
    - agglomeration + imperfect substitutability
  - Spatial distribution of immigration matters for impact of immigration across tradable occupations (through GE)

Theoretical literature review

Closest theoretical relation (but not focusing on immigration):

- Rybczynski (1955): ↑ in a factor's endowment ⇒ crowding in
- Grossman and Rossi-Hansberg (2008): ↓ in offshoring costs ⇒ two effects closely related to the forces giving rise to crowding in and crowding out
- Acemoglu and Guerrieri (2008): provide a condition under which capital deepening ⇒ crowding in or crowding out

Related theory focusing on immigration:

- Peri and Sparber (2009): crowding out; reallocation margin of adjustment benefits natives
- Ottaviano, Peri and Wright (2013): implications of immigration and offshoring for native employment in partial-equilibrium model of one industry (no comparisons across industries)

Relative to both literatures, we:

- provide general conditions under which there is crowding in or out,
- show crowding out weaker in more tradable occupations
- and focus on changes in within-group wages

Empirical literature review

- Testing "strong" Rybczynski (FPI, fixed factor intensity, magnification)
  - Evidence against Rybczynski: Hanson & Slaughter, 2002; Gandal et al., 2004; Card & Lewis, 2007; Dustmann & Glitz, 2015
- Test new predictions for *differential* adjustment across more to less price-sensitive industries/occupations, resuscitating "relaxed" Rybczynski logic

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- Differential adjustment btw tradable and non-tradable to local shocks
  - Housing: Mian & Sufi, 2014
  - Immigration: Dustmann & Glitz, 2015; Hong & McLaren, 2016; Peters, 2017
- While encompassing such between-sector impacts, we allow for differences in occupational adjustment *within* tradables when compared to *within* nontradables

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- Trade + native adjustment to immigration: Ottaviano, Peri, & Wright, 2013
- We characterize strength of crowding in/out, show how they differ w/in tradable versus w/in nontradable occupations/industries

Theory

Model setup (I)

- Exogenous supply of workers in region r: N_r^k for $k =$ Domestic, Immigrant
  - Comparative static exercises to follow: log changes in factor supplies n_r^k
- Final non-traded good in region r, CES over occupations w/ elasticity η

$$Y_r = \left(\sum_{o \in \mathcal{O}} \mu_{ro}^{\frac{1}{\eta}} \left(Y_{ro} \right)^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}$$

- Absorption of each occupation o, Armington (CES) over origins with elasticity $\alpha > \eta$, trade subject to bilateral o-specific iceberg costs

$$Y_{ro} = \left(\sum_{j \in \mathcal{R}} Y_{jro}^{\frac{\alpha-1}{\alpha}} \right)^{\frac{\alpha}{\alpha-1}}$$

- Market clearing equates output with absorption (+ trade costs)

$$Q_{ro} = \sum_{j \in \mathcal{R}} \tau_{rjo} Y_{rjo}$$

Model setup (II)

- Production of occupation o in region r, elasticity of substitution ρ Alternative

$$Q_{ro} = \left(\left(A^I_{ro} L^I_{ro} \right)^{\frac{\rho-1}{\rho}} + \left(A^D_{ro} L^D_{ro} \right)^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}}$$

- L^k_{ro}: efficiency units of type $k = D, I$ workers employed in occupation o

$$L^k_{ro} = \int_{z \in \mathcal{Z}^k_{ro}} \varepsilon(z, o)\, dz$$

where $\varepsilon(z,o) \sim$ Fréchet with parameter $\theta > 0$, where $\uparrow \theta \Rightarrow \downarrow$ dispersion

- Worker z chooses o that maximizes wage income $\underbrace{W^k_{ro}}_{\text{"occ. wage"}} \times \underbrace{\varepsilon(z,o)}_{\text{eff. units}}$

- Labor markets clear

$$N^k_r = \sum_{o \in \mathcal{O}} N^k_{ro}$$

- Balanced trade by region

Comments on assumptions | Why these features? | Fixed immigrant wages

Comparative statics: no trade (I)

Output, price, wage bill

- Let S^I_{ro} denote immigrant cost share of occupation o in region r
  - Higher S^I_{ro} is relatively immigrant-intensive occupation
  - $S^I_{ro} \geq S^I_{ro'}$ iff $\left(A^I_{ro}/A^D_{ro}\right)^{\rho-1} \geq \left(A^I_{ro'}/A^D_{ro'}\right)^{\rho-1}$

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- Consider an increase in the share of immigrants: $n^I_r > n^D_r \iff$
  - $\uparrow$ in relative output of immigrant (I)-intensive occupations
  - $\downarrow$ in relative price of I-intensive occupations
  - $\uparrow$ in relative wage bill ($=$ output $\times$ price) of I-intensive occupations if $\eta > 1$
- A higher value of $\eta \Rightarrow$
  - larger changes in relative quantities
  - smaller changes in relative prices
  - larger increase in relative wage bill of I-intensive occupations

Relation to Rybczynski

Comparative statics: no trade (II)

Allocations and wages

- Consider an increase in the share of immigrants: $n_r^I > n_r^D \iff$
  - share of k workers in I-intensive occupations falls iff $\rho > \eta$
    - $\rho \to 0 \Rightarrow$ factor ratios insensitive w/in each o, crowding-in dominates
    - $\eta \to 0 \Rightarrow$ output ratios insensitive across o, crowding-out dominates
  - occupation wages adjust to induce workers to reallocate (for any $\theta < \infty$)

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- Log change in factor allocations and relative occupation wages

$$n_{ro}^k = \alpha_r^k + \beta_r^k S_{ro}^I (n_r^I - n_r^D)$$

$$w_{ro}^k - w_{ro'}^k = \frac{n_{ro}^k - n_{ro'}^k}{1+\theta}$$

where $\beta_r^k < 0 \iff \rho > \eta$

Comparative statics: small open economy (restrictions)

Extend previous analysis, imposing two restrictions

1. Region r: negligible share of exports, absorption in each o for all $r' \neq r \Rightarrow$
   - elasticity of region r's occupation output to its price
   $$\epsilon_{ro} \equiv \left(1 - \left(1 - S_{ro}^X\right)\left(1 - S_{ro}^M\right)\right)\alpha + \left(1 - S_{ro}^X\right)\left(1 - S_{ro}^M\right)\eta$$
   where S_{ro}^X (S_{ro}^M) is the export (import) share of o output (absorption) in r
2. $\mathcal{O}$ grouped into two disjoint sets, $\mathcal{O}(T)$ and $\mathcal{O}(N)$, with S_{ro}^M and S_{ro}^X common for all $o \in \mathcal{O}(g)$ for $g = T, N$
   - letting $\mathcal{O}(T)$ denote the more traded set of occupations, $\epsilon_{rT} > \epsilon_{rN}$

Comparative statics: small open economy (results)

- All comparative static expressions across two occupations within $g = T, N$ same as in closed economy, except allocation and wage effects w/in g depend on sign of $\epsilon_{rg} - \rho$ instead of $\eta - \rho$,
  - e.g., crowding out within $\mathcal{O}(g) \iff \rho > \epsilon_{rg} \iff \beta^k_{rg} < 0$

$$n^k_{ro} = \alpha^k_{rg} + \beta^k_{rg} S^I_{ro}(n^I_r - n^D_r) \text{ for all } o \in \mathcal{O}(g)$$

- $\epsilon_{rT} > \epsilon_{rN} \Rightarrow \beta^k_{rT} > \beta^k_{rN}$. An increase in immigrant share of population $\Rightarrow$
  - Allocations: less crowding out of I-intensive occupations w/in T than N
  - Wages: $\downarrow$ wage of I-intensive occupations smaller w/in T than N
  - Wage bill: $\uparrow$ payments of I-intensive occupations bigger w/in T than N

Comparative statics: changes in aggregate productivity

- Immigration may affect aggregate regional productivity: agglomeration/ congestion externalities
  - See, e.g., Allen & Arkolakis (2014), Desmet & Rossi-Hansberg (2015), Redding (2016), and review in Rossi-Hansberg and Redding (2016)
- Analytic results proven allowing for arbitrary changes in regional productivity
  - These results are *relative across occupations within a region*
- Changes in regional productivity may affect *aggregate* outcomes
- Under certain conditions, easy to characterize

Details

Connecting theory and data

Empirical extensions

Native allocations (e.g.)

$$n_{ro}^{D} = \alpha_{rg}^{D} + \alpha_{o}^{D} + \beta_{rg}^{D} S_{ro}^{I} n_{r}^{I} \text{ for all } o \in \mathcal{O}(g)$$

1. Incorporate national occupation fixed effects
2. Allow for changes over time in the composition of workers (e.g. w/ different education levels e)
   - in dependent variable by estimating regression separately for each native e
   - and in independent variable, $S_{ro}^{I} n_{r}^{I}$, by using

$$x_{ro} \equiv \sum_{e} S_{reo}^{I} \frac{\Delta N_{re}^{I}}{N_{re}^{I}}$$

3. Restrict $\beta_{g}^{k} = \beta_{rg}^{k}$ for all r

Good fit when run same (non-structural) regression in model-generated data

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$$n_{ro}^D = \alpha_{rg}^D + \alpha_o^D + \beta_{rg}^D x_{ro} \text{ for all } o \in \mathcal{O}(g)$$

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Empirical extensions

Native allocations (e.g.)

$$n^D_{ro} = \alpha^D_{rg} + \alpha^D_o + \beta^D_g x_{ro} \text{ for all } o \in \mathcal{O}(g)$$

1. Incorporate national occupation fixed effects
2. Allow for changes over time in the composition of workers (e.g. w/ different education levels e)
   - in dependent variable by estimating regression separately for each native e
   - and in independent variable, $S^I_{ro} n^I_r$, by using

$$x_{ro} \equiv \sum_e S^I_{reo} \frac{\Delta N^I_{re}}{N^I_{re}}$$

3. Restrict $\beta^k_g = \beta^k_{rg}$ for all r

Good fit when run same (non-structural) regression in model-generated data

Endogeneity

Native allocations (e.g.)

- Recall regression $n_{ro}^D = \alpha_{rg}^D + \alpha_o^D + \beta_g^D x_{ro} + \iota_{ro}^D$, where $x_{ro} \equiv \sum_e S_{reo}^I \frac{\Delta N_{re}^I}{N_{re}^I}$
- Possible correlation between x_{ro} and ι_{ro}?
  - α_{rg}^D controls for region and T, N level shocks
  - α_o controls for national occupation-level shocks
  - Remaining concern: $r \times o$ shocks may affect ΔN_{re}^I
    - if immigrants in r concentrate in specific occupations
- Use variant of Card instrument

$$x_{ro}^* \equiv \sum_e S_{reo}^I \frac{\Delta N_{re}^{I*}}{N_{re}^I} \quad \text{with} \quad \Delta N_{re}^{I*} \equiv \sum_s f_{res} \Delta N_{es}^{-r}$$

where s is a source (country or country group) of immigrants

Asm. 1 $r \times o$ shocks uncorrelated with country s immigration in *other* regions times initial concentration of s immigrants in r ($\Delta N_{es}^{-r} \times f_{res}$)

Asm. 2 $r \times o$ shocks uncorrelated initial share of immigrants in $r \times o$ wage bill (S_{reo}^I)

- Also: use S_{-reo}^I, lags on S_{reo}^I, drop manufacturing/routine os, check placebos

Data

Data and definitions (I)

Basics

- Census Integrated Public Use Micro Samples (IPUMS):
  - 1980: 5 percent census; 2012 three-year ACS: 3 percent sample (11-13)
  - Base sample: non-institutionalized individuals between age 16 and 64
  - Foreign-born share of U.S. working age population ↑ from 6.6 to 16.4 percent
- Local labor markets: region = commuting zone (CZ) – ADH (2013)
  - clusters of counties characterized by "strong" commuting ties within, "weak" commuting ties across CZs
  - 722 CZs covering the mainland of the Unites States
- Immigrants: those born outside of U.S. and not born to U.S. citizens
- Instrument:
  - twelve sources (e.g. Mexico, China, India, Western Europe)
  - three education groups (HSD, HSG – SMC, CLG+)
- Education: two domestic groups (SMC-, CLG+)

Data and definitions (II)

Occupation aggregation and tradability

- **Occupation aggregation**: use Census occupation codes
  - Slight aggregation in baseline (50 occupations)
  - Use almost full (aggregate agriculture) disaggregation in robustness (64)
- **Occupation tradability**: Use Blinder and Krueger (JOLE 2013) measure of occupation "offshorability"
  - BK measure based on professional coders' assessment of ease with which each occupation could potentially be offshored
  - Goos et al. (2014) provide evidence supporting this measure:
    - construct an index of actual offshoring by occupation using fact sheets compiled in the European Restructuring Monitor
    - regress measure of actual offshoring by occupation on BK measure
    - they are strongly and positively correlated
  - Grouped into 25 tradable and 25 non-tradable, using median
- Results robust using industries instead of occupations using any of three measures of industry tradability

Data and definitions (II)

Occupation tradability

Most tradable occupations	Least tradable occupations
Fabricators	Firefighting
Printing Machine Operator	Therapists
Woodworking Machine Operator	Construction Trade
Metal and Plastic Processing Operator	Personal Service
Textile Machine Operator	Private Household Occupations
Math and Computer Science	Guards
Records Processing	Vehicle Mechanic
Machine Operator, Other	Electronic Repairer
Precision Production, Food and Textile	Health Assessment
Computer, Communication Equipment Operator	Extractive

- 19 of 50 occupations achieve the minimum tradability measure

Industry tradability

Empirics: Allocation regressions

Domestic allocation results

Ignoring occupation tradability

$$n_{ro}^D = \alpha_r^D + \alpha_o^D + \beta^D x_{ro} + \iota_{ro}^D$$

	(1)	(2)	(3)	(1)	(2)	(3)
		Low Ed			High Ed	
	OLS	2SLS	RF	OLS	2SLS	RF
β^D	-.088	-.1484**	-.0988**	-.1298***	-.2287***	-.2099***
	(.0646)	(.0685)	(.0407)	(.0399)	(.0472)	(.0366)
Obs	33723	33723	33723	26644	26644	26644
R-sq	.822	.822	.822	.68	.68	.679
F-stat (first stage)		129.41			99.59	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%.

- Ignoring differences between more and less tradable occupations: evidence that immigrants crowd out native workers

Domestic allocation results

$$n^D_{ro} = \alpha^D_{rg} + \alpha^D_o + \beta^D x_{ro} + \beta^D_N \mathbb{I}_o(N) x_{ro} + \iota^D_{ro}$$

	(1)	(2) Low Ed	(3)	(1)	(2) High Ed	(3)
	OLS	2SLS	RF	OLS	2SLS	RF
β^D	.089*	.0086	.0053	.0223	-.0335	-.0209
	(.0492)	(.0884)	(.0609)	(.036)	(.066)	(.0599)
β^D_N	-.3034***	-.3034***	-.2383***	-.3088***	-.3734***	-.33***
	(.0615)	(.1011)	(.0906)	(.0973)	(.1261)	(.1133)
Obs	33723	33723	33723	26644	26644	26644
R-sq	.836	.836	.836	.699	.699	.699
Wald Test: P-values	0.00	0.00	0.00	0.00	0.00	0.00
F-stat (first stage)		105.08			72.28	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\beta^D + \beta^D_N = 0$.

1. $\beta^D = 0$: Neither crowding in nor out within T
2. $\beta^D_N < 0$: More crowding out within N than within T
3. $\beta^D + \beta^D_N < 0$: Crowding out within N (Wald test)

Immigrant version Binned scatterplots

Robustness: domestic allocation

- Checking robustness to confounding secular trends
  - Restrict CZs, excluding 5 largest immigrant-receiving CZs Details
  - Sample years:
    - 1980-2007 Details
    - 1990-2012 Details
  - Dropping workers employed in manufacturing industries Details
  - Dropping workers employed in routine-intensive occupations Details
  - Use national S^{I}_{-reo} rather than regional S^{I}_{reo} Details
  - Averaging of 1970, 1980 to calculate S^{I}_{reo} Details
- Checking robustness to definitions of tradability
  - Different cutoffs for occupation tradability Details
  - Occupation aggregation: All 1990 Census occupation codes Details
  - Analysis by industry using three different measures of tradability Details

Empirics: Occupation wage bills

Occupation wage bill

- Assume $wb_{ro} = p_{ro}q_{ro} + \iota_{ro}$ where ι_{ro} uncorrelated with x_{ro} (theory: $\iota_{ro} = 0$)

$$wb_{ro} = \alpha_{rg} + \alpha_o + \gamma x_{ro} + \gamma_N \mathbb{I}_o(N) x_{ro} + \iota_{ro}$$

	(1) OLS	(2) 2SLS	(3) RF
γ	.3918***	.3868**	.3266**
	(.1147)	(.1631)	(.1297)
γ_N	-.3512***	-.4009***	-.3287***
	(.1157)	(.1362)	(.0923)
Obs	34892	34892	34892
R-sq	.897	.897	.897
Wald Test: P-values	0.38	0.89	0.98
F-stat (first stage)		127.82	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\gamma + \gamma_N = 0$.

- $\gamma_N < 0 \iff \epsilon_T > \epsilon_N \iff$ WB $\uparrow$ more w/ exposure in $\mathcal{O}(T)$ than $\mathcal{O}(N)$
- Previous work: wage and employment changes, but not wage bill changes; silent about net impacts on VA across immigrant-intensive industries

Binned scatterplots

Robustness: occupation wage bill

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Extended model and calibration

Extended model

Two extensions

1. Workers differentiated by their education level, e (2 domestic, 3 immigrant)

$$L_{reo}^{k} = T_{reo}^{k} \int_{z \in \mathcal{Z}_{reo}^{k}} \varepsilon(z, o)\, dz$$

where $T_{reo}^{k} = \bar{T}_{reo}^{k} N_r^{\lambda}$, N_r is population in r, and λ governs the extent of regional agglomeration/congestion

- Efficiency units of type k workers perfect substitutes across e

$$L_{ro}^{k} = \sum_{e} L_{reo}^{k}$$

2. Native workers choose in which region to live, following e.g. Redding (2016)

$$N_{re}^{D} = \frac{\left(A_{re}^{D} \frac{Wage_{re}^{D}}{P_r}\right)^{\nu}}{\sum_{j \in \mathcal{R}} \left(A_{je}^{D} \frac{Wage_{je}^{D}}{P_j}\right)^{\nu}} N_e^{D}$$

Data and parameter requirements

- Parameters: Calibration
  - α (trade elasticity), θ (skill dispersion), ν (natives' mobility), λ (aggloremation): literature-based
  - η (occupation substitutability) and ρ (native, immigrant substitutabilty): choose to target allocation regressions
- Initial shares required for "hat algebra"
  - Income share of each of group (k, e) by region
  - Population share of each of domestic education group by region
  - Share of wage payments of each group across occupations by region
  - Since bilateral trade shares by occupation hard to measure
    - ★ Assume no trade costs for $o \in \mathcal{O}(T)$, ∞ trade costs for $o \in \mathcal{O}(N)$, balanced trade by region $\Rightarrow$ need only total occupation production by region
- Changes in immigrant labor supply by education, region
  - Calibration: Card instrument by education and region
  - Two counterfactuals

Extended model

Wage regression

- Model has predictions for changes in occupation wages. Empirical version:

$$w_{ro}^{D} = \alpha_{rg}^{D} + \alpha_{o}^{D} + \chi^{D} x_{ro} + \chi_{N}^{D} \mathbb{I}_{o}\left(N\right) x_{ro} + \iota_{ro}^{D}$$

  - Estimated using model-generated data, we obtain $\chi^{D} = 0$ and $\chi_{N}^{D} = -0.15$
  - roughly equal to $\beta^{D}/(\theta+1)$ and $\beta_{N}^{D}/(\theta+1)$

- Unfortunately do not observe w_{ro}^{D} because of selection
- However, we do observe $wage_{re}^{D}$, which to a first-order approximation is

$$wage_{re}^{D} = \sum w_{ro}^{D} \pi_{reo}^{D}$$

- Combining the two equations and estimating using model-generated data, we obtain $\chi^{D} = 0$ and $\chi_{N}^{D} = -0.17$

Domestic average group wage results

	(1) OLS	(2) 2SLS	(3) RF
$\chi^D + \chi^D_N$	-.8185***	-.9149***	-.7255***
	(.1119)	(.2246)	(.1682)
χ^D	.1984	.2423	.5021***
	(.1217)	(.17)	(.1773)
Obs	1444	1444	1444
R-sq	.679	.665	.673
Wald Test: P-values	0.00	0.00	0.00

Significance levels: * 10%, ** 5%, ***1%. All regressions include an education FE and an occ-ed FE. For the Wald test, the null hypothesis is $\chi^D_N = 0$.

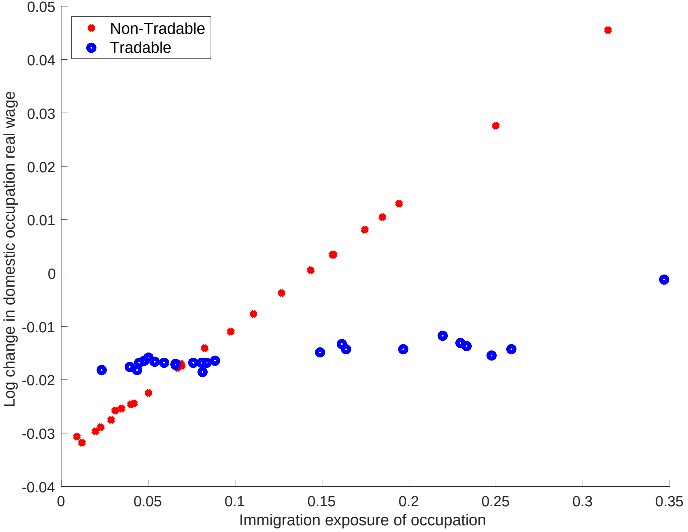
- Consistent with allocation results, exposure to immigration
  - in N decreases average wage ($\chi^D + \chi^D_N < 0$)
  - in N decreases average wage more than in T ($\chi^D_N < 0$)
  - in T has no effect on average wage (in 2SLS)

Aggregate wage effects

Counterfactuals

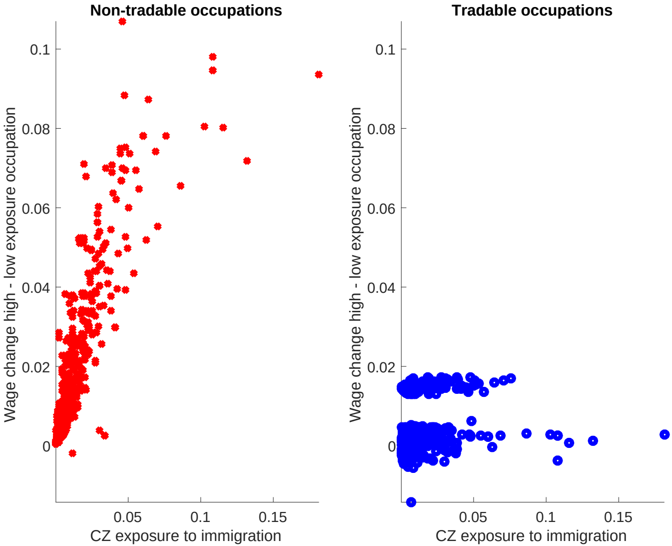
Halve Latin American immigrants

Occupation wage changes in Los Angeles



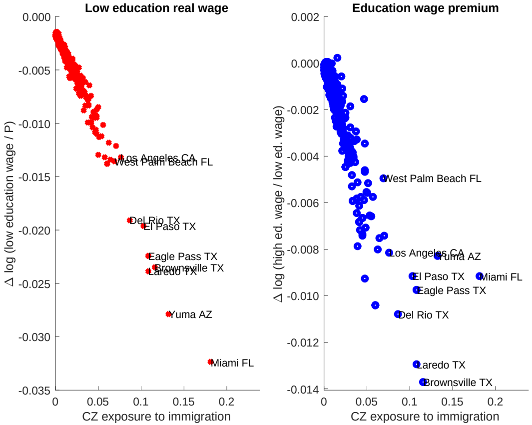
Halve Latin American immigrants

Wage change most - least exposed occupations to immigration



Halve Latin American immigrants

Changes in real wage (low education) and education wage premium

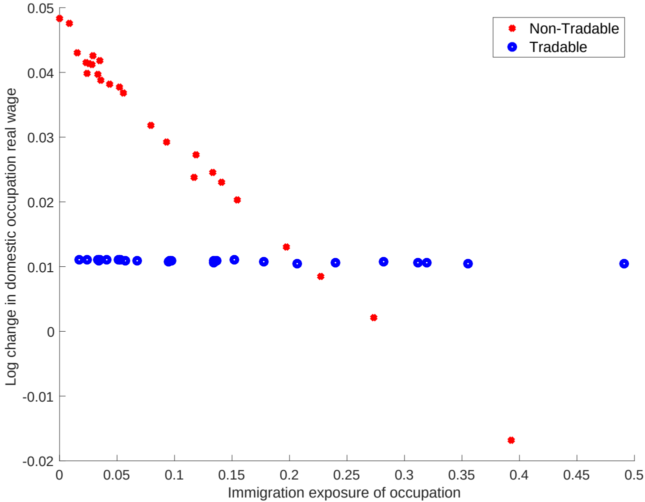


- Left panel: effect largely accounted for by changes P_r not W_r

$$x_r^l \equiv \left| \sum_e S_{re}^l n_{re}^l \right|$$

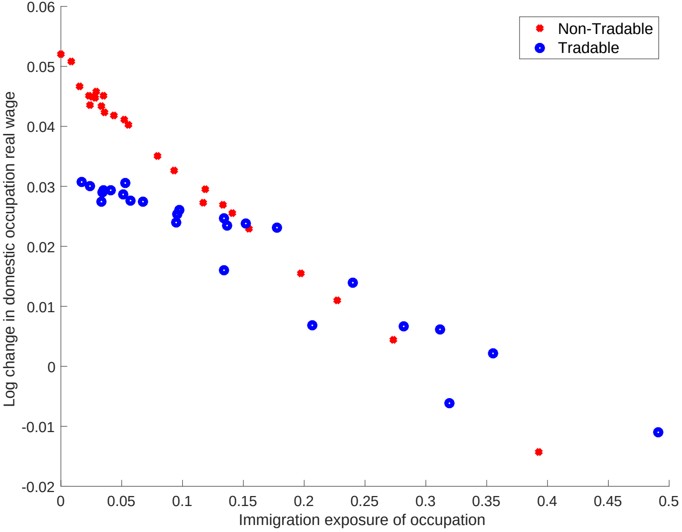
Doubling of college-educated immigrants

Occupation wage changes in Los Angeles (Fixing prices outside of LA, no regional mobility)



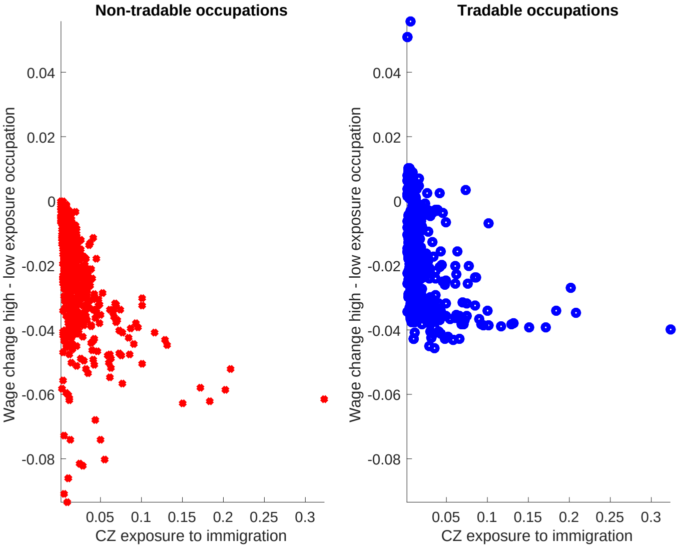
Doubling of college-educated immigrants

Occupation wage changes in Los Angeles (General equilibrium)



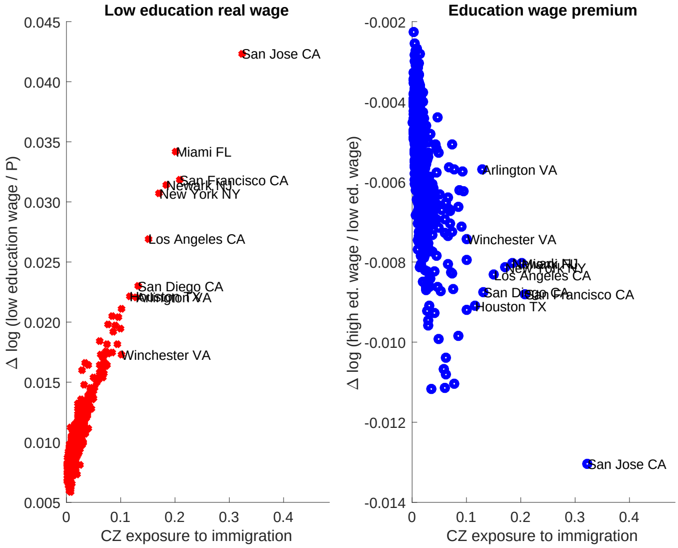
Doubling of college-educated immigrants

Wage change most - least exposed occupations to immigration



Doubling of college-educated immigrants

Changes in real wage (low education) and education wage premium



Conclusions

- Theoretically and empirically investigate differential impact of immigration across workers who are differentially exposed because
  - CZs receive different immigrant supply shocks
  - Immigrants are differentially important across occupations
  - Impact of a shock varies systematically within T vs. within N
    - ⋆ Reviving Rybczynski logic in comparison across differentially tradable jobs
- Theoretically and empirically, show
  1. relatively more crowding in across T occupations than across N occupations
     - ⋆ crowding out within N and neither crowding in nor out within T
  2. $\Rightarrow$ natives that are more exposed to immigration within T benefit relatively more from immigration than those exposed within N
- Quantitatively, show
  - large within CZ effects of immigration
  - nature of the shock matters for impact differential impact within T

APPENDIX

Comments on assumptions

- Fréchet plays a technical role only: $\uparrow$ sloping labor supply curves
  - One of many ways to avoid corner solutions in open economy when goods from different regions are perfect substitutes, $\alpha \to \infty$, as in Rybczynski theorem
  - To dispense with this assumption: $\theta \to \infty$
- CES plays a minor role in analytic results
  - Constant elasticity not relevant for local comparative statics
  - We prove all results without functional forms in simplified model

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Why these features?

Focus: Effect of immigration on reallocation and relative wages across occupations

Model limits to an...

- ... aggregate production function if $A^k_{ro} = A^k_r$ and no regional trade
  - $Q_r = Q_{ro} = \left(\left(A^I_r L^I_{ro}\right)^{\frac{\rho-1}{\rho}} + \left(A^D_r L^D_{ro}\right)^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}}$
  - In this case, changes in factor supplies do not affect
    - relative outputs, prices, wage bills across occupations
    - share of either factor allocated to any occupation
- ... with homogeneous labor within k if $\theta = \infty$
  - In this case, changes in factor supplies do not affect relative wage between two workers within k

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Fixed immigrant wages

- Suppose infinitely elastic supply of immigrants per occupation and region (wages determined in global market)
- Change in productivity of immigrants in region r, common across o
- Comparative statics mirror those in our baseline model (for changes in supply or in productivity of immigrants)
  - crowding in or out, and implications for occupation wages, depend on same comparison of two elasticities
- Special case: occupation price sensitivity $\to 0$, using free-entry condition

$$0 = -S_{ro}^{I} a_{r}^{I} + \left(1 - S_{ro}^{I}\right) w_{ro}^{D} \Rightarrow w_{ro}^{D} = \frac{S_{ro}^{I}}{1 - S_{ro}^{I}} a_{r}^{I}$$

  - Resembles "productivity-effect" of GRH (for w/group, btw/occupation wages)

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Alternative occupation production function

- o output is a Cobb-Douglas combination of a continuum of tasks, $z \in [0, 1]$
- Within k, worker productivity may vary across o, but not across z w/in o
- Efficiency units of D and I are perfect substitutes in z; for $\rho > 1$ output is

$$Y_o(z) = L_o^D(z)\left(\frac{A_o^D}{z}\right)^{\frac{1}{\rho-1}} + L_o^I(z)\left(\frac{A_o^I}{1-z}\right)^{\frac{1}{\rho-1}}$$

- Task cost function is $C_o(z) = \min\{C_o^D(z), C_o^I(z)\}$
- Alternative assumptions yield same equilibrium conditions:

$$P_o = \exp\left(\frac{1}{1-\rho}\right)\left(A_o^D(W_o^D)^{1-\rho} + A_o^I(W_o^I)^{1-\rho}\right)^{\frac{1}{1-\rho}}$$

$$\frac{L_o^D}{L_o^I} = \frac{A_o^D}{A_o^I}\left(\frac{W_o^D}{W_o^I}\right)^{-\rho}$$

- Equivalently, Eaton and Kortum (2002) Fréchet assumptions
  - See Dekle, Eaton, and Kortum (2007)

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Comparative statics: autarky

Relation to Rybczynski

- Our results strictly extend the Rybczynski (1955) theorem
  - Imposes: homogeneous factors ($\theta = \infty$), two goods ($O = 2$), fixed relative occupation prices ($\eta = \infty$)
  - Predicts: if $S^I_{r1} > S^I_{r2}$ and $n^I_r > n^D_r$, then $q_{r1} > n^I_r > n^D_r > q_{r2}$
    - ★ Corollary: $n^k_{r1} = q_{r1} > n^I_r > n^D_r > q_{r2} = n^k_{r2}$
- In a special case of our model (more general than Rybczynski theorem) without specific functional forms for production functions, we obtain a simplified version of our extended Rybczynski theorem above:
  - immigration induces crowding in or crowding out depending on a simple comparison of *local* elasticities
- Also related to Acemoglu and Guerrieri (2008):
  - Imposes: homogeneous factors ($\theta = \infty$), two goods ($O = 2$), Cobb-Douglas good production function ($\rho = 1$)
  - Predicts: crowding in if and only if $\eta > 1$

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Comparative statics: changes in aggregate productivity

- Immigration may affect aggregate regional productivity (i.e. $\Rightarrow a_r \neq 0$)
  - congestion externalities: immigrant inflow reduces productivity ($a_r < 0$)
  - agglomeration externalities: immigrant inflow increases productivity ($a_r > 0$)
- All analytic results proven allowing for arbitrary a_r. These results are *relative across occupations within a region*.
- Implications of $a_r \neq 0$ *for aggregates* straightforward in two cases:
  1. region r is autarkic or
  2. region r is a small open economy and $\alpha = \infty$
- In either case, changes in prices and quantities satisfy

$$n_{ro}^{k} = p_{ro}^{y} = p_{ro} = \tilde{w}_r = 0$$
$$w_{ro}^{k} = q_{ro} = y_r = a_r$$

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Industry tradability

- Use geographical Herfindahl index following Mian and Sufi, 2014

Most tradable industries	Least tradable industries
Tobacco manufactures	Agriculture, forestry and fisheries
Transportation equipment	Utilities and sanitary services
Entertainment and recreation industries	Construction
Professional and photographic equipment	Food and kindred products
Petroleum and coal products	Lumber, woods products (except furniture)
Toys, amusement and sporting goods	Paper and allied products
Printing, publishing and allied industries	Stone, clay, glass and concrete products
Apparel and other finished textile products	Mining
Manufacturing industries, others	Retail trade
Finance, insurance and real estate	Personal services

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Immigrant allocation results

- Conduct same exercises for changes in immigrant allocations
  - Consider three immigrant groups: HSD-, HSG & SMC, COL+

	(1a)	(2a) Low Ed	(3a)	(1b)	(2b) Med Ed	(3b)	(1c)	(2c) High Ed	(3c)
	OLS	2SLS	RF	OLS	2SLS	RF	OLS	2SLS	RF
β^I	.3345	.6316	.1753	-.2132	-.3846	-.26	-.8253***	-1.391***	-.9635***
	(.2889)	(.6106)	(.3309)	(.1937)	(.3099)	(.1934)	(.1717)	(.265)	(.1971)
β^I_N	-1.425***	-2.036**	-1.379***	-.8943***	-1.203***	-.8488***	-.4716***	-.6842**	-.3991**
	(.3988)	(.8431)	(.379)	(.2317)	(.3529)	(.134)	(.1736)	(.2895)	(.1814)
Obs	5042	5042	5042	13043	13043	13043	6551	6551	6551
R-sq	.798	.797	.799	.729	.728	.73	.658	.649	.662
Wald Test: P-values	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F-stat (first stage)		863.39			185.66			128.32	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\beta^I + \beta^I_N = 0$.

- Results strongly consistent with theory

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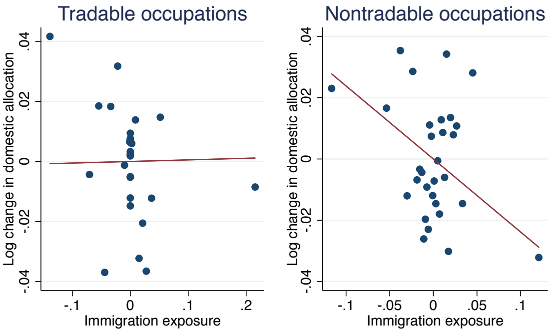
Domestic allocation results: Low Education

Binned scatterplots



Binscatter for β^D (left panel) and β_N^D (right panel) for low education

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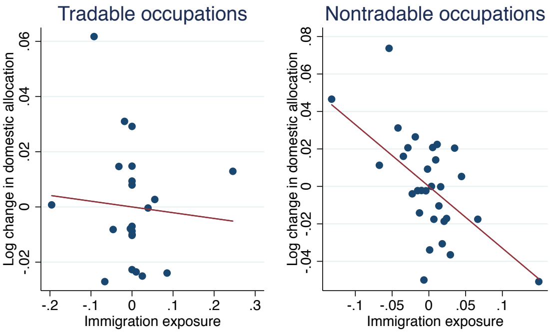
Domestic allocation results: High Education

Binned scatterplots



Binscatter for β^D (left panel) and β^D_N (right panel) for high education

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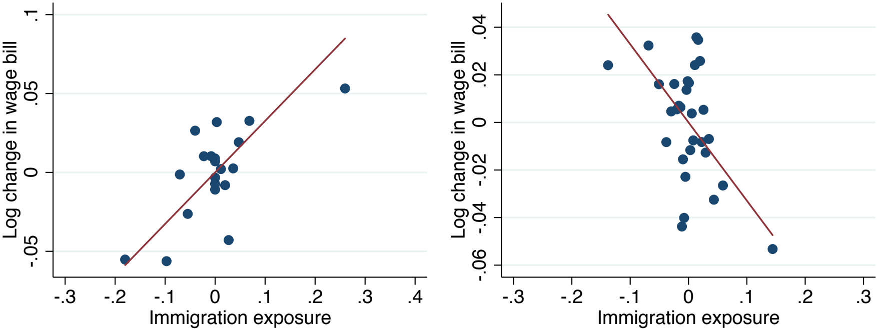
Occupation wage bill

Binned scatterplots



Binscatter for γ (left panel) and γ_N (right panel)

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Robustness: Drop top 5 immigrant-receiving CZs

- Drop 5 largest immigrant-receiving CZs:
  - LA/Riverside/Santa Ana
  - New York
  - Miami
  - Washington DC
  - Houston

	(1)	(2) Low Ed	(3)	(1)	(2) High Ed	(3)
	OLS	2SLS	RF	OLS	2SLS	RF
β^D	.0881	.0406	.0274	.0084	-.0544	-.0508
	(.0534)	(.0895)	(.0739)	(.0431)	(.0722)	(.0597)
β^D_N	-.2722***	-.3577***	-.3422***	-.1791**	-.2222*	-.1961
	(.0854)	(.0779)	(.0934)	(.0874)	(.1295)	(.1182)
Obs	33473	33473	33473	26405	26405	26405
R-sq	.827	.827	.827	.687	.687	.687
Wald Test: P-values	0.04	0.00	0.00	0.03	0.00	0.01
F-stat (first stage)		26.98			35.39	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\beta^D + \beta^D_N = 0$.

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Robustness: Terminal year (1980-2007)

	(1)	(2)	(3)	(1)	(2)	(3)
		Low Ed			High Ed	
	OLS	2SLS	RF	OLS	2SLS	RF
β^D	.081	-.0404	-.0495	-.0341	-.0967	-.1033
	(.0797)	(.1525)	(.1059)	(.0436)	(.0665)	(.0764)
β^D_N	-.4851***	-.4517**	-.3543*	-.3301***	-.3677***	-.3093***
	(.0858)	(.1895)	(.1915)	(.0988)	(.1152)	(.086)
Obs	31596	31596	31596	23215	23215	23215
R-sq	.789	.789	.788	.649	.648	.649
Wald Test: P-values	0.00	0.00	0.00	0.00	0.00	0.00
F-stat (first stage)		134.76			73.53	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\beta^D + \beta^D_N = 0$.

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Robustness: Start year (1990-2012)

	(1)	(2)	(3)	(1)	(2)	(3)
		Low Ed			High Ed	
	OLS	2SLS	RF	OLS	2SLS	RF
β^D	.1875**	.1396	.1908**	-.0481	-.2219*	-.146
	(.0895)	(.1035)	(.0768)	(.0892)	(.1316)	(.1187)
β_N^D	-.2702**	.0145	-.0068	-.216**	-.3388***	-.3051***
	(.1148)	(.3739)	(.2308)	(.1053)	(.1311)	(.1118)
Obs	33957	33957	33957	28089	28089	28089
R-sq	.776	.776	.776	.601	.6	.602
Wald Test: P-values	0.25	0.60	0.36	0.00	0.00	0.00
F-stat (first stage)		55.35			47.28	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\beta^D + \beta_N^D = 0$.

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Robustness: tradability cutoff (23 T and 23 NT)

Include the top 23 most tradable (and least tradable) occupations, dropping 4 middle occupations

	(1)	(2)	(3)	(1)	(2)	(3)
		Low Ed			High Ed	
	OLS	2SLS	RF	OLS	2SLS	RF
β^D	.1824***	.0745	.0599	.1063**	.043	.05
	(.0594)	(.0888)	(.0663)	(.0521)	(.0897)	(.0901)
β^D_N	-.3914***	-.401***	-.3439***	-.3921***	-.4523***	-.4008***
	(.0846)	(.0917)	(.0828)	(.1092)	(.1384)	(.1256)
Obs	30835	30835	30835	24038	24038	24038
R-sq	.831	.831	.831	.697	.696	.697
Wald Test: P-values	0.01	0.00	0.00	0.00	0.00	0.00
F-stat (first stage)		112.65			71.65	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\beta^D + \beta^D_N = 0$.

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Robustness: tradability cutoff (21 T and 21 NT)

Include the top 21 most tradable (and least tradable) occupations, dropping 8 middle occupations

	(1)	(2)	(3)	(1)	(2)	(3)
		Low Ed			High Ed	
	OLS	2SLS	RF	OLS	2SLS	RF
β^D	.2383***	.1571*	.1177*	.0866*	.0332	.0436
	(.0585)	(.0849)	(.0673)	(.0511)	(.0869)	(.0868)
β_N^D	-.4393***	-.4809***	-.3941***	-.3964***	-.4863***	-.4239***
	(.0958)	(.0948)	(.0874)	(.1096)	(.1317)	(.1171)
Obs	28035	28035	28035	21262	21262	21262
R-sq	.827	.827	.827	.692	.691	.692
Wald Test: P-values	0.02	0.00	0.00	0.00	0.00	0.00
F-stat (first stage)		105.66			63.63	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\beta^D + \beta_N^D = 0$.

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Robustness: tradability cutoff (30 T and 20 NT)

Separate 50 occupations into 30 tradable and 20 non-tradable occupations

	(1)	(2) Low Ed	(3)	(1)	(2) High Ed	(3)
	OLS	2SLS	RF	OLS	2SLS	RF
β^D	.0353	-.0846	-.0407	-.0114	-.0683	-.0617
	(.0508)	(.0846)	(.0571)	(.0308)	(.0551)	(.0488)
β^D_N	-.2262***	-.2515***	-.2448***	-.3026***	-.382***	-.3042***
	(.0727)	(.0813)	(.0752)	(.0928)	(.1155)	(.0934)
Obs	33723	33723	33723	26644	26644	26644
R-sq	.832	.832	.832	.7	.7	.7
Wald Test: P-values	0.02	0.00	0.00	0.00	0.00	0.00
F-stat (first stage)		99.52			53.11	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\beta^D + \beta^D_N = 0$.

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Robustness: tradability cutoff (20 T and 30 NT)

Separate 50 occupations into 20 tradable and 30 non-tradable occupations

	(1)	(2)	(3)	(1)	(2)	(3)
		Low Ed			High Ed	
	OLS	2SLS	RF	OLS	2SLS	RF
β^D	.232***	.1484*	.1156*	.0867	.0267	.0454
	(.0585)	(.0844)	(.067)	(.0574)	(.0943)	(.0919)
β^D_N	-.3931***	-.2963***	-.2335***	-.3181***	-.3521***	-.3248***
	(.084)	(.083)	(.0735)	(.0936)	(.1186)	(.1151)
Obs	33723	33723	33723	26644	26644	26644
R-sq	.84	.84	.839	.698	.698	.699
Wald Test: P-values	0.01	0.00	0.00	0.00	0.00	0.00
F-stat (first stage)		117.27			58.42	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\beta^D + \beta^D_N = 0$.

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Robustness: Drop manufacturing industries

Drop observations in manufacturing industries

	(1)	(2)	(3)	(1)	(2)	(3)
		Low Ed			High Ed	
	OLS	2SLS	RF	OLS	2SLS	RF
β^D	.0888***	.1151**	.0808*	-.001	-.0622	-.0528
	(.0325)	(.0554)	(.0436)	(.0298)	(.0478)	(.0401)
β^D_N	-.249***	-.3847***	-.2964***	-.2523***	-.3121***	-.2522***
	(.0448)	(.0662)	(.0567)	(.0792)	(.0938)	(.0788)
Obs	32022	32022	32022	24581	24581	24581
R-sq	.785	.784	.785	.687	.686	.687
Wald Test: P-values	0.01	0.00	0.00	0.00	0.00	0.00
F-stat (first stage)		103.77			149.30	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\beta^D + \beta^D_N = 0$.

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Robustness: Drop routine-intensive occupations

Drop workers employed in the most routine-intensive occupations ($\geq$ 75th percentile)

	(1)	(2) Low Ed	(3)	(1)	(2) High Ed	(3)
	OLS	2SLS	RF	OLS	2SLS	RF
β^D	.0826*	.1375**	.11	-.0517	-.0746	-.0517
	(.0442)	(.0655)	(.0672)	(.036)	(.0614)	(.057)
β^D_N	-.3045***	-.4347***	-.3592***	-.2212**	-.3263**	-.2901**
	(.0972)	(.0831)	(.0643)	(.0921)	(.1284)	(.1146)
Obs	32997	32997	32997	24693	24693	24693
R-sq	.822	.822	.822	.706	.706	.707
Wald Test: P-values	0.01	0.00	0.00	0.00	0.00	0.00
F-stat (first stage)		80.33			73.75	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\beta^D + \beta^D_N = 0$.

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Robustness: Using S^I_{-reo} instead of S^I_{reo}

Use the national immigrant cost share of occupation o

	(1)	(2)	(3)	(1)	(2)	(3)
		Low Ed			High Ed	
	OLS	2SLS	RF	OLS	2SLS	RF
β^D	.089*	1.154*	.6561*	.0223	.2168	.0711
	(.0492)	(.6034)	(.3382)	(.036)	(.3651)	(.2351)
β^D_N	-.3034***	-1.817***	-1.163***	-.3088***	-2.565***	-2.064***
	(.0615)	(.5879)	(.4443)	(.0973)	(.4197)	(.5177)
Obs	33723	33723	33723	26644	26644	26644
R-sq	.836	.822	.836	.699	.623	.701
Wald Test: P-values	0.00	0.01	0.04	0.00	0.00	0.00
F-stat (first stage)		8.88			16.27	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\beta^D + \beta^D_N = 0$.

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Robustness: Averaging 1970 and 1980 for S^I_{reo}

Use the average values in 1970 and 1980 to calculate immigrant share of labor payment, S^I_{reo}

	(1)	(2)	(3)	(1)	(2)	(3)
		Low Ed			High Ed	
	OLS	2SLS	RF	OLS	2SLS	RF
β^D	.089*	-.0009	-.0049	.0223	-.0728	-.0375
	(.0492)	(.0931)	(.058)	(.036)	(.0718)	(.0473)
β^D_N	-.3034***	-.3007***	-.2272***	-.3088***	-.5027***	-.2387**
	(.0615)	(.1153)	(.0856)	(.0973)	(.1767)	(.1038)
Obs	33723	33723	33723	26644	26644	26644
R-sq	.836	.836	.836	.699	.697	.699
Wald Test: P-values	0.00	0.00	0.00	0.00	0.00	0.00
F-stat (first stage)		102.93			83.89	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\beta^D + \beta^D_N = 0$.

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Robustness: 1990 Census Occupation Codes

	(1)	(2)	(3)	(1)	(2)	(3)
		Low Ed			High Ed	
	OLS	2SLS	RF	OLS	2SLS	RF
β^D	.1185**	.0363	.0231	.0094	.001	.0077
	(.0577)	(.1048)	(.0764)	(.0312)	(.0576)	(.0504)
β^D_N	-.1376*	-.081	-.0423	-.2684***	-.3983***	-.3435***
	(.0736)	(.0913)	(.0751)	(.0869)	(.1133)	(.0992)
Obs	42226	42226	42226	32405	32405	32405
R-sq	.834	.834	.834	.681	.68	.681
Wald Test: P-values	0.76	0.41	0.60	0.00	0.00	0.00
F-stat (first stage)		91.06			28.7	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\beta^D + \beta^D_N = 0$.

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Robustness: Industry analysis

- 34 industries: sub-headings of 1990 Census Industry Classification System

(1) Tradability: use geographical Herfindahl index following Mian and Sufi, 2014

	(1)	(2)	(3)	(1)	(2)	(3)
		Low Ed			High Ed	
	OLS	2SLS	RF	OLS	2SLS	RF
β^D	.2907*	.4908	.5968*	.3276**	.3569*	.5005**
	(.1742)	(.3402)	(.3523)	(.1669)	(.2143)	(.2207)
β_N^D	-.3994**	-.6781***	-.72***	-.5129***	-.8084***	-.8323***
	(.163)	(.2371)	(.2285)	(.1826)	(.2245)	(.1603)
Obs	22789	22789	22789	17924	17924	17924
R-sq	.821	.821	.822	.709	.709	.71
Wald Test: P-values	0.09	0.18	0.39	0.08	0.01	0.04
F-stat (first stage)		74.79			303.29	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\beta^D + \beta_N^D = 0$.

Back

Robustness: Industry analysis

(2) Tradability: Use Mian and Sufi (2014)'s industry tradability measure directly

	(1)	(2) Low Ed	(3)	(1)	(2) High Ed	(3)
	OLS	2SLS	RF	OLS	2SLS	RF
β^D	.0533	.202	.3287	.1379	.2336	.2982**
	(.134)	(.3541)	(.3511)	(.0994)	(.1582)	(.1415)
β_N^D	.0367	-.1272	-.2625	-.2079	-.4766**	-.4024**
	(.1288)	(.2653)	(.2543)	(.1287)	(.1982)	(.1676)
Obs	22789	22789	22789	17924	17924	17924
R-sq	.818	.817	.818	.707	.707	.708
Wald Test: P-values	0.32	0.56	0.58	0.64	0.35	0.67
F-stat (first stage)		104.58			315.96	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\beta^D + \beta_N^D = 0$.

Back

Robustness: Industry analysis

(3) Tradability: categorize

- (T) goods-producing industries: agriculture, mining and manufacturing
- (N) service industries

	(1)	(2)	(3)	(1)	(2)	(3)
		Low Ed			High Ed	
	OLS	2SLS	RF	OLS	2SLS	RF
β^D	.2441**	.5744	.6119	.4303***	.5429	.5789**
	(.1168)	(.4335)	(.4063)	(.1313)	(.3904)	(.2888)
β^D_N	-.3473**	-.4971	-.4842	-.7248***	-.9742**	-.8986***
	(.1372)	(.4113)	(.3481)	(.1803)	(.4814)	(.318)
Obs	22067	22067	22067	17202	17202	17202
R-sq	.827	.826	.828	.723	.723	.723
Wald Test: P-values	0.35	0.46	0.27	0.01	0.00	0.01
F-stat (first stage)		51.65			81.62	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\beta^D + \beta^D_N = 0$.

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Robustness: Drop top 5 immigrant-receiving CZs

- Drop 5 largest immigrant-receiving CZs:
  - LA/Riverside/Santa Ana
  - New York
  - Miami
  - Washington DC
  - Houston

	(1) OLS	(2) 2SLS	(3) RF
γ	.2844*** (.0736)	.1696 (.1053)	.1388 (.1016)
γ_N	-.2067** (.0881)	-.1979** (.0969)	-.1829** (.0931)
Obs	34642	34642	34642
R-sq	.895	.895	.895
Wald Test: P-values	0.14	0.58	0.35
F-stat (first stage)		36.98	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\gamma + \gamma_N = 0$.

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Robustness: Terminal year (1980-2007)

	(1) OLS	(2) 2SLS	(3) RF
γ	.4057***	.4454***	.328***
	(.0993)	(.1246)	(.0926)
γ_N	-.5488***	-.6431***	-.4809***
	(.2034)	(.1286)	(.0933)
Obs	33200	33200	33200
R-sq	.853	.853	.852
Wald Test: P-values	0.27	0.04	0.10
F-stat (first stage)		160.91	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\gamma + \gamma_N = 0$.

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Robustness: Start year (1990-2012)

	(1) OLS	(2) 2SLS	(3) RF
γ	.5592***	.5133***	.7175***
	(.0818)	(.1302)	(.1192)
γ_N	-.4636***	-.2602*	-.5572***
	(.091)	(.1497)	(.0945)
Obs	35127	35127	35127
R-sq	.869	.869	.87
Wald Test: P-values	0.08	0.17	0.02
F-stat (first stage)		67.81	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\gamma + \gamma_N = 0$.

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Robustness: tradability cutoff (23 T and 23 NT)

Include the top 23 most tradable (and least tradable) occupations, dropping 4 middle occupations

	(1) OLS	(2) 2SLS	(3) RF
γ	.5961***	.6624***	.4943***
	(.1253)	(.1468)	(.1068)
γ_N	-.5629***	-.7093***	-.5223***
	(.1321)	(.1357)	(.0855)
Obs	32004	32004	32004
R-sq	.897	.896	.896
Wald Test: P-values	0.45	0.61	0.70
F-stat (first stage)		134.40	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\gamma + \gamma_N = 0$.

Back

Robustness: tradability cutoff (21 T and 21 NT)

Include the top 21 most tradable (and least tradable) occupations, dropping 8 middle occupations

	(1) OLS	(2) 2SLS	(3) RF
γ	.5898***	.6554***	.5115***
	(.1276)	(.1563)	(.1109)
γ_N	-.5533***	-.6957***	-.5321***
	(.1332)	(.1316)	(.0843)
Obs	29122	29122	29122
R-sq	.893	.893	.892
Wald Test: P-values	0.41	0.65	0.77
F-stat (first stage)		150.63	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\gamma + \gamma_N = 0$.

Back

Robustness: tradability cutoff (30 T and 20 NT)

Separate 50 occupations into 30 tradable and 20 non-tradable occupations

	(1) OLS	(2) 2SLS	(3) RF
γ	.349***	.2964*	.2742**
	(.1037)	(.1515)	(.1265)
γ_N	-.3232***	-.3465***	-.3023***
	(.0926)	(.0822)	(.0676)
Obs	34892	34892	34892
R-sq	.895	.895	.895
Wald Test: P-values	0.52	0.59	0.70
F-stat (first stage)		153.04	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\gamma + \gamma_N = 0$.

Back

Robustness: tradability cutoff (20 T and 30 NT)

Separate 50 occupations into 20 tradable and 30 non-tradable occupations

	(1) OLS	(2) 2SLS	(3) RF
γ	.6055***	.6847***	.5256***
	(.1317)	(.162)	(.1139)
γ_N	-.5629***	-.6817***	-.5043***
	(.1244)	(.122)	(.0863)
Obs	34892	34892	34892
R-sq	.902	.901	.901
Wald Test: P-values	0.31	0.97	0.75
F-stat (first stage)		98.59	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\gamma + \gamma_N = 0$.

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Robustness: Drop manufacturing industries

Drop observations in manufacturing industries

	(1) OLS	(2) 2SLS	(3) RF
γ	.0962**	.0036	.0108
	(.0441)	(.062)	(.0523)
γ_N	-.0411	-.0311	-.0353
	(.0492)	(.0685)	(.0508)
Obs	33367	33367	33367
R-sq	.858	.858	.858
Wald Test: P-values	0.12	0.59	0.47
F-stat (first stage)		122.67	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\gamma + \gamma_N = 0$.

Back

Robustness: Drop routine-intensive occupations

Drop workers in the most routine-intensive occupations ($\geq$ 75th percentile)

	(1) OLS	(2) 2SLS	(3) RF
γ	.3282**	.3854*	.3458**
	(.1341)	(.2166)	(.1755)
γ_N	-.2904**	-.4286**	-.3768***
	(.1382)	(.1756)	(.1256)
Obs	33817	33817	33817
R-sq	.89	.89	.891
Wald Test: P-values	0.46	0.69	0.70
F-stat (first stage)		97.61	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\gamma + \gamma_N = 0$.

Back

Robustness: Using S^I_{-reo} instead of S^I_{reo}

Use the national immigrant cost share of occupation o

	(1) OLS	(2) 2SLS	(3) RF
γ	.3918***	2.299***	1.081**
	(.1147)	(.4259)	(.4653)
γ_N	-.3512***	-2.296***	-1.275***
	(.1157)	(.441)	(.4854)
Obs	34892	34892	34892
R-sq	.897	.863	.896
Wald Test: P-values	0.38	0.99	0.34
F-stat (first stage)		9.34	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\gamma + \gamma_N = 0$.

Back

Robustness: Averaging 1970 and 1980 for S^I_{reo}

Use the average values in 1970 and 1980 to calculate immigrant share of labor payment, S^I_{reo}

	(1) OLS	(2) 2SLS	(3) RF
γ	.3918***	.592**	.3582**
	(.1147)	(.2319)	(.1541)
γ_N	-.3512***	-.6301***	-.3794***
	(.1157)	(.2223)	(.1392)
Obs	34892	34892	34892
R-sq	.897	.897	.897
Wald Test: P-values	0.38	0.62	0.70
F-stat (first stage)		141.15	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\gamma + \gamma_N = 0$.

Back

Robustness: 1990 Census Occupation Codes

	(1) OLS	(2) 2SLS	(3) RF
γ	.3655***	.3594**	.3271***
	(.0994)	(.1473)	(.124)
γ_N	-.1811**	-.164	-.1377
	(.0842)	(.1105)	(.0906)
Obs	44296	44296	44296
R-sq	.893	.893	.892
Wald Test: P-values	0.00	0.03	0.00
F-stat (first stage)		154.86	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\gamma + \gamma_N = 0$.

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Robustness: Industry analysis

- 34 industries: sub-headings of 1990 Census Industry Classification System

(1) Tradability: use geographical Herfindahl index following Mian and Sufi, 2014

	(1) OLS	(2) 2SLS	(3) RF
γ	.5301*	.8334*	.8106**
	(.2829)	(.4563)	(.359)
γ_N	-.4665	-.7836*	-.8098**
	(.2994)	(.457)	(.3499)
Obs	22736	22736	22736
R-sq	.831	.831	.833
Wald Test: P-values	0.47	0.68	0.99
F-stat (first stage)		90.13	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\gamma + \gamma_N = 0$.

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Robustness: Industry analysis

(2) Tradability: Use Mian and Sufi (2014)'s industry tradability measure directly

	(1) OLS	(2) 2SLS	(3) RF
γ	.3683**	.8298**	.6888**
	(.1744)	(.3579)	(.2757)
γ_N	-.1855	-.7337**	-.6164***
	(.1605)	(.2935)	(.2237)
Obs	22736	22736	22736
R-sq	.827	.825	.828
Wald Test: P-values	0.06	0.54	0.46
F-stat (first stage)		131.86	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\gamma + \gamma_N = 0$.

Back

Robustness: Industry analysis

(3) Tradability: categorize

- (T) goods-producing industries: agriculture, mining and manufacturing
- (N) service industries

	(1) OLS	(2) 2SLS	(3) RF
γ	.4437***	.9535**	.7295**
	(.1661)	(.4569)	(.3101)
γ_N	-.4743***	-.8382*	-.5719*
	(.1803)	(.5033)	(.3148)
Obs	22014	22014	22014
R-sq	.838	.836	.839
Wald Test: P-values	0.80	0.35	0.16
F-stat (first stage)		61.31	

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. For the Wald test, the null hypothesis is $\gamma + \gamma_N = 0$.

Back

Aggregate immigration wage effects

$$wage^D_{rCLG+} - wage^D_{rSMC-} = \beta_0 + \beta_1 \left(x^I_{rCLG+} - x^I_{rSMC-} \right) + \beta_2 z_r + \zeta_r$$

	(1) OLS	(2) 2SLS	(3) RF
β_1	-.0233	-.0103	-.0105
	(.0247)	(.0367)	(.0378)
Obs	722	722	722
R-sq	.49	.48	.49

Standard errors clustered by state in parentheses. Significance levels: * 10%, ** 5%, ***1%. All regressions include a constant term, the initial share of employment in manufacturing, initial share of employment in routine occupations, initial log ratio of college-educated to non-college education adults, and initial share of women in employment.

Model (without controls): $\beta = -0.066$, $R^2 = 0.53$

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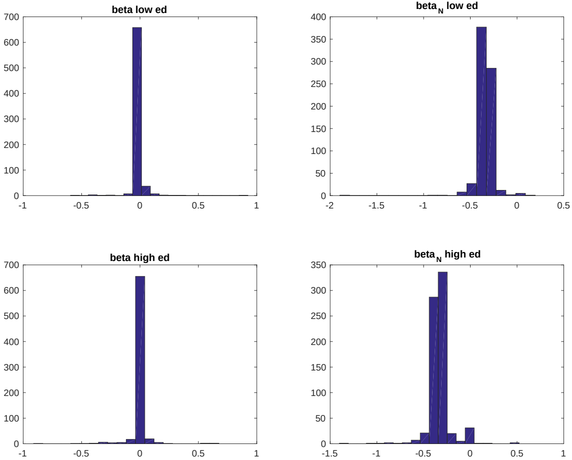
Assigning parameter values

- Literature-based
  - $\alpha = 5$ (trade elasticity $= \alpha - 1 = 4$)
  - $\theta = 1$ (BMV 2016 and HHJK 2016) $\rightarrow \frac{w_{ro}^k - w_{ro'}^k}{n_{ro}^k - n_{ro'}^k} = \frac{1}{\theta+1} = 0.5$
  - $\nu = 1.5$ (review of estimates in FMSZ 2016) $\rightarrow \frac{n_{re}^D - n_{r'e}^D}{wage_{re}^D - wage_{r'e}^D - p_r + p_{r'}} = \nu = 1.5$
  - $\lambda = 0.05$ (review of estimates in Combes and Gobillon 2015)
- Choose η and ρ to target:
  - domestic allocation RF regression: $0.5 \times (\beta^{LD} + \beta^{HD}) = 0$
  - domestic allocation RF regression: $0.5 \times (\beta_N^{LD} + \beta_N^{HD}) = -0.295$
    - ⋆ $\rho = 5$, $\eta = 1.93$

Assigning parameter values

- Literature-based
  - $\alpha = 5$ (trade elasticity $= \alpha - 1 = 4$)
  - $\theta = 1$ (BMV 2016 and HHJK 2016) $\rightarrow \frac{w^k_{ro} - w^k_{ro'}}{n^k_{ro} - n^k_{ro'}} = \frac{1}{\theta+1} = 0.5$
  - $\nu = 1.5$ (review of estimates in FMSZ 2016) $\rightarrow \frac{n^D_{re} - n^D_{r'e}}{wage^D_{re} - wage^D_{r'e} - p_r + p_{r'}} = \nu = 1.5$
  - $\lambda = 0.05$ (review of estimates in Combes and Gobillon 2015)
- Choose η and ρ to target:
  - domestic allocation RF regression: $0.5 \times (\beta^{LD} + \beta^{HD}) = 0$
  - domestic allocation RF regression: $0.5 \times (\beta^{LD}_N + \beta^{HD}_N) = -0.295$
    - $\rho = 5$, $\eta = 1.93$
- Additional remarks on allocation regressions:
  - for natives and immigrants: $R^2 = 0.99$
  - immigrants: $\beta^{eD} < 0$, $\beta^{eD}_N < 0$, consistent with data

Cross-CZ variation in β_r and β_{Tr}



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Comparative statics: no trade (I)

- Log change in relative quantities and prices

$$q_{ro} - q_{ro'} = \frac{\eta(\theta+\rho)}{\theta+\eta}\tilde{w}_r\left(S^I_{ro} - S^I_{ro'}\right)$$

$$p_{ro} - p_{ro'} = -\frac{1}{\eta}\left(q_{ro} - q_{ro'}\right)$$

  - $\tilde{w}_r \equiv w^D_{ro} - w^I_{ro} = \left(n^I_r - n^D_r\right)\Psi_r$ and $\Psi_r > 0$ (instance of law of demand)

- $n^I_r > n^D_r \iff \tilde{w}_r > 0 \iff$
  - $\uparrow$ in output of immigrant-intensive occupations
  - $\downarrow$ in price of immigrant-intensive occupations
  - $\uparrow$ ($\downarrow$) in wage bill of immigrant-intensive occupations if $\eta > 1$ ($\eta < 1$)

- higher value of $\eta \Rightarrow$
  1. $\uparrow q_{ro} - q_{ro'}$,
  2. $\downarrow |p_{ro} - p_{ro'}|$, and
  3. $\uparrow wb_{ro} - wb_{ro'}$

Comparative statics: no trade (II)

- Log change in relative factor allocations and occupation wages for $k = D, I$

$$n^k_{ro} - n^k_{ro'} = \frac{\theta + 1}{\theta + \eta} \tilde{w}_r \left(S^I_{ro} - S^I_{ro'} \right) (\eta - \rho)$$

$$w^k_{ro} - w^k_{ro'} = \frac{n^k_{ro} - n^k_{ro'}}{\theta + 1}$$

  - $\tilde{w}_r \equiv w^D_{ro} - w^I_{ro} = \left(n^I_r - n^D_r \right) \Psi_r$ and $\Psi_r > 0$ (instance of law of demand)

- $n^I_r > n^D_r \iff \tilde{w}_r > 0 \iff$
  - share of k workers in I-intensive occupations rises iff $\eta > \rho$

Comparative statics: no trade (II)

- Log change in relative factor allocations and occupation wages for $k = D, I$

$$n^k_{ro} - n^k_{ro'} = \frac{\theta + 1}{\theta + \eta} \tilde{w}_r \left(S^I_{ro} - S^I_{ro'} \right) (\eta - \rho)$$

$$w^k_{ro} - w^k_{ro'} = \frac{n^k_{ro} - n^k_{ro'}}{\theta + 1}$$

  - $\tilde{w}_r \equiv w^D_{ro} - w^I_{ro} = \left(n^I_r - n^D_r \right) \Psi_r$ and $\Psi_r > 0$ (instance of law of demand)

- $n^I_r > n^D_r \iff \tilde{w}_r > 0 \iff$
  - share of k workers in I-intensive occupations rises iff $\eta > \rho$. Intuition:
    - ★ $\rho \to 0 \Rightarrow$ factor ratios insensitive w/in each o, crowding-in dominates
    - ★ $\eta \to 0 \Rightarrow$ output ratios insensitive across o, crowding-out dominates
  - occupation wages adjust to induce workers to reallocate (for any $\theta < \infty$)

Comparative statics: small open economy (results)

- All comparative static expressions across two occupations within $g = T, N$ same as in closed economy, with η replaced by ϵ_{rT} or ϵ_{rN}, e.g.

$$n^k_{ro} - n^k_{ro'} = \frac{\theta + 1}{\theta + \epsilon_{rg}} \left(\epsilon_{rg} - \rho\right) \tilde{w}_r \left(S^I_{ro} - S^I_{ro'}\right) \text{ for all } o, o' \in \mathcal{O}(g)$$

- Sign of $\epsilon_{rT} - \rho$ determines crowding in or crowding out within T
  - Same for N
- Moreover: If $\epsilon_{rT} > \epsilon_{rN}$, then $\uparrow$ in immigration:
  - Output: larger increase of I-intensive occupations w/in T than N
  - Allocations: less crowding out of I-intensive occupations w/in T than$N$
  - Wages: $\downarrow$ wage of I-intensive occupations smaller w/in T than N
  - Wage bill: $\uparrow$ payments of I-intensive occupations bigger w/in T than N