Computerization and Immigration: Theory and Evidence from the United States [1]

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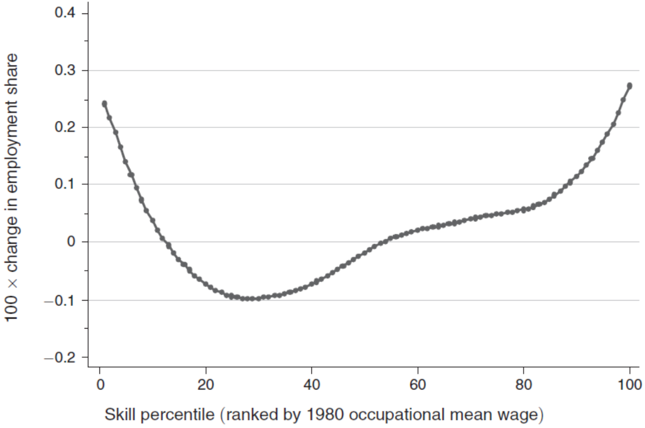
[1] The views expressed in the paper are those of the authors only and do not involve the responsibility of the Bank of Italy.

- **Labor market polarization** likely due to **routine-substituting** technological innovation (Autor et al., 2003; Autor & Dorn, 2013)



Changes Employment (Natives+Foreign Born) by Skill Percentile, 1980-2010

Source: Figure 1 in Autor & Dorn (2013)

Immigration

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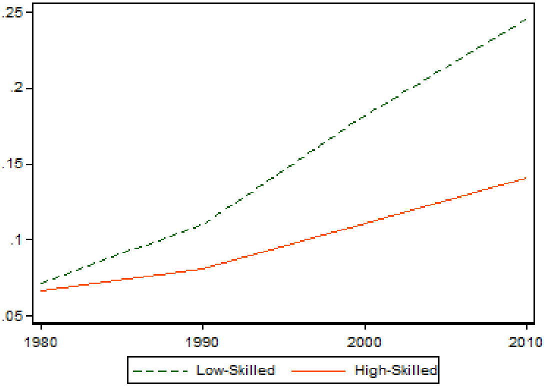

Low and high-educated immigrants as share of the population
Data: IPUMS 1980-2010

Research question

The goal of this paper is to answer **two** simple, yet extremely relevant, **questions** we know little about

1. Does technological growth attract migrants?
    - Is it true for both high and low educated (*skilled*)?
2. Does immigration **attenuate** or **exacerbate** the tendency of **native** job polarization?
    - Can **cross-regional variation** in technology adoption inform us on natives and immigrants job polarization?
    - How the combination of technology and immigration **impact** (**native**) **welfare** in the long-run?

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In this paper

We provide empirical evidence and theoretical support to understand the following:

1. In the data, is **technology adoption** (computer use on the job) associated **with immigration inflows (and polarization)**?
2. We then rationalize these facts in a simple **GE model** with **3 tasks**, exogenous **routine-substituting technological change** and **endogenous immigration**
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Immigration and Polarization

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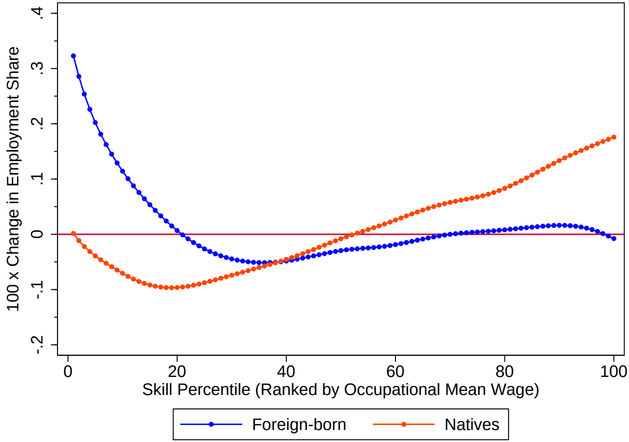

Changes in Foreign-born and Natives' Employment by Skill Percentile 1980-2010

Preview of results

Empirically, we observe that

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- job polarization **at the low-end** can be mainly attributed to immigrants

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The model simulations predict that **immigration**:

- contributes to **technological progress**
- combined with technology adoption, **induces occupational upgrading**
- is net welfare enhancing for natives

Outline

1. Introduction
2. Contributions to the literature
3. Immigration and Technology Shocks: Definition and Identification
4. Empirical Results
5. Model and Simulations
6. Conclusions

This paper contributes to

An extensive literature on **polarization** and **routine-substituting** (Autor et al., 2003; Goos & Manning, 2007; Autor & Dorn, 2013)

Labor supply matters too (Cerina et al., 2017):

- **Low-end polarization** is **mitigated** by undocumented migrants (Mandelman & Zlate, 2014)
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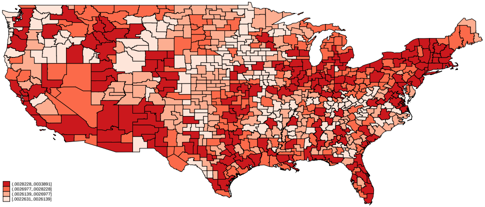
Even more literature on **immigration** (Card, 2001; Peri & Sparber, 2009; Ottaviano & Peri, 2012; Dustmann & al., 2015; Lull, 2017)
We are the first to **show** that:

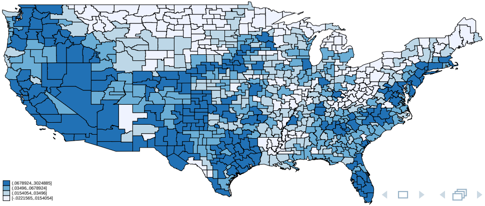
- Areas with **technological progress** attracts **low-skilled migrants** (Cadena & Kovak, 2016; Jaimovich & Siu, 2017: high-skilled $\uparrow$ only)
- *Absent* immigration, polarization, capital accumulation and growth would change

722 self-contained local labor markets: **Commuting Zones (CZs)**

Change in routine-substituting technology (*proxy*: PC use), 1980-2010



Change in foreign-born share, 1980-2010



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- *AD* proxy technological change with task-based routine-intensity of CZs

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- *AD* proxy technological change with task-based routine-intensity of CZs

We use an inferred measure of PC adoption for all 722 CZs ($\sim$ to Autor et al., 2003):

- Industry-level PC use from the CPS as of mid-2000s
- We exploit variation in 1980 local labor markets **industrial composition**

Identification of technology adoption (II)

$$\text{PC use}_{c,t} = \sum_j \omega_{j,c,1980} * \Delta \frac{\text{PC at work}_{j,US,t}}{empl_{j,US,1980}}$$

where:

- $\Delta \frac{\text{PC at work}_{j,US,t}}{empl_{j,US,1980}} = \frac{\text{PC at work}_{j,US,2005}}{empl_{j,US,1980}} - \underbrace{\frac{\text{PC at work}_{j,US,1980}}{empl_{j,US,1980}}}_{\sim 0}$
- $\Delta \frac{\text{PC at work}_{j,US,t}}{empl_{j,US,1980}} \sim \frac{\text{PC at work}_{j,US,2005}}{empl_{j,US,1980}}$
- $\omega_{j,c,1980} = \frac{empl_{j,c,1980}}{\sum_j empl_{j,c,1980}}$

c: CZ; t: survey year; j: industry

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- $\omega_{j,c,1980} = \frac{empl_{j,c,1980}}{\sum_j empl_{j,c,1980}}$

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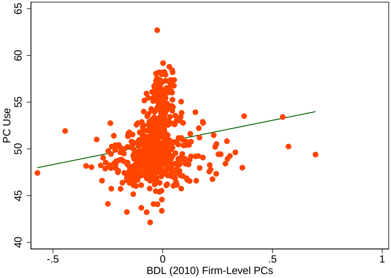
We control for generic labor demand shocks (Bartik-style proxy):

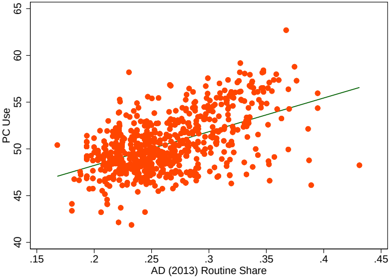
- $\text{Labor Productivity}_{c,t} = \sum_j \omega_{j,c,1980} * \Delta \log(wage)_{j,-c,t}$

Identification of technology adoption (III)

- PC use proxy positively correlates with other measure of RBTC



PC Use and BDL's (2010) PC Firm-level Use



PC Use and AD's (2013) CZ-Routine Intensity

US and foreign born migration and PC adoption

$$\frac{\Delta Pop_{c,h,t}}{Pop_{c,1980}} = \alpha + \beta \Delta \text{PC use}_{c,t} + \gamma \Delta \text{Labor Productivity}_{c,t} + \phi_s + \Delta \varepsilon_{s,h,t} \quad (1)$$

for each skill h, CZ c between 1980 and 2010.

US and foreign born employment

US and foreign born migration and PC adoption

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for each skill h, CZ c between 1980 and 2010.

	Low Skilled	High Skilled
Panel A: Natives		
PC use	0.219	2.419**
	(0.314)	(0.641)
Labor Productivity	-0.790	-4.008*
	(0.893)	(1.913)
Obs.	722	722
R2	0.64	0.55
Panel B: Foreign Born		
PC use	0.555^{+}	1.038**
	(0.299)	(0.210)
Labor Productivity	0.187	1.028^{+}
	(0.562)	(0.556)
Obs.	722	722
R2	0.67	0.79

Note: 722 CZs, 1980-2010. Standard errors (in parentheses) are clustered at the state level. **, *, + indicate significance at 1-percent, 5-percent and 10-percent level, respectively.

US and foreign born employment

US and foreign born occupational share and PC adoption

$$\Delta EmplSh^{k}_{c,t} = \alpha + \beta \Delta \text{PC use}_{c,t} + \gamma \Delta \text{Labor Productivity}_{c,t} + \phi_s + \Delta\varepsilon^{k}_{s,t} \quad (2)$$

for each CZ c, occupation/task group k between 1980 and 2010.

Summary Stats

US and foreign born occupational share and PC adoption

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for each CZ c, occupation/task group k between 1980 and 2010.

	Manag/Prof Occ	Cler/Ret/Prod Occ	Serv/Trans Occ
Panel A: Natives			
PC use	0.558**	-0.646**	0.088
	(0.063)	(0.089)	(0.076)
Labor Productivity	-0.099	0.244	-0.146
	(0.164)	(0.273)	(0.241)
Obs.	722	722	722
R2	0.60	0.73	0.46
Panel B: Foreign Born			
PC use	0.595*	-1.036**	0.441+
	(0.252)	(0.175)	(0.257)
Labor Productivity	-1.620	0.394	1.226
	(0.996)	(0.441)	(0.929)
Obs.	722	722	722
R2	0.51	0.41	0.43

Note: 722 CZs, 1980-2010. Standard errors (in parentheses) are clustered at the state level. **, *, + indicate significance at 1-percent, 5-percent and 10-percent level, respectively.

Summary Stats

Additional Results

- Similar results using task specialization indexes Tasks
- Additional results on US wages Wages
- Preliminary IV results exploiting early 'PC-adopters' CZs produce consistent results (forthcoming)
- **Pre-trends** indicates no patterns in group-specific migration Migration Pre-Trends

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Summary of stylized facts

Our reduced form approach identifies few interesting facts:

1. **Immigrants** inflows are **associated with PC adoption**
   - It holds both for low-skilled (*new results*) and high-skilled
2. **PC adoption** also correlated with natives' **job polarization**
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A model to rationalize automation and immigration built on A&D(2013)

Two sectors, **goods** and **services** are **complementary** in utility:

1. CES utility
   - $U = (\rho C_s^{\frac{\sigma-1}{\sigma}} + (1-\rho) C_g^{\frac{\sigma-1}{\sigma}})^{\frac{\sigma}{\sigma-1}}$, with $\sigma \in (0,1]$
2. Goods can be saved to accumulate **capital** and **human capital**
   - $C_g = Y_g - p_k K - p_a L_a$; $C_s = Y_s$

Service production linear ($Y_s = L_s$). Goods production:

1. **Complementarity between K and L_a**
   - $Y_g = \left[(\alpha_a L_a)^{\beta} + X^{\beta}\right]^{1/\beta}$, $\beta < 0$, $\alpha_a > 1$
2. **Substitution between K and L_r**
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Labor amounts and migration (I)

- Labor ability is ranked: **manual** simpler than **routine**, simpler than **analytical**
- Each worker i has η_i amount of routine ability (manual ability stand'd to 1)
- Workers can **upgrade to analytical** ability ($\phi\eta_i, \phi > 1$) at cost p_a
- Two thresholds: Equilibrium wages makes workers **indifferent** between **manual and routine** and **routine and analytical**

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$$w_r \eta^* = w_s,$$

$$w_a \phi \hat{\eta} - p_a = w_r \hat{\eta}$$

Labor amounts and migration (II)

Unskilled migration positively depends on low-skill manual wages (Grogger & Hanson, 2011)

- $mig = \begin{cases} (1+w_s)^{\epsilon} - (k+p_s) & \text{if } (1+w_s)^{\epsilon} - k > p_s \\ 0 & \text{otherwise} \end{cases}$
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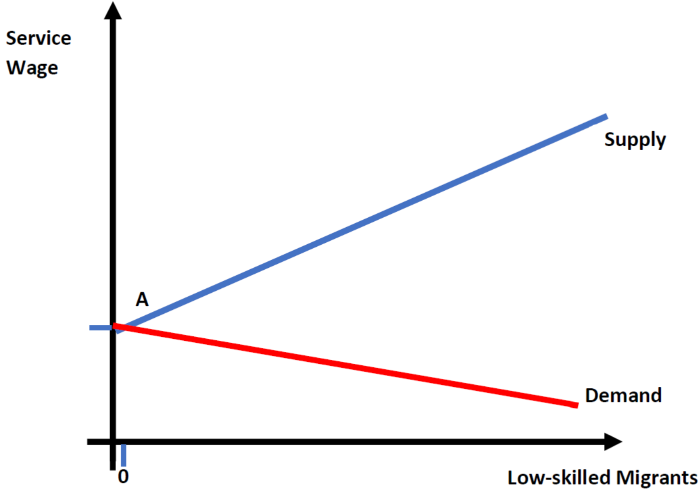
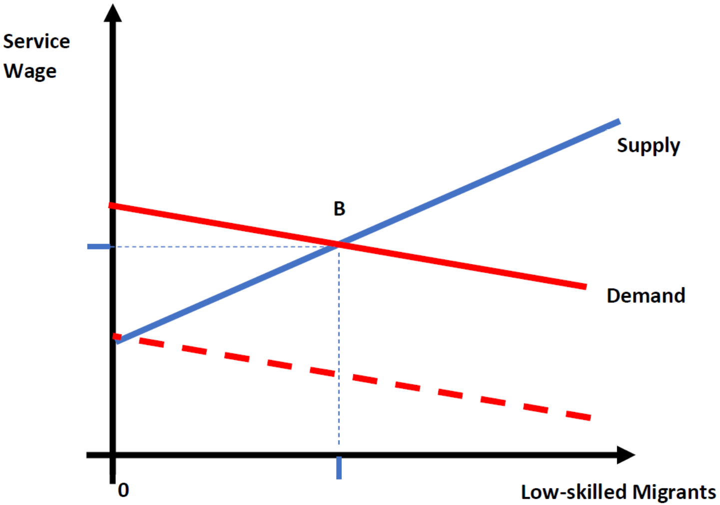
Assuming $\eta \sim f(\eta) = e^{-\eta}$, labor amounts are:

- $L_r = \int_{\eta^*}^{\hat{\eta}} \eta e^{-\eta} d\eta$
- $L_a = \int_{\hat{\eta}}^{\infty} \phi \eta e^{-\eta} d\eta$
- $L_m = 1 + \mathbf{mig} - e^{-\eta^*}$

Supply of low-educated migration and service wages:
No migration, no tech (ε^s given)

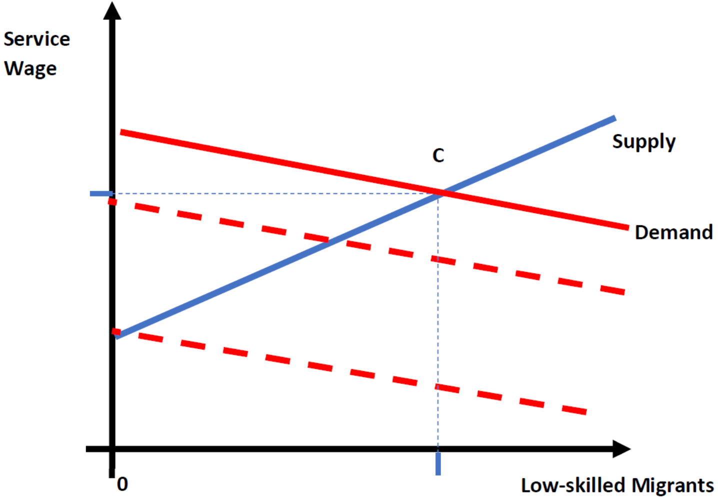


Supply of low-educated migration and service wages:
$\downarrow p_k$ (ε^s given)



Partial Equilibrium Intuition

Supply of low-educated migration and service wages:
$\downarrow p_k$ & demand effect (ε^s given)



With respect to Autor and Dorn (2013)

We **depart** from Autor and Dorn (2013) in three ways:

1. Native workers can upgrade their skills and occupation (by accumulating **human capital endogenously**):
2. **Endogenous migration** in response to $p_k \downarrow$

$\Rightarrow$ We simulate the model to evaluate **counterfactual** scenarios

Simulation setup

We set the parameters as to **match initial labor shares** and **low-skilled migration inflows** in the last 30 years:

1. Elasticity of substitution in *production* **higher** than that in *consumption* ($\frac{1}{1-\gamma} > \sigma$)
   - $\sigma = 0.5$, $\beta = -10, \gamma = 0.5$
   - $\rho = 0.025$, $\alpha_a = 7.5$
2. Other parameters
   - $\phi = 2$, $p_m = 0.25$ (*simulation with* p_a *ongoing work*)
   - $\epsilon_s = 0.2$

$\Rightarrow$ We simulate the model for a **225% exogenous decline** of p_k cumulated over 30 years

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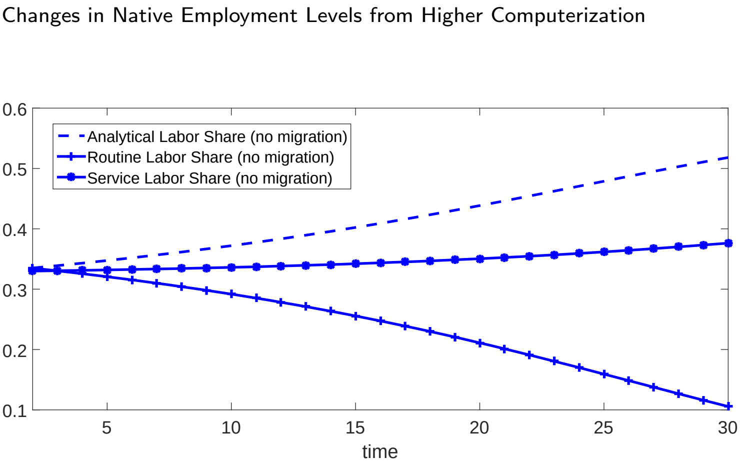
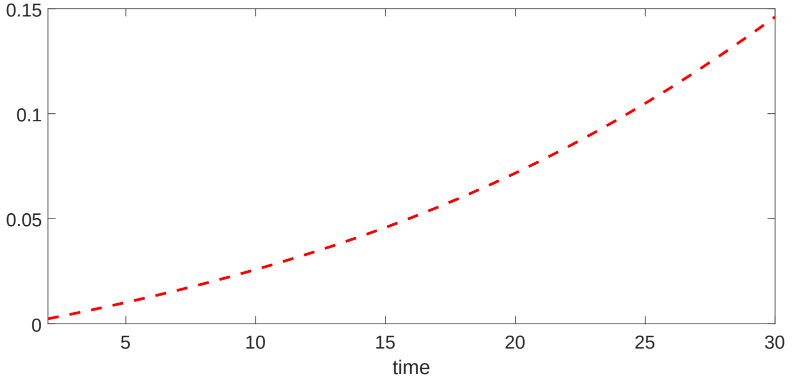
Model simulations (figures)

1) Technological progress without migration generates employment polarization:

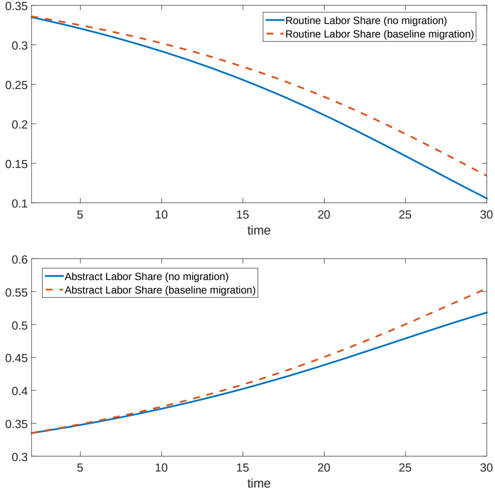


2) Technological progress attracts low-skilled migrants:

Changes in Unskilled Migrants from Higher Computerization



3) Immigration allows natives to upgrade their skills:



Changes in Native Routine and Analytical Employment Levels from Higher Computerization and Immigration

Model simulations (table)

We *target* a 15 p.p. increase in migration, initial occupational shares ($L_a = 0.27$, $L_r = 0.35$, $L_m = 0.38$) and a 225 percent ↓ in computer price

Table. Baseline Simulation

Variables	W/ Baseline Migration	No Migration	Driving Channel w/Migration
$\%\Delta Population$	14.4		
$\Delta L^{natives}_{manual}$	-1.8		
$\Delta L^{natives}_{routine}$	-20.2		
$\Delta L^{natives}_{analytical}$	21.9		
$\%\Delta W_s$	71.0		
$\%\Delta W_r$	-47.8		
$\%\Delta W_a$	262.3		
$\%\Delta K$	367.4		
$\%\Delta Y_{goods}$	98.8		

Occupation Shares 1980-2010

Model simulations (table)

We *target* a 15 p.p. increase in migration, initial occupational shares ($L_a = 0.27$, $L_r = 0.35$, $L_m = 0.38$) and a 225 percent $\downarrow$ in computer price

Table. Baseline Simulation

Variables	W/ Baseline Migration	No Migration	Driving Channel w/Migration
$\%\Delta Population$	14.4	**0**	$\uparrow w_s$ given $\varepsilon_s > 0$
$\Delta L^{natives}_{manual}$	-1.8	**4.6**	$\downarrow \hat{\eta}, \eta^*$
$\Delta L^{natives}_{routine}$	-20.2	**-22.9**	$\downarrow \eta^*$
$\Delta L^{natives}_{analytical}$	21.9	**18.3**	$\downarrow \hat{\eta}$
$\%\Delta W_s$	71.0	**160.1**	$\uparrow mig$
$\%\Delta W_r$	-47.8	**-51.5**	$\uparrow L_r$
$\%\Delta W_a$	262.3	**236.1**	L_a, K complements
$\%\Delta K$	367.4	**333.6**	L_a, K complements
$\%\Delta Y_{goods}$	98.8	**84.5**	

Occupation Shares 1980-2010

Extension: High-skilled migrants

High-skill migrants supply analytical tasks depending on the level of **analytical wages**:

$$\eta_s \left[(1 + w_a)^{\epsilon_a} - k \right] \geq p_m^a$$

Graphs

Extension: High-skilled migrants

High-skill migrants supply analytical tasks depending on the level of **analytical wages**:

$$\eta_s \left[(1 + w_a)^{\epsilon_a} - k \right] \geq p_m^a$$

Now, we have two sources of analytical labor, possibly competing:

$$L_a = \int_{\hat{\eta}}^{\infty} \phi \eta e^{-\eta} d\eta + \int_{\bar{\eta}}^{\infty} \phi \eta_s e^{-\eta} d\eta \tag{3}$$

Graphs

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Skilled migration:

- $\varepsilon_a > 0$s: drop in p_k raises skilled migration to ~ 7.5 percent of total native skilled population
- Allows for **more capital** accumulation (through production complementarities)
- Favor **unskilled migrants** inflows (through demand)

$\Rightarrow$ Although quantitatively different, **main results hold**

Graphs

Model simulations (figures)

Technological progress attracts high-skilled migrants:

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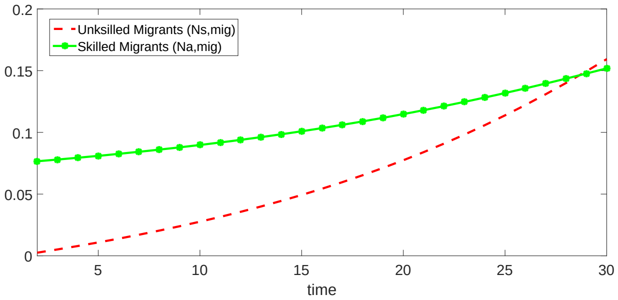

Natives in manufacturing gain (higher earnings and cheaper services):

- $Util_{manuf} = \left(\frac{\rho^{1+\sigma} w_s^{-\sigma} + (1-\rho)^{1+\sigma}}{(1-\rho)^{\sigma} + \rho^{\sigma} w_s^{1-\sigma}}\right) (w_r L_r + w_a L_a)(L_a + L_r)$.

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Natives who work in services lose as lower wages more than offset cheaper services:

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- What is the net effect of immigration?

Aggregate Welfare – Indirect Utility Calculations (I)

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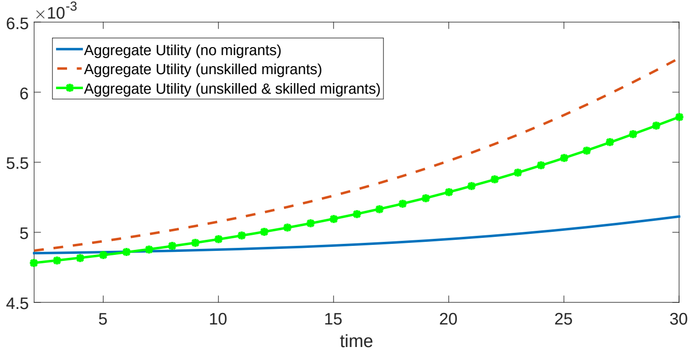
- What is the net effect of immigration?

Migration in the U.S. has been net positive for overall welfare:



Changes in Native Aggregate Utility with Both Types of Migration

- Computerization alone raises welfare by 5.4 percent (blue line)
- Computerization and both types of migration raises welfare by 21.8 percent (green line)
- As long as native labor share in services is not too large

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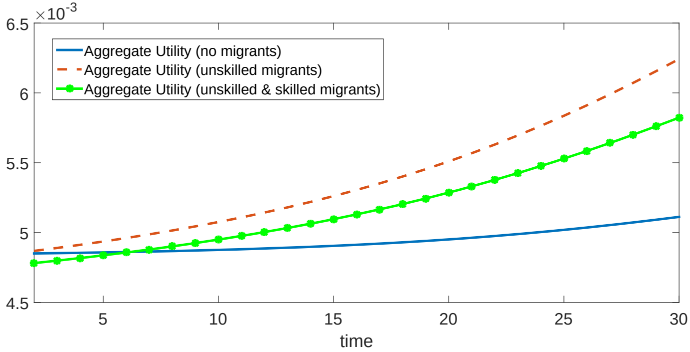

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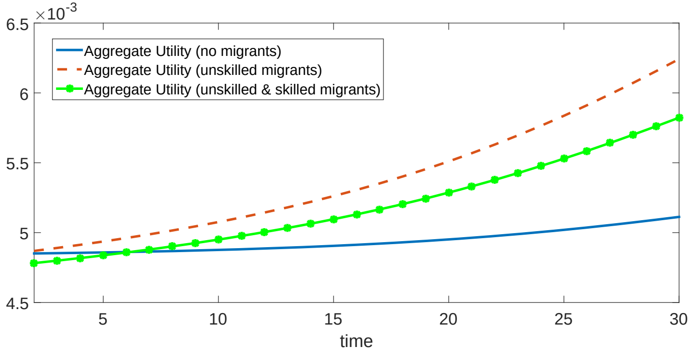

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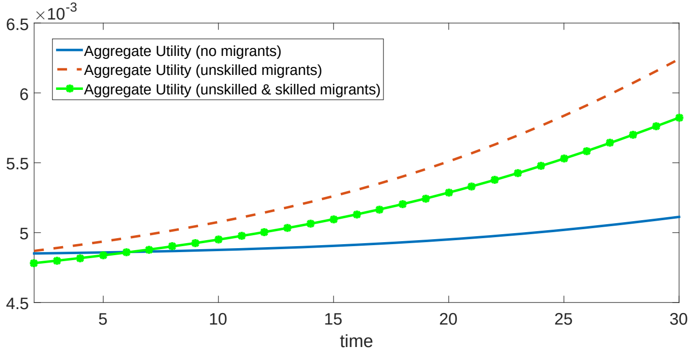

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Summary - Connecting model to empirics (I)

Routine-substituting technological progress proxied by country-wise PC use:

1. **attracts low-skilled immigrants** through higher service wages
    - We document **unskilled migration** response which complements existing work (Moretti, 2013; Cadena & Kovak, 2016): due to an increase demand for manual tasks (Mazzolari & Ragusa, 2013)
    - High-skilled migration response comes at no surprise
2. Associated with **job polarization**
    - Consistent with previous literature
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Immigration:

1. Further hastens technological progress
2. Induces occupational upgrading among natives in the long run: **natives** join more **routine & analytical** occupations (i.e., balance back unbalanced growth)
3. Has negative effects on *service* wages

$\Rightarrow$ Natives' welfare depends on the share of service workers at t_0

- Overall welfare increased in the baseline parametrization

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Appendix

US and foreign born employment and PC adoption

$$\frac{\Delta Empl_{c,h,t}}{Empl_{c,1980}} = \alpha + \beta \Delta \text{PC use}_{c,t} + \gamma \Delta \text{Labor Productivity}_{c,t} + \phi_s + \Delta\varepsilon_{s,h,t} \quad (4)$$

for each skill h, CZ c between 1980 and 2010.

Back

US and foreign born employment and PC adoption

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for each skill h, CZ c between 1980 and 2010.

	Low Skilled	High Skilled
Panel A: Natives		
PC use	0.115	2.047**
	(0.304)	(0.635)
Labor Productivity	-0.681	-3.745^{+}
	(0.896)	(2.080)
Obs.	722	722
R2	0.59	0.52
Panel B: Foreign Born		
PC use	0.416	1.008**
	(0.301)	(0.199)
Labor Productivity	0.247	1.078^{+}
	(0.549)	(0.539)
Obs.	722	722
R2	0.66	0.79

Note: 722 CZs, 1980-2010. Standard errors (in parentheses) are clustered at the state level. **, *, + indicate significance at 1-percent, 5-percent and 10-percent level, respectively.

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Observed Occupational Share Changes

Table. Occupational Employment Shares

Prevalently	Managers/prof/ tech *Analytical/Cognitive*	Clerical/sales/ operators *Routine*	Services/transp/ construct *Manual*
Panel A: Natives			
1980	0.276	0.409	0.315
2010	0.405	0.304	0.292
Delta	0.129	-0.106	-0.023
Panel B: Foreign born			
1980	0.241	0.420	0.339
2010	0.294	0.250	0.456
Delta	0.053	-0.169	0.116

Back to Regressions
Back to Simulation

Job polarization: Task supply approach

We construct measures of task supply based on the DOT indexes of **Manual**, **Routine** and **Analytical Task** intensity (Peri & Sparber, 2009; Autor & Dorn, 2013)

Occupations and Task Index in 1980

	Analytical/ Cognitive	Routine	Manual/ Communication
Managers/prof/tech	0.807	0.343	0.478
Clerical/sales/operators	0.415	0.664	0.358
Services/construct/transp	0.322	0.451	0.737
Average Specialization	0.493	0.505	0.517
% of Total	32%	34%	34%

Natives and Immigrants Tasks: Table

Natives and Foreign-born Task Specialization Indexes

	Analytical	Manual	Routine
Panel A. Natives		*All*	
1980	0.321	0.339	0.340
2010	0.370	0.331	0.299
Delta %	**15.26**	**-2.36**	**-12.06**

Panel B. Foreign-born		*All*	
1980	0.292	0.353	0.355
2010	0.313	0.367	0.319
Delta %	**7.19**	**3.97**	**-10.14**

US and foreign born task specialization and PC adoption

$$\Delta EmplSh^{k}_{c,h,t} = \alpha + \beta \Delta \text{PC use}_{c,t} + \gamma \Delta \text{Labor Productivity}_{c,t} + \phi_s + \Delta \varepsilon^{k}_{s,h,t} \quad (5)$$

for each skill h, CZ c, occupation/task group k between 1980 and 2010.

Back

US and foreign born task specialization and PC adoption

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for each skill h, CZ c, occupation/task group k between 1980 and 2010.

	Analytical Task	Routine Task	Manual Task
Panel A: Natives			
PC use	0.142**	-0.255**	0.113**
	(0.036)	(0.025)	(0.016)
Labor Productivity	-0.075	0.093	-0.018
	(0.074)	(0.064)	(0.044)
Obs.	722	722	722
R2	0.52	0.74	0.57
Panel B: Foreign Born			
PC use	0.078	-0.208**	0.130+
	(0.104)	(0.068)	(0.066)
Labor Productivity	-0.318	0.049	0.269
	(0.385)	(0.148)	(0.284)
Obs.	722	722	722
R2	0.54	0.40	0.43

Note: 722 CZs, 1980-2010. Standard errors (in parentheses) are clustered at the state level. **, *, + indicate significance at 1-percent, 5-percent and 10-percent level, respectively.

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1950-1980 migration and 1980-2010 PCs adoption

$$\frac{\Delta Pop_{c,h,t}}{Pop_{c,1950}} = \alpha + \beta \Delta \text{PC use}_{c,1980-2010} + \gamma \Delta \text{Labor Productivity}_{c,1980-2010} + \phi_s + \Delta \varepsilon^k_{s,h,} \quad (6)$$

for each skill h, CZ c, occupation/task group k between 1950 and 1980.

Back

1950-1980 migration and 1980-2010 PCs adoption

$$\frac{\Delta Pop_{c,h,t}}{Pop_{c,1950}} = \alpha + \beta \Delta \text{PC use}_{c,1980-2010} + \gamma \Delta \text{Labor Productivity}_{c,1980-2010} + \phi_s + \Delta\varepsilon^k_{s,h,} \quad (6)$$

for each skill h, CZ c, occupation/task group k between 1950 and 1980.

	Low Skilled	High Skilled
Panel A: Natives		
PC use	4.565	3.321
	(4.946)	(3.789)
Labor Productivity	-4.648	-3.541
	(8.080)	(7.774)
Obs.	722	722
R2	0.48	0.51
Panel B: Foreign Born		
PC use	0.458	0.426
	(0.761)	(0.386)
Labor Productivity	-0.385	-0.479
	(1.125)	(0.766)
Obs.	722	722
R2	0.52	0.54

Note: 722 CZs, 1950-1980. Standard errors (in parentheses) are clustered at the state level. **, *, + indicate significance at 1-percent, 5-percent and 10-percent level, respectively.

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US wages and PC adoption

$$\Delta log(w)^k_{c,t} = \alpha + \beta \Delta \text{PC use}_{c,t} + \gamma \Delta \text{Labor Productivity}_{c,t} + \phi_s + \Delta \varepsilon^k_{s,t} \quad (7)$$

for each skill h, CZ c, occupation/task group k between 1980 and 2010.

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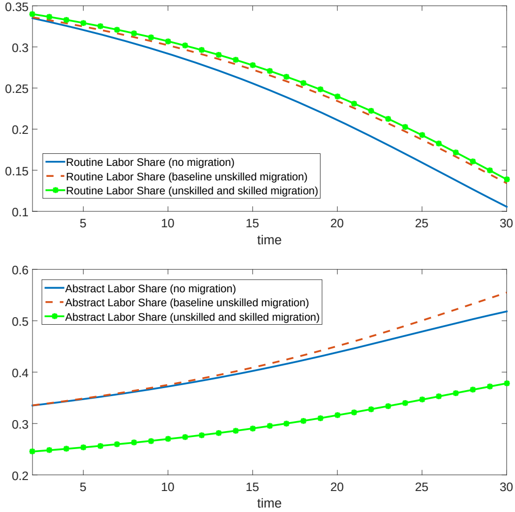
for each skill h, CZ c, occupation/task group k between 1980 and 2010.

	Manag/Prof Occ	Cler/Ret/Prod Occ	Serv/Trans Occ
PC use	0.046**	-0.045**	0.006
	(0.004)	(0.006)	(0.005)
Labor Productivity	-0.000	0.031+	-0.002
	(0.012)	(0.018)	(0.016)
Obs.	722	722	722
R2	0.66	0.73	0.46

Note: 722 CZs, 1980-2010. Standard errors (in parentheses) are clustered at the state level. **, *, + indicate significance at 1-percent, 5-percent and 10-percent level, respectively. Back

Skilled migration: Employment

Routine and Analytical Employment w/out and w/Skilled Migration



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