Immigration, Task Complementarity and Total Factor Productivity

Robert T. Remuszka

December 2024

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?

A Preview

Immigration's Effects

(i) Immigration may hurt or help factor productivity $\rightarrow$ A "Laffer Curve" for immigration policy

(ii) $\uparrow$ Immigration by 1% of the population $\implies$ A persistent increase of ≈ 2 percentage points in the growth rate of TFP for each horizon from 1 and 10 years

$\implies$ US immigration policy from 1994 to 2023 was "too tight"

Outline

Illustrative Model

- Task based framework that endogenizes TFP
- Implies empirical test for "tightness" of migration policy

Empirics

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

Next Steps

- Build "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,

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

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: Producers of I supply the same quantity of $I(I)$ using either type of labor (Acemoglu and Autor, 2011)

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

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

The Effects of Increased Migration

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

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

$\therefore \boldsymbol{\frac{dI}{dF} > 0}$ since...

(i) $z^D(I)/z^F(I)$ increases in I and

(ii) $\int_I^1 z^D(i)^{\frac{\rho}{1-\rho}} di / \int_0^I z^F(i)^{\frac{\rho}{1-\rho}} di$ decreases in I

Two Implications

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

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

Two implications follow:
(i) Policy which increases F increases productivity iff

$$\frac{z^D(I)}{z^F(I)} < 1$$

(ii) The gain (loss) of such policy is increasing (decreasing) in Z iff $\rho < 0.5$ (> 0.5)

Empirical Test of Policy Tightness

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 $\Delta F > 0$
$\implies I < I^*$ where I^* is such that $z^D(I^*)/z^F(I^*) = 1$. I.e. policy is "too tight"

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,

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

Expression for output in the simple model above suggests,

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

State-Level TFP Measure

Using a panel of US states we can write

$$u_{s,t} = \delta_s + \gamma_t + e_{s,t}$$

The specification of interest is then

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

$\rightarrow \hat{Z}_{s,t} = \hat{\delta}_s + \hat{e}_{s,t}$

Data and Sample

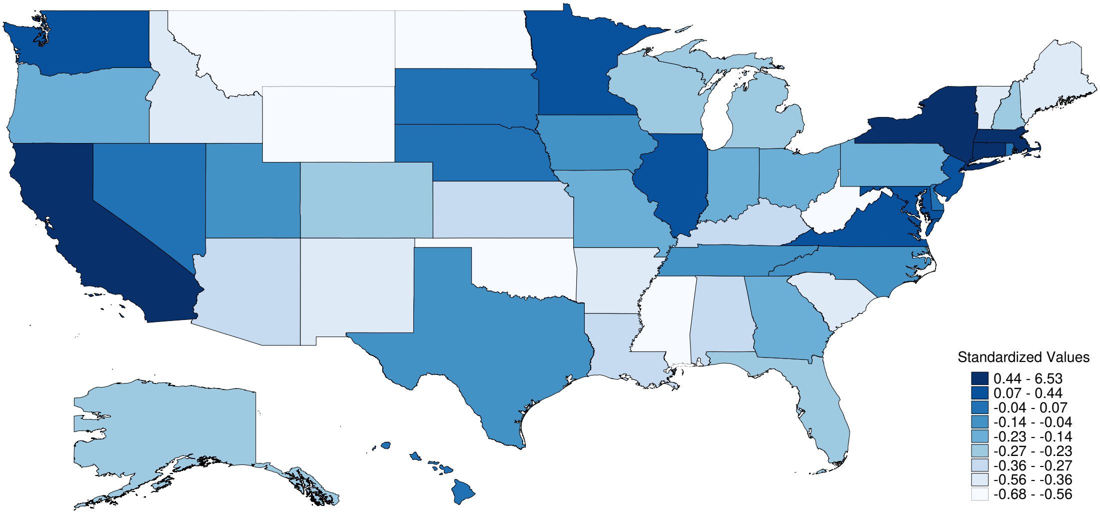
GDP by State:
Source: Bureau of Economic Analysis (BEA)

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

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

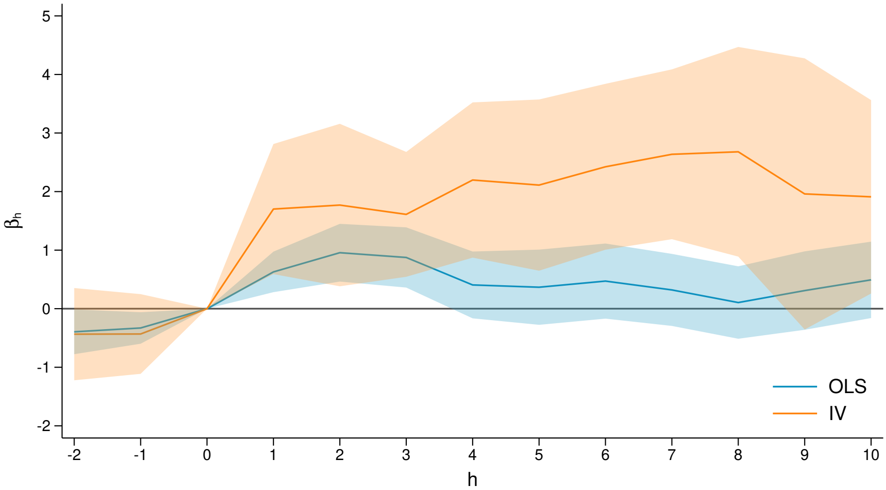
where $w_{i,s,t} = F_{i,s,t}/L_{s,t}$ and g is the growth rate of group i in state s

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



Error bands correspond to 90% level of 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 that I^* for which $z^D(I^*)/z^F(I^*) = 1$. How much should we loosen migration policy to achieve I^*?

Appendix

References I

Acemoglu, D. and Autor, D. (2011). Skills, Tasks and Technologies: Implications for Employment and Earnings. *Handbook of Labor Economics*.

Acemoglu, D. and Restrepo, P. (2018). The Race Between Man and Machine: Implications of Technology for Growth, Factor Shares, and Employment. *American Economic Review*, 108(6):1488–1542.

Acemoglu, D. and Restrepo, P. (2019). Automation and New Tasks: How Technology Displaces and Reinstates Labor. *Journal of Economic Perspectives*, 33(2):3–30.

Borjas, G. J. (2019). Immigration and Economic Growth. *National Bureau of Economic Research*.

Borusyak, K., Hull, P., and Jaravel, X. (2024). A Practical Guide to Shift-Share Instruments. Technical report, National Bureau of Economic Research.

Card, D. (2001). Immigrant Inflows, Native Outflows, and the Local Labor Market Impacts of Higher Immigration. *Journal of Labor Economics*, 19(1):22–64.

References II

Costinot, A. and Vogel, J. (2010). Matching and Inequality in the World Economy. *Journal of Political Economy*, 118(4):747–786.

Costinot, A. and Vogel, J. (2015). Beyond Ricardo: Assignment Models in International Trade. *Annual Review of Economics*, 7(1):31–62.

Flood, S., King, M., Renae, R., Ruggles, S., Warren, R. J., Backman, D., Chen, A., Cooper, G., Richards, S., Schouweiler, M., and Westberry, M. (2024). Ipums CPS: Version 12.0.

Jordà, Ò. and Taylor, A. M. (2024). Local Projections. *National Bureau of Economic Research*.

Peri, G. (2012). The Effect of Immigration on Productivity: Evidence From US States. *Review of Economics and Statistics*, 94(1):348–358.

Peri, G. and Sparber, C. (2009). Task Specialization, Immigration, and Wages. *American Economic Journal: Applied Economics*, 1(3):135–169.

Ramey, V. A. (2016). Macroeconomic Shocks and Their Propagation. *Handbook of Macroeconomics*, 2:71–162.

References III

Ruggles, S., Flood, S., Goeken, R., Grover, J., Meyer, E., Pacas, J., and Sobek, M. (2024). Ipums USA: Version 15.0.