Immigration, Task Specialization and Total Factor Productivity

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Introduction

Immigration is central to the modern American public policy debate

- Evidence regarding effects on productivity is mixed
- Studies looking at the timing of productivity effects is limited

Yet...

Anecdotes for positive productivity effects abound,
$\rightarrow$ 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
- Useful to study GE effects of migration policy

Literature

Empirics:
(i) Positive effects of immigration on TFP $\rightarrow$ Peri (2012) + Ortega and Peri (2014a)
(ii) Negative effects of immigration on TFP $\rightarrow$ Ortega and Peri (2009) + Ortega and Peri (2014b)

Theory:
(i) Task assignment models $\rightarrow$ Acemoglu and Autor (2011), Acemoglu and Restrepo (2019, 2018)

Methodological:
(i) Shift Share Empirical Design $\rightarrow$ Goldsmith-Pinkham et al. (2020), Borusyak et al. (2024), Card (2001)
(ii) Dynamic Effect Estimation $\rightarrow$ Ramey (2016), Jordà (2005)

Illustrative Model

Environment

Final Good (FG) Tech. FG is produced by combining
(i) Capital K
(ii) A continuum of intermediate inputs ("tasks")

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

Task Tech. Each task is produced by combining foreign-born $f(i)$ and domestic-born $d(i)$ labor,

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

$\rightarrow \alpha^D, \alpha^F$ parameterize absolute advantage

Final Good Problem

Fix the capital stock. FG producer takes task price $p(i)$ as given solves

$$\max_{\{l(i)\}_{i\in[0,1]}} \left\{ K^{\theta} \left[\left(\int_0^1 l(i)^{\rho} di \right)^{\frac{1}{\rho}} \right]^{1-\theta} - \int_0^1 p(i) l(i) di \right\}$$

Defining $L \equiv \left(\int_0^1 l(i)^{\rho} di \right)^{\frac{1}{\rho}}$, task demand is

$$l(i) = \left(\frac{1-\theta}{p(i)} \right)^{\frac{1}{1-\rho}} \left(\frac{K}{L} \right)^{\frac{\theta}{1-\rho}} L$$

Task Producer Problem

Intermediate producers act competitively and solve

$$\max_{\{d(i),f(i)\}} \quad p(i)l(i) - w^D d(i) - w^F f(i) \quad \text{s.t.}$$

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

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

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

Comparative advantage suggests foreign born and domestic born want to specialize

Task Producer Problem

Specialization implies a "cutoff" task I such that,

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

and

$$\begin{cases} p(i)\alpha^F z^F(i) = w^F \quad \text{for} \quad i < I \\ p(i)\alpha^D z^D(i) = w^D \quad \text{for} \quad i \geq I \end{cases}$$

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,

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

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,

$$\ln Y_{st} = \mathbb{E}[\ln Y_{st} | K_{st}, F_{st}, D_{st}] + u_{st}$$

Expression for output in the simple model above suggests,

$$\mathbb{E}[\ln Y_{st} | K_{st}, F_{st}, D_{st}] = \theta \ln K_{st} + \frac{1-\theta}{\rho} \ln \left(\lambda_t^{1-\rho} (\alpha^F F_{st})^\rho + [1-\lambda_t]^{1-\rho} (\alpha^D D_{st})^\rho \right)$$

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

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

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

Data and Sample

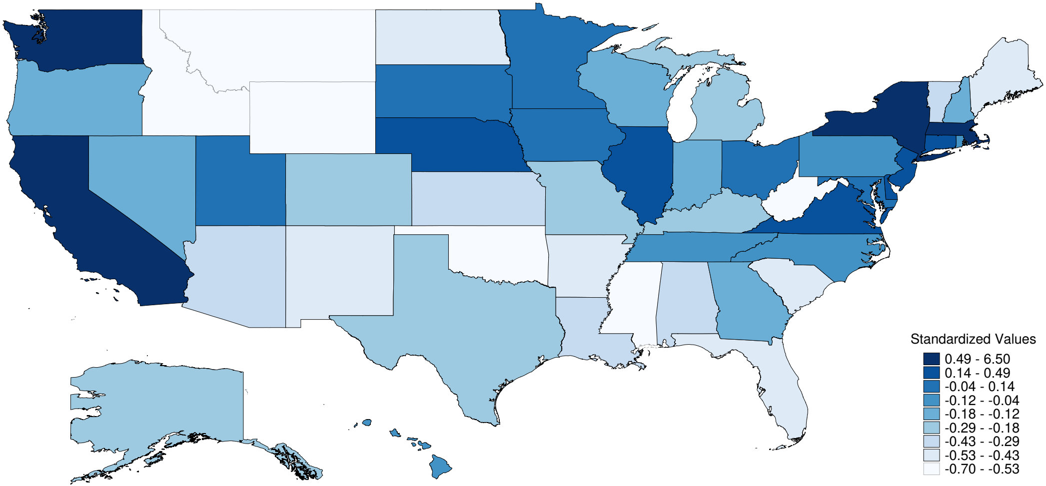
GDP by State:
Source: Bureau of Economic Analysis (BEA)

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



Dynamic Effects by Local Projection

Interested in the following structural relationship

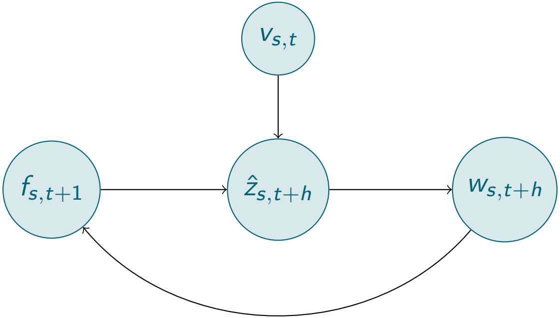
$$\hat{z}_{s,t+h} = \phi_s + \eta_t + \beta_h f_{s,t+1} + v_{s,t}, \quad h = 1, 2, \ldots$$

where

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

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

Identification Challenge - Illustration



Identification Challenge - Two Identities

Let m index migrant groups (Canada, Mexico, etc) and g a growth rate;

$$f_s = \sum_m x_{m,s} g_{m,s}$$

$$g_{m,s} = g_m + \tilde{g}_{m,s}$$

(i) $x_{m,s} = F_{m,s}/L_s$
(ii) g_m is a national growth rate (group m)
(iii) $\tilde{g}_{m,s}$ is the s-specific growth rate

$\tilde{g}_{m,s}$ formalizes the primary threat to identification

Shift Share Design

Instrument for f_s by replacing $g_{m,s}$ with g_m

$$f_s = \sum_m x_{m,s} g_{m,s} \implies q_s = \sum_m x_{m,s} g_m$$

Then, 2SLS suggests

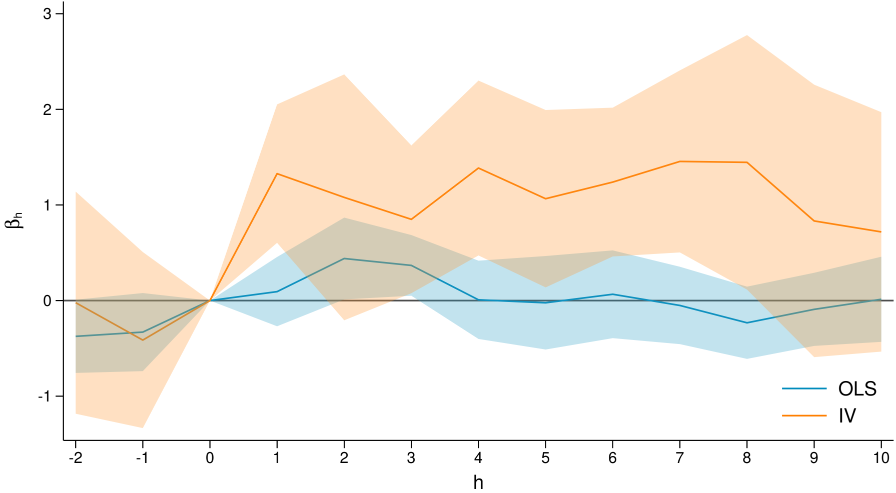
$$f_{s,t+1} = \phi'_s + \eta'_t + \gamma' q_{s,t+1} + e'_{s,t} \quad \text{(First Stage)}$$
$$\hat{z}_{s,t+h} = \phi_s + \eta_t + \beta_h \hat{f}_{s,t+1} + v_{s,t} \quad \text{(Second Stage)}$$

Instrument Construction: Use lagged shares,

$$q_{s,t+1} = \sum_m x_{m,s,t-1} g_{m,t+1}$$

Baseline - Immigration and TFP

First Stage
Leave One Out
Exclusion “Test”



Standard errors clustered by year; 90% confidence

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^*?
- Explore alternative choices of welfare criteria

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

Optimal Migration Policy - Simple Framework

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

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

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

$$1 = d + f$$

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

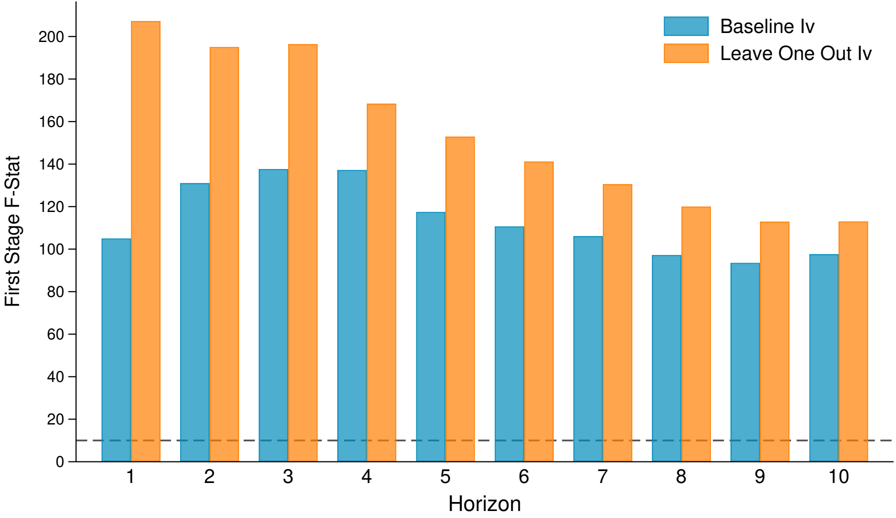
$$Z(I) = \int_0^I z(i)^{F\,\frac{\rho}{1-\rho}}\,di + \int_I^1 z(i)^{D\,\frac{\rho}{1-\rho}}\,di$$

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

Return

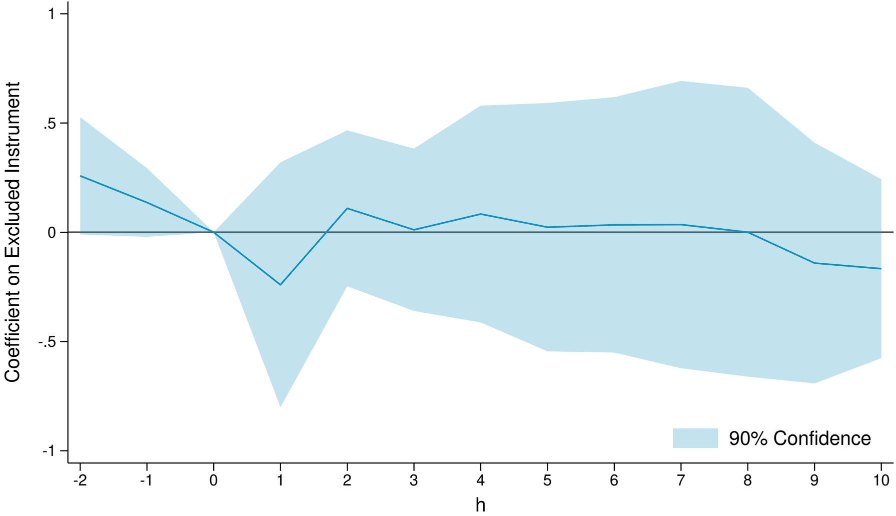
TFP Regressions - First Stage

◂ TFP Regressions



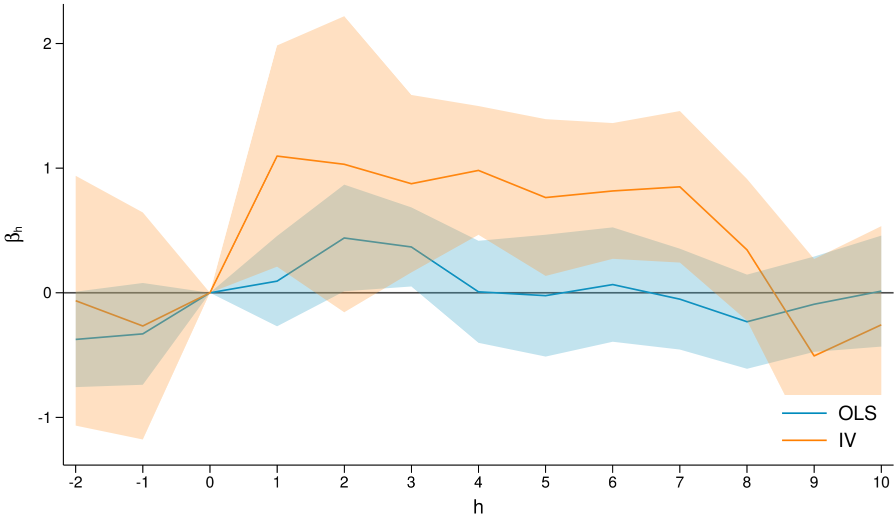
"Test" of Exclusion Restriction

◂ TFP Regressions



TFP Regressions - Leave One Out Instrument

◂ TFP Regressions



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