Immigration, Task Specialization and Total Factor Productivity

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Introduction

Immigration is central to the modern American public policy debate

- Much research focuses on labor market effects (wages and employment)
- Dearth of research focusing on productivity effects and their timing

And Yet...

Historical (and contemporary) anecdotes abound,

- Andrew Carnegie, Nikola Tesla, Sergey Brin, Albert Einstein, Elon Musk, . . .

The Question

But,
Those anecdotes are all about high-skill immigrants...

Question(s)
(i) What are the short and longer-run effects of immigration on measured TFP?
(ii) How do these effects depend on the skill composition of the immigrant flow and the stance of immigration policy?

Outline

Illustrative Model

- Task based framework that endogenizes TFP
  (i) Reconciles contradictory evidence in literature
  (ii) Immigration may hurt or help factor productivity$\rightarrow$ A "Laffer Curve" for immigration policy

Empirics

- Dynamic TFP responses to immigration shocks
  (i) Instrumental variables + Local Projection $\rightarrow$ LPIV estimator

Next Steps

- Quantitative "Ricardo-Roy" model based on the illustrative model here
- Counterfactual immigration policies
  - Vary skill composition of migrant inflows keeping inflow size fixed
  - Vary size of inflows while keeping skill composition fixed

Literature

Immigration and Growth/TFP: Borjas (2019), Peri (2012)

Shift-Share Designs and Immigration: Card (2001); Borusyak et al. (2024); Peri (2012); Peri and Sparber (2009)

Task Composition and Growth: Acemoglu and Restrepo (2019, 2018)

Dynamic Treatment Effects: Jordà and Taylor (2024); Ramey (2016)

Task Complementarity & Ricardo-Roy Models: Costinot and Vogel (2015, 2010)

Illustrative Model

One Sector Model: Final Good Tech

Three factors of production: Foreign born, native born & physical capital

Intermediate labor services (tasks) $l(i)$ combine with capital K to produce Y,

$$Y = K^{\theta} \left\{ \left(\int_0^1 l(i)^{\rho} di \right)^{\frac{1}{\rho}} \right\}^{1-\theta} \qquad \rho \in (0,1), \quad \theta \in (0,1)$$

Preview: For any given capital stock K TFP, Z is labor-augmenting,

$$Y = K^{\theta} \{ZL\}^{1-\theta}$$

and endogenously depends on allocation task allocation between foreign and native-born

Simple Model - Task Technology

Final good producer purchases labor services $l(i)$ from perfectly competitve intermediate producers with tech

$$l(i) = \alpha^D z^D(i)d(i) + \alpha^F z^F(i)f(i)$$

(i) $d(i)$ is domestic labor demanded and $f(i)$ is foreign-born labor demanded
(ii) α^D, α^F parametrize absolute advantage

Assumption: Domestic labor has comparative advantage (CA) in certain tasks, i.e.

$$\frac{z^D(i')}{z^F(i')} > \frac{z^D(i)}{z^F(i)}, \quad \text{all} \quad i' > i$$

Simple Model - Task Specialization

Comparative advantage suggests foreign born and domestic born want to specialize

- Starting point: Complete specialization
- Later Quantitative Model (Ricardo-Roy): Partial specialization by Extreme Value shocks

$\rightarrow$ Our assumption on comp. advantage implies a "cutoff" task I such that,

$$\begin{cases} d(i) = 0 \quad \text{and} \quad f(i) > 0 \quad \text{for} \quad i < I \\ d(i) > 0 \quad \text{and} \quad f(i) = 0 \quad \text{for} \quad i \geq I \end{cases}$$

No Arbitrage: Minimum unit costs are the same using either factor at cutoff I,

$$\rightarrow \frac{\alpha^D z^D(I)}{\alpha^F z^F(I)} = \frac{w^D}{w^F}$$

Simple Model - TFP and Task Allocation

With supply F of foreign born and supply D of domestic born equilibrium output (at market clearing wages) is,

$$
\begin{aligned}
Y &= K^{\theta}\left(Z(I)\left\{\lambda(I)^{1-\rho}(\alpha^{F}F)^{\rho} + [1-\lambda(I)]^{1-\rho}(\alpha^{D}D)^{\rho}\right\}^{\frac{1}{\rho}}\right)^{1-\theta} \\
&= K^{\theta}(Z(I)L(I))^{1-\theta}
\end{aligned}
$$

where

$$
Z(I) = \left(\int_0^I z^F(i)^{\frac{\rho}{1-\rho}}di + \int_I^1 z^D(i)^{\frac{\rho}{1-\rho}}di\right)^{\frac{1-\rho}{\rho}}
$$

and

$$
\lambda(I) = \frac{\int_0^I z^F(i)^{\frac{\rho}{1-\rho}}di}{\int_0^I z^F(i)^{\frac{\rho}{1-\rho}}di + \int_I^1 z^D(i)^{\frac{\rho}{1-\rho}}di}
$$

Equilibrium of the Simple Model

An equilibrium of the illustrative model is a set of quantities $\{l(i), d(i), f(i)\}_{i\in[0,1]}$, task prices $\{p(i)\}_{i\in[0,1]}$, factor prices $\{w^D, w^F\}$ and a cutoff task I such that

(i) Final goods and labor-service producers maximize profits

(ii) The markets for labor services, domestic born workers and foreign born workers clear

(iii) The cutoff task I satisfies the no-arbitrage condition

Effects of Migration on TFP

Proposition ($dI/dF > 0$)

The measure of tasks allocated to foreign-born labor rises with supply of foreign born labor.

▸ *Proof*

Proposition (Migration "Laffer Curve")

There exists a cutoff task I^* for which $dZ/dF \geq 0$ when $I \leq I^*$ and $dZ/dF \leq 0$ when $I \geq I^*$. This I^* is defined by $z^D(I^*)/z^F(I^*) = 1$.

▸ *Proof*

A Sufficient Statistic for Policy

That Z increases iff $z^D(I)/z^F(I) < 1$,

$\rightarrow$ Regressing measured TFP on plausibly exogenous migration flows can yield conclusions about whether productivity stands to rise or fall following proposed migration policy

If TFP Rises for $\Delta F > 0$

$\implies I < I^*$ I.e. policy is "too tight" relative to a productivity-maximizing policy

Alternative Criterion

Let us now turn to an empirical framework that implements this test...

Empirics

Measuring TFP

The log of output in state s at time t can be written,

$$\ln Y_{st} = \mathbb{E}[\ln Y_t | K_t, F_t, D_t] + u_{st}$$

Expression for output in the simple model above suggests,

$$\mathbb{E}[\ln Y_t | K_t, F_t, D_t] = \theta \ln K_t + \frac{1-\theta}{\rho} \ln \left(\lambda_t^{1-\rho} (\alpha^F F_t)^\rho + [1-\lambda_t]^{1-\rho} (\alpha^D D_t)^\rho \right)$$

State-Level TFP Measure

Using a panel of US states we can write

$$u_{st} = \delta_s + \gamma_t + e_{st}$$

The specification of interest is then

$$\ln Y_{st} = \delta_s + \gamma_t + \theta \ln K_t + \frac{1-\theta}{\rho} \ln \left(\lambda_t^{1-\rho} (\alpha^F F_t)^\rho + [1-\lambda_t]^{1-\rho} (\alpha^D D_t)^\rho \right) + e_{st}$$

$\rightarrow \hat{Z}_{s,t} = \exp \left(\frac{\hat{\delta}_s + \hat{e}_{s,t}}{1-\hat{\theta}} \right)$

Data and Sample

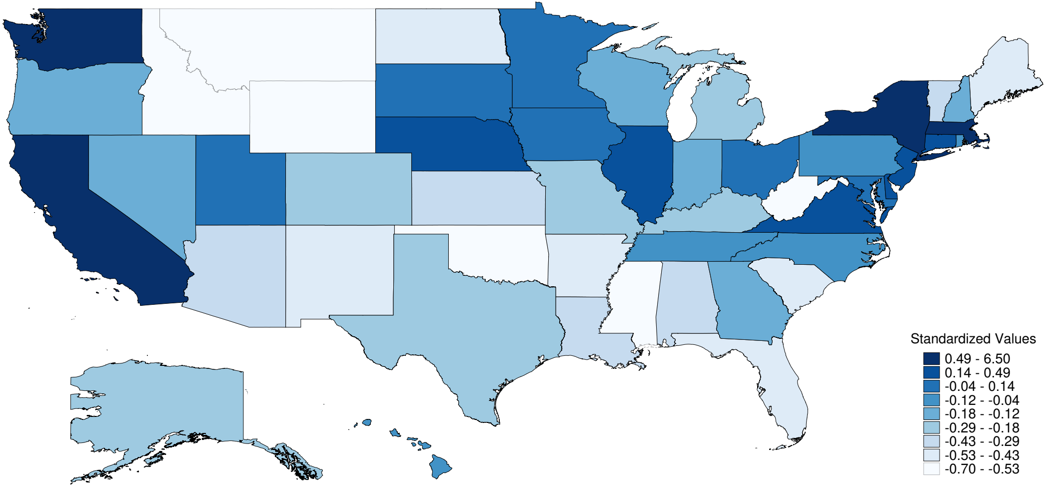
GDP by State:
Source: Bureau of Economic Analysis (BEA)

Capital by State:
Constructed from:
(i) Value added by industry by state (BEA)
(ii) Fixed asset accounts by indsutry (BEA)

Foreign/Domestic Labor:
Source: ACS (Ruggles et al., 2024) for 2000-2022, CPS (Flood et al., 2024) for 1994-1999,2023,2024

Sample:
Period, 1994-2023
Full time workers ($\geq$ 35 hours per week), Age 16+

TFP Estimates, 2019



Local Projections of TFP on Migration Flows

Interested in estimating dynamic treatment effect

$$\hat{z}_{s,t+h} = \phi_s + \eta_t + \beta_h f_{s,t+1} + v_{s,t}, \quad h = 1, 2, \ldots$$

where

(i) $\hat{z}_{s,t+h} = \frac{\hat{Z}_{s,t+h} - \hat{Z}_{s,t}}{\hat{Z}_{s,t}}$,

(ii) $f_{s,t+1} = \frac{F_{s,t+1} - F_{s,t}}{L_{s,t}}$ where $L_{s,t}$ is employment in state s

Threat to Identification: $\mathbb{E}(v_{s,t} | f_{s,t+1}) \neq 0$

$\rightarrow$ Namely, factors which cause higher TFP growth are correlated with migration flows

A Shift Share Instrument

Let i index various migrant groups (Canada, Mexico, etc). Decompose $f_{s,t+1}$ as

$$f_{s,t+1} = \sum_i w_{i,s,t} g_{i,s,t+1}$$

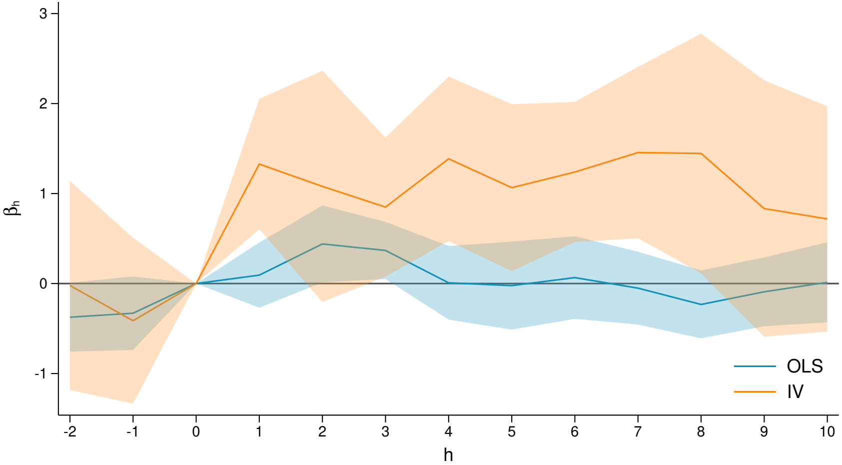
where $w_{i,s,t} = F_{i,s,t}/L_{s,t}$ and g is the growth rate of group i in state s

Then, a shift-share instrument for $f_{s,t+1}$ is given by

$$x_{s,t+1} = \sum_i w_{i,s,t-j} G_{i,t+1} \quad \text{some } j \in \{0, 1, \ldots\}$$

(i) $w_{i,s,t-1} \equiv F_{i,s,t-1}/L_{s,t-1}$
(ii) $G_{i,t+1}$ is the national growth rate of migrant group i

Dynamic Effects of Immigration on TFP



Standard errors clustered by year, 90% confidence. Shift-share IV constructed using j = 1.

Next Steps

Next Steps

Empirics:

- Implement H-1B visa lottery instrument
- Incorporate ONET data: What is the task content of immigrant occupations? Does comparative advantage vanish at higher skill levels? The H-1B instrument should shed light on this

Quantitative Model:

- Build prototype Ricardo-Roy model. Empirical tests in this slide-deck suggest that we are below I^*. How much should we loosen migration policy to achieve I^*?

Appendix

Proof of $dI/dF > 0$

Proof.

Using market clearing and the no-arbitrage condition, I is implicitly defined by

$$\left(\frac{\alpha^D z^D(I)}{\alpha^F z^F(I)}\right)^{\frac{1}{1-\rho}} = \frac{F}{D} \frac{\int_I^1 z^D(i)^{\frac{\rho}{1-\rho}} di}{\int_0^I z^F(i)^{\frac{\rho}{1-\rho}} di}.$$

By inspection, an increase in F will increase the right hand side of this relation. Since this is an equilibrium condition and $z^D(I)/z^F(I)$ is assumed to increase in I, it must be that I rises to restore equality. ◂ Return □

Existence of I^*

Proof.

Using the expression for $Z(I)$ we have that

$$\frac{dZ}{dF} = \frac{1-\rho}{\rho} Z^{1-\frac{\rho}{1-\rho}} \left(\frac{dI}{dF}\right) \left(z^F(I)^{\frac{\rho}{1-\rho}} - z^D(I)^{\frac{\rho}{1-\rho}}\right)$$

Since $dI/dF \geq 0$ it follows that TFP rises when

$$z^D(I)/z^F(I) \leq 1.$$

$\square$

◂ Return

A Ramsey Problem

Let lower case letters denote per-capita terms and $N = D + F$. A policy which maximizes per capita welfare in the static economy is given by

$$\max_{f,I,y} \quad y \quad \text{s.t.}$$

$$y = k^{\theta}\left(Z(I)\left\{\lambda(I)^{1-\rho}(\alpha^F f)^{\rho} + [1-\lambda(I)]^{1-\rho}(\alpha^D d)^{\rho}\right\}^{\frac{1}{\rho}}\right)^{1-\theta}$$

$$1 = d + f$$

$$f \leq \bar{f}$$

$$Z(I) = \int_0^I z(i)^{F\,\frac{\rho}{1-\rho}}\,di + \int_I^1 z(i)^{D\,\frac{\rho}{1-\rho}}\,di$$

$$\left(\frac{\alpha^D z^D(I)}{\alpha^F z^F(I)}\right)^{\frac{1}{1-\rho}} = \frac{f}{d}\,\frac{\int_I^1 z^D(i)^{\frac{\rho}{1-\rho}}\,di}{\int_0^I z^F(i)^{\frac{\rho}{1-\rho}}\,di}$$

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