Immigration, Innovation, and Growth

Stephen J. Terry
University of Michigan and NBER

Thomas Chaney
USC and CEPR

Konrad B. Burchardi
IIES Stockholm and CEPR

Lisa Tarquinio
University of Western Ontario

Tarek A. Hassan
Boston University, NBER, and CEPR

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Motivation

- Canonical models suggest immigration should cause innovation, economic dynamism, and growth through new ideas, more effort, higher demand.

A key challenge for identification:
Omitted factors jointly determine immigration,
AND innovation, dynamism, and growth.

This paper:

- Construct plausibly exogenous **immigration shocks** to US counties using 130 years of census data.
- Estimate causal effect on local innovation, wages.
- Interpret through the lens of quantitative growth model.

Main Contributions

1. Isolate plausibly exogenous shocks to county-level immigration 1975-2010.
2. Immigration causes a significant increase in local innovation and local wage growth.
   - The positive effect of immigration on wages increasing in natives' education.
   - The impact of immigration increases significantly with immigrants' schooling level.
3. Validate causal identification in a structural model of immigration and growth.

Related Literature

- Endogenous growth & innovation mechanisms, Spatial growth models
  Aghion & Howitt 1992, Romer 1990, Peretto 1998, Young 1998, Jones 1995, Jones, et al. 2017, Desmet et al. 2018, Peters 2023
  - → Test short-term reduced-form predictions at county level, identify size of local scale effects
- Empirical work on the effects of immigration
  Altonji & Card 1991, Borjas 1999, Sequeira, Nunn, & Qian 2018, Akcigit, et al. 2017, Peters 2017, Peri, et al. 2022
  - → Identify effects on local innovation, dynamism, and income growth.
- General issues with Shift-Share designs
  Borusyak et al., 2021; Goldsmith-Pinkham et al., 2020; Adao et al. 2019.
  - → Show a path to resolving identification issues relating to "endogenous shares"

Data

- **Immigration and Ancestry**
  - IPUMS datasets from US Census, 1880-2010:

$$I^t_{o,d} = \text{\# individuals in US county } d \text{ born in foreign country } o \text{ who immigrated between } t \text{ and } t-1.$$

$$A^t_{o,d} = \text{\# of individuals in } d \text{ with } o \text{ ancestry at time } t$$

- **Innovation**
  - USPTO Patent Microdata 1975-2010: number of successful patent applications in county d between time $t-1$ and t
- **Wages**
  - BLS Quarterly Census of Empl. and Wages, 1975-2010: wages per worker in county d at time t
  - IPUMS Wages, 1980-2000: wages per native non-mover worker in county d at time t

Identification: The Problem

Equation of interest:

$$Y_d^t - Y_d^{t-1} = \delta_t + \delta_s + \beta I_d^t + \epsilon_d^t$$

- But: Migrants are likely drawn to places that are innovative.

→ OLS biased: $cov(I_d^t, \epsilon_d^t) \neq 0$. Need instrument.

- Conventional Card (2001)-type instrument: interaction of 'push factor' with 'social pull' factor in migration

$$I_{o,d}^t = \alpha + ... + \gamma \underbrace{I_o^t}_{\text{push}} \times \underbrace{A_{o,d}^{t-1}}_{\text{social}} + \nu_{o,d}^t$$

- But: Ancestry patterns likely correlated with unobserved factors linked to innovation (e.g.: Indian engineers in Silicon Valley).

⇒ Combine Card instrument with an instrument for ancestry composition of US counties (Burchardi-Chaney- Hassan'19).

Identification: Economic Factors in Historical Migration

$$I_{o,d}^{t} = \alpha + ... + \gamma \underbrace{I_{o}^{t}}_{\text{push}} \times \underbrace{A_{o,d}^{t-1}}_{\text{social}} + \nu_{o,d}^{t}$$

- Add economic pull factor: Migrants choose destinations attractive to the average migrant arriving at the time.
- The stock of ancestry cumulates as a function of historical immigration flows. Iterate to solve.
  - → Instrument Ancestry with historical interactions of push and economic pull factors.
- To be extra safe, use broad leave-out categories, e.g.
  - Push: all migrants leaving o but settling in another region
  - Pull: fraction of European migrants settling in d

Identification: Economic Factors in Historical Migration

$$I^t_{o,d} = \alpha + \underbrace{I^t_o}_{\text{push}} \times (\theta \underbrace{I^t_d / I^t}_{\text{economic}} + \gamma \underbrace{A^{t-1}_{o,d}}_{\text{social}}) + \nu^t_{o,d}$$

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  - Pull: fraction of European migrants settling in *d*

Identification: Economic Factors in Historical Migration

$$A_{o,d}^{t-1} = \ldots + \sum_{\tau=1880}^{t-1} \beta^{\tau} \underbrace{I_o^{\tau}}_{\text{push}} \underbrace{I_d^{\tau} / I^{\tau}}_{\text{economic}} + u_{o,d}^{t}$$

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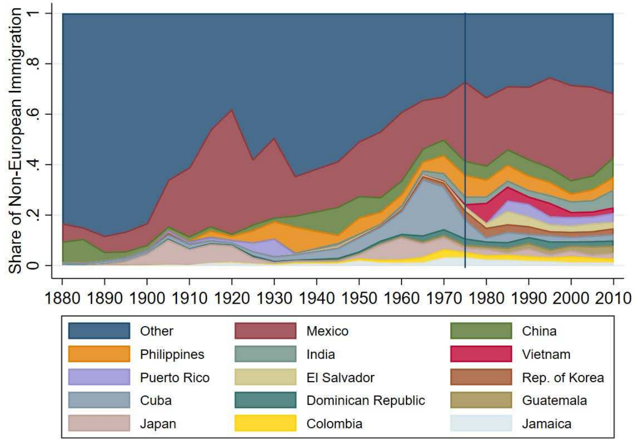
  - Push: all migrants leaving *o* but settling in another region
  - Pull: fraction of European migrants settling in *d*

Push Factor

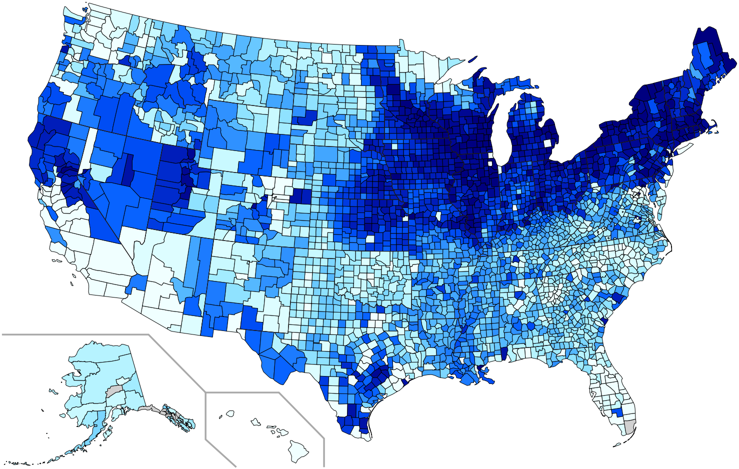
Top non-European origin countries



Notes: The figure shows the share of non-European immigration by origin country, breaking out migrants from the largest senders of migrants to the U.S. overall.

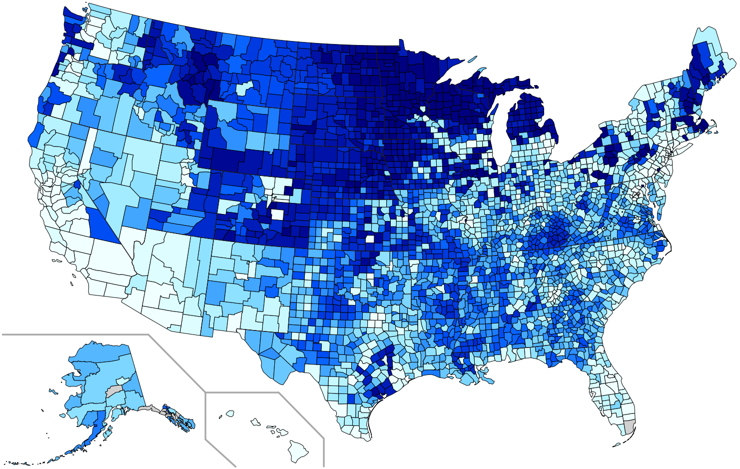
Economic Pull Factor

Destinations of Immigrants Pre 1880



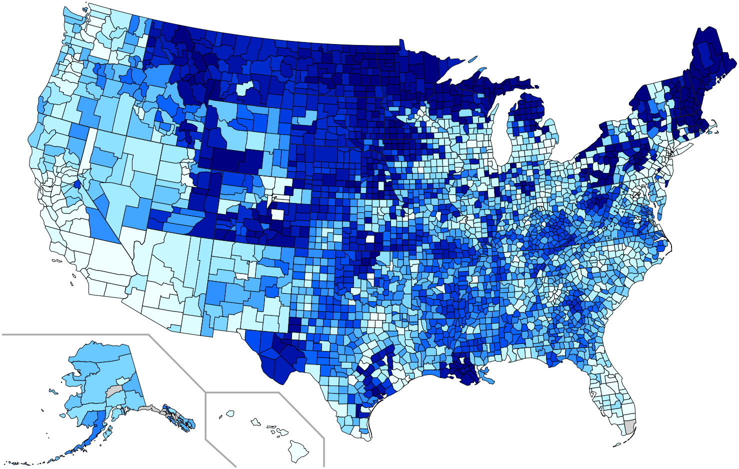
Economic Pull Factor

Destinations of Immigrants 1880-1890



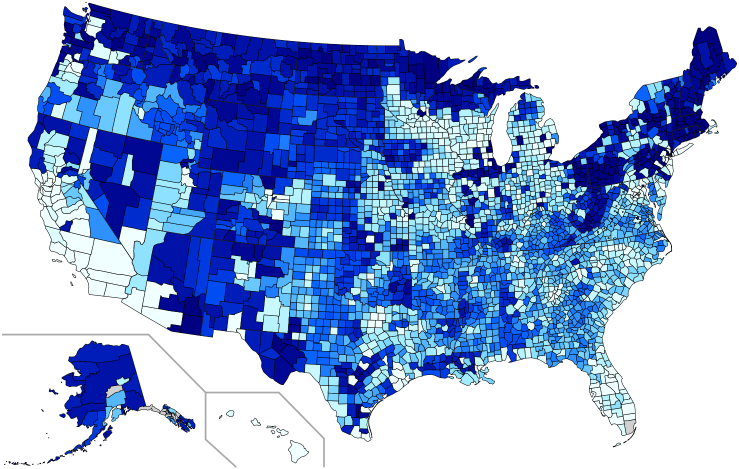
Economic Pull Factor

Destinations of Immigrants 1890-1900



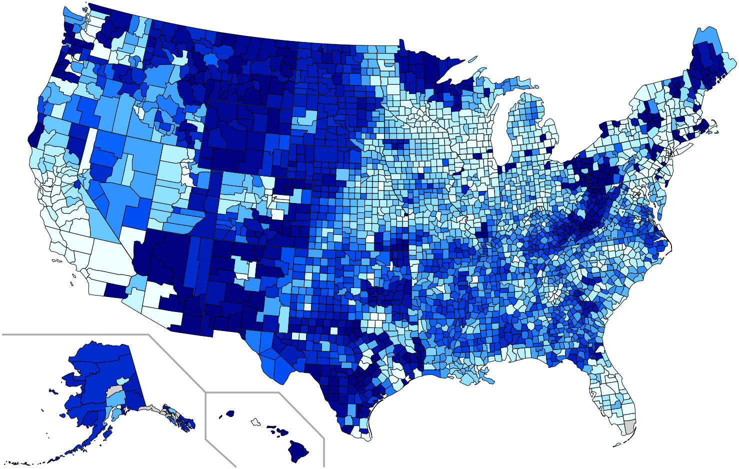
Economic Pull Factor

Destinations of Immigrants 1900-1910



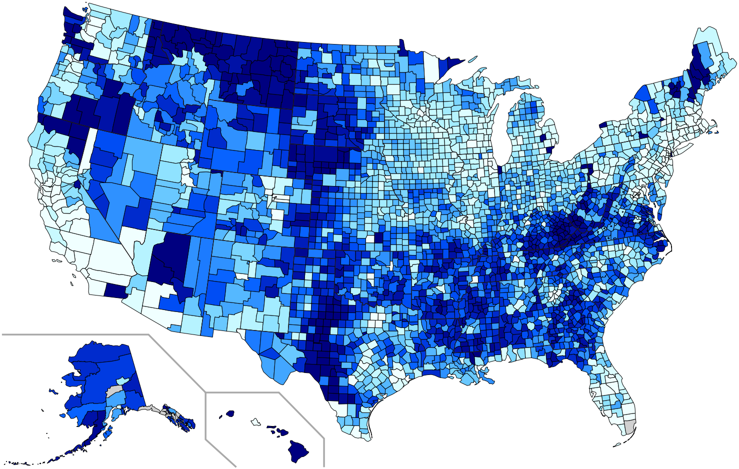
Economic Pull Factor

Destinations of Immigrants 1910-1920



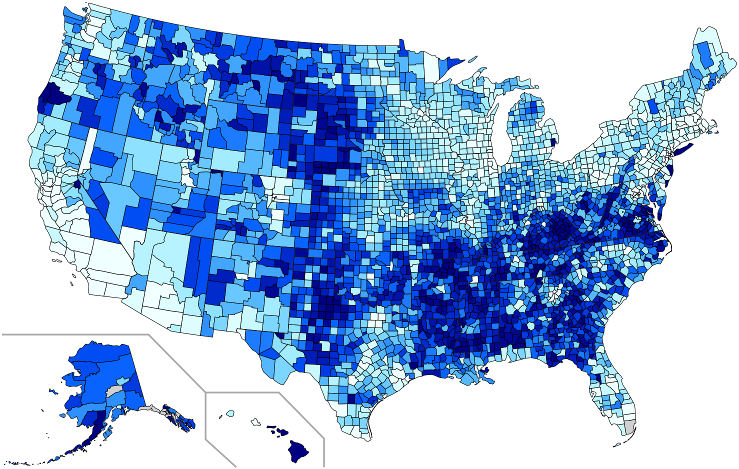
Economic Pull Factor

Destinations of Immigrants 1920-1930



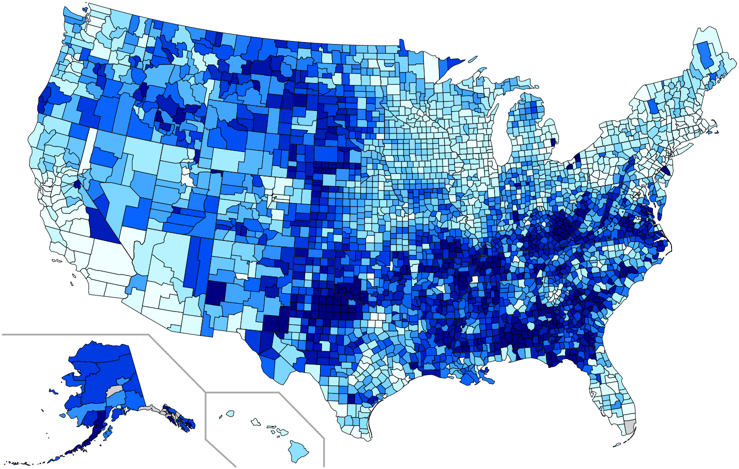
Economic Pull Factor

Destinations of Immigrants 1930-1950



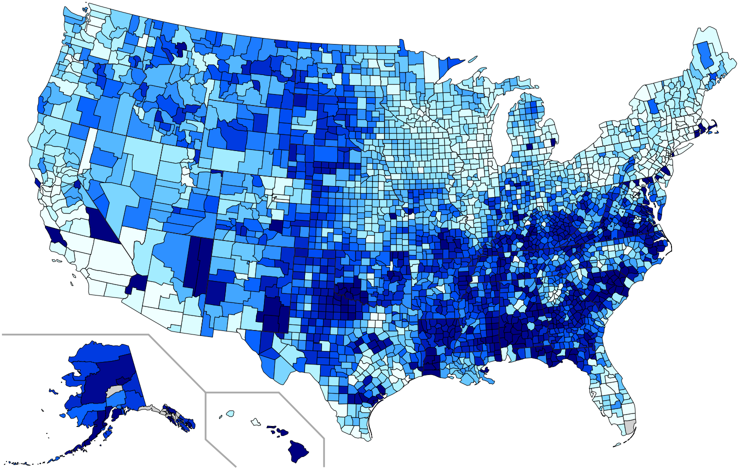
Economic Pull Factor

Destinations of Immigrants 1950-1960



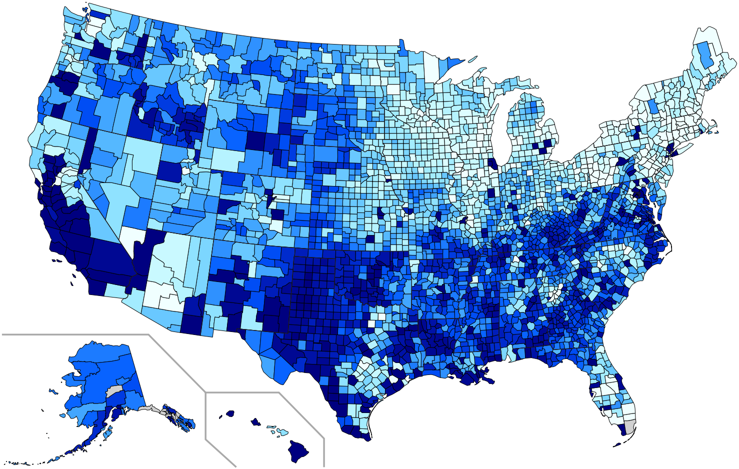
Economic Pull Factor

Destinations of Immigrants 1960-1970



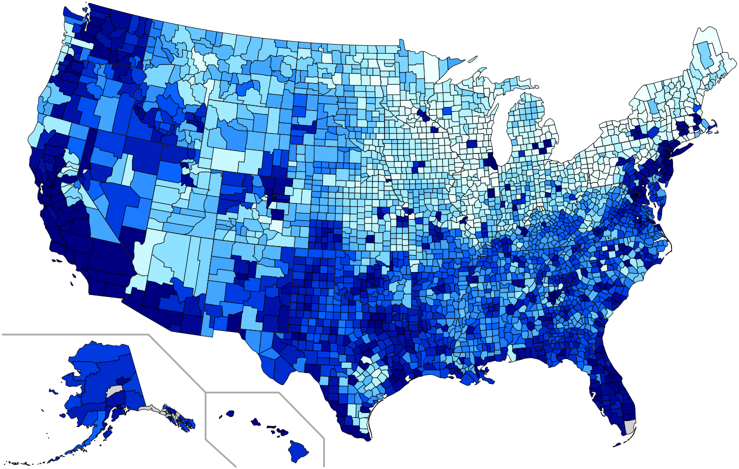
Economic Pull Factor

Destinations of Immigrants 1970-1980



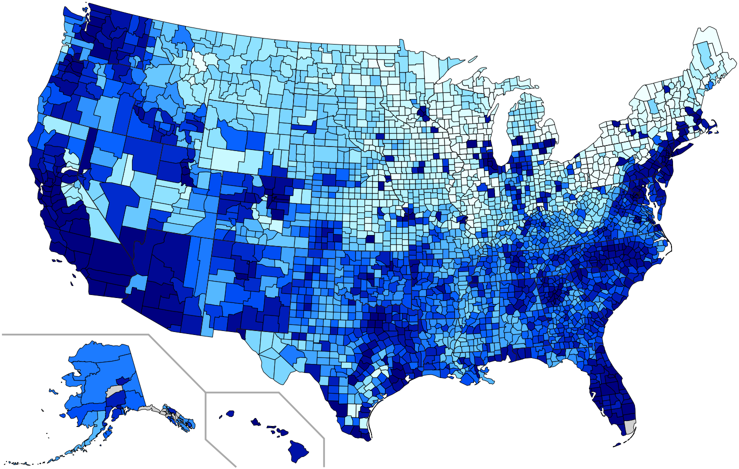
Economic Pull Factor

Destinations of Immigrants 1980-1990



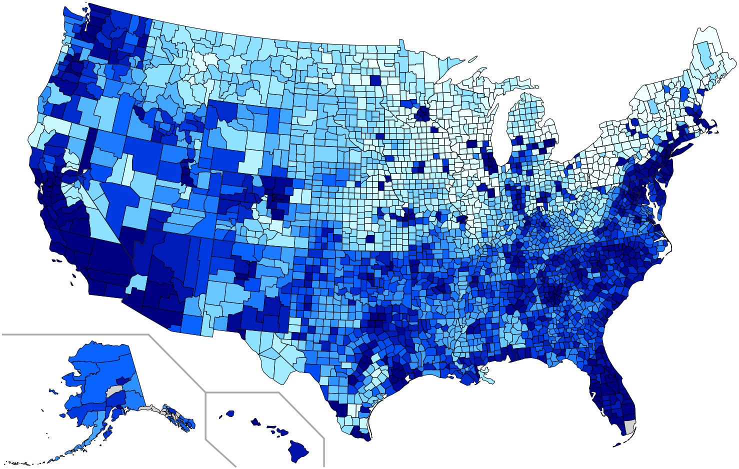
Economic Pull Factor

Destinations of Immigrants 1990-2000



Economic Pull Factor

Destinations of Immigrants 2000-2010



Construct an Instrument for I_d^t in 3 steps

Step 1 Construct instrumented ancestry as

$$\hat{A}_{o,d}^{t-1} = \sum_{\tau=1880}^{t-1} \hat{\beta}_{r(d)}^{\tau} \left(I_{o,-r(d)}^{\tau} \frac{I_{Euro,d}^{\tau}}{I_{Euro}^{\tau}} \right)^{\perp}$$

Step 2 Use this exogenous variation in ancestry to fit a recursive model of migration (similar to Card shift-share).

$$I_{o,d}^{t} = X_{o,d}'\beta + \gamma^{t}[\hat{A}_{o,d}^{t-1} \times \tilde{I}_{o,-r(d)}^{t}] + \nu_{o,d}^{t}$$

Step 3 Sum predicted immigration across origins to isolate an exogenous **immigration shock** to county d at time t.

$$\hat{I}_{d}^{t} = \sum_{o} \hat{\gamma}^{t}[\hat{A}_{o,d}^{t-1} \times \tilde{I}_{o,-r(d)}^{t}].$$

Step 1: Time | Step 1: County | Step 2: Table | Step 3: Maps

Identifying Assumption

Any confounding factors that drive temporary increases in a given US county's innovation post-1975 ($\epsilon_{d,t}$) do not systematically correlate with pre-1975 immigration from a given origin to other regions within the US ($I_{o,-r(d),\tau}$) interacted with the simultaneous settlement of European migrants in that US destination ($I_{Europe,d,\tau}/I_{Europe,\tau}$).

Immigration and Innovation post 1970

	OLS	OLS	IV	IV
	Δ^{5yr} *Patent Flows Per Capita*			
Immigration_d^t	0.200**	0.309	0.122***	0.181**
	(0.096)	(0.197)	(0.045)	(0.087)
N	18,846	18,846	18,846	18,846
F-Stat			911	85
Geography FE	State	County	State	County
Time FE	Y	Y	Y	Y

Notes: Standard errors are clustered by state.

- +12k migrants (1 s.d.) $\rightarrow$ +32% innovation (rel. to mean).

Robustness

- Obtain almost identical results when we use other reasonable leave-out categories or hold constant $A_{o,d}^{1975}$.
- Do not suffer from issues relating to correlation between pre-existing shares and the error term (Adão et al., 2018).
- Results not driven by specific origins.
- Results hold with county FE, "bad" controls.
- Use population growth as endogenous variable.
- Alternative functional forms.

Effects on Local Wages

	Δ^{5yr} *Average Annual Wage*		Δ^{10yr} *Avg. Annual Wage All Native Non-Movers*
	(1)	(2)	(3)
Immigration_d^t	0.149***	0.217**	0.108***
	(0.030)	(0.098)	(0.034)
N	21,977	21,976	6,274
First Stage F-Stat	903	37	936
AR Wald F-Test p-value	0.000	0.039	0.006
Geography FE	State	County	State
Time FE	Yes	Yes	Yes

Notes: Standard errors are clustered by state.

- One S.D. increase in adult immigration $\rightarrow$ 5% increase in local average wage.

Effects on Local Inventors

	Δ^{5yr} Patent Flows Per Capita			
	All Inventors	*Domestic Inventors*	*Immigrant Inventors*	*Teams of Domestic & Immigrant Inventors*
	(1)	(2)	(3)	(4)
Immigration_d^t	0.085**	0.069**	0.003***	0.009**
	(0.037)	(0.030)	(0.001)	(0.004)
N	18,846	18,846	18,846	18,846
First Stage F-Stat	911	911	911	911
AR Wald F-Test p-value	0.037	0.038	0.004	0.027
Share of Patents	100%	92%	1%	3%
Geography FE	State	State	State	State
Time FE	Yes	Yes	Yes	Yes

Notes: Standard errors are clustered by state.

- Domestic inventors: those whose first patent is filed in US.
- At least some of the effect on innovation driven by more inventions by domestic US inventors.

Effects on Local Wages & Inequality

	Δ^{10yr} Wages					
	All Native Non-Movers (1)	*Less than High School* (2)	*High School* (3)	*1 to 3 Years of College* (4)	*4 Years of College* (5)	*5+ Years of College* (6)
Immigration_d^t	0.108***	-0.007	0.017***	0.029**	0.085***	0.247***
	(0.034)	(0.007)	(0.005)	(0.011)	(0.025)	(0.085)
N	6,274	6,274	6,274	6,274	6,274	6,274
First Stage F-Stat	936	936	936	936	936	936
AR Wald F-Test p-value	0.006	0.323	0.001	0.021	0.003	0.010
Geography FE	State	State	State	State	State	State
Time FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Standard errors are clustered by state.

- Largest effects on wages of highly skilled natives. No detectable effect on wages of workers without HS degree.

Education & Immigration's Effect on Innovation

- Generalize IV to instrument separately for effect of educated migrants.
- Leverage dramatic differences in education across origins and over time.
- Run a separate **first stage**

$$Education_d^t = \delta_s + \delta_t + \sum_{o=1}^{20} \kappa_o \hat{I}_{o,d}^t + \nu_d^t$$

where $Education_d^t$ is the total number of years of education of adult immigrants to d at t

- to then disentangle in the **second stage**

$$Y_d^t - Y_d^{t-1} = \delta_s + \delta_t + \beta \widehat{Immigration_d^t} + \gamma \widehat{Education_d^t} + \epsilon_d^t$$

Education & Innovation

	Δ^{5yr} *Patent Flows Per Capita*		Δ^{5yr} *Avg. Annual Wage*	
	(1)	(2)	(3)	(4)
Immigration_d^t	0.254***		0.298***	
	(0.082)		(0.058)	
$\mathbf{1}\{\text{Low Avg. Years Education}\} \times \text{Immigration}_d^t$		-1.671		-0.264
		(5.620)		(0.259)
$\mathbf{1}\{\text{Medium Avg. Years Education}\} \times \text{Immigration}_d^t$		0.105*		0.183***
		(0.062)		(0.064)
$\mathbf{1}\{\text{High Avg. Years Education}\} \times \text{Immigration}_d^t$		1.705**		1.637***
		(0.830)		(0.360)
$\text{Average Years Education}_d^t \times \text{Immigration}_d^t$	0.281***		0.251***	
	(0.094)		(0.055)	
N	18,846	18,846	21,977	21,977

Notes: All specifications include state and time fixed effects. Standard errors are clustered by state.

- Effect of highly educated migrants (s.d. above mean) approx $5\times$ and $4\times$ larger than (local) average effect.

Structural Model

Regional growth model with endogenous immigration and ancestry accumulation:

1. rationalize the impact of immigration on innovation, which flows through a labor supply channel,
2. exploit the IV results for identification of the elasticity of innovation to researchers,
3. aggregate the model to quantify the macro impact of immigration to the US in recent decades, and
4. show our instruments are orthogonal to confounding factors within the model.

Find a large contribution of immigration to US growth in recent decades, totaling on the order of 5% of income per capita.

Model Details | Shock | Moments | IRF | INA | Identification

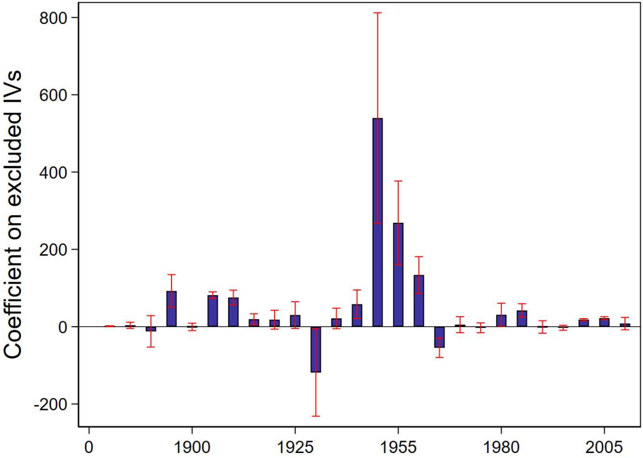
Conclusion

- We study the medium-term impact of immigration on innovation, dynamism, and growth at the local level.
- Identify plausibly exogenous shocks to immigration at the county level 1975-2010.
- Find that more immigration causes
  - more innovation (patents per person)
  - more dynamism and creative destruction
  - higher wages for native non-movers, particularly high-skilled ones.
- Highly educated immigrants boost innovation by more.
- Immigration causes positive spillovers to nearby areas.
- Structural estimation suggests reasonably large effects of immigration on aggregate economic growth.

THANK YOU

BACKUP SLIDES

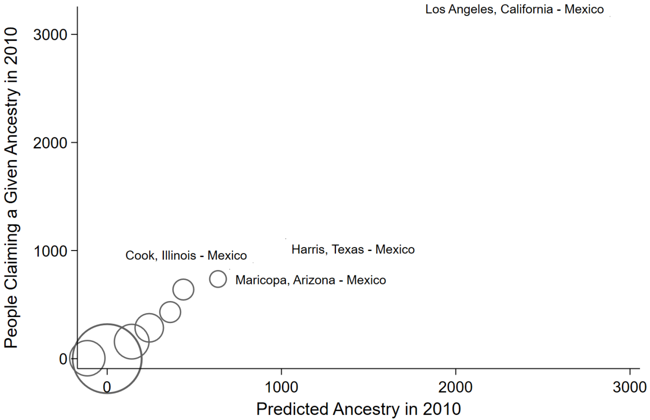
Step 1: Effect of historical push-pull on Ancestry today



Notes: Red lines give 95% confidence intervals. Standard errors are clustered at the origin country level. (F-stat 32,645.9, R^2 0.5041)

Return Add'l Slides

Step 1: Fit of Predicted Ancestry



Notes: This figure plots actual ancestry in 2010 against predicted ancestry, with the size of each circle indicating the log number of observations in a given bin of predicted ancestry. The labeled counties are those with the highest number of individuals declaring a given ancestry in 2010.

Return Add'l Slides

Instrument Construction: Step 2

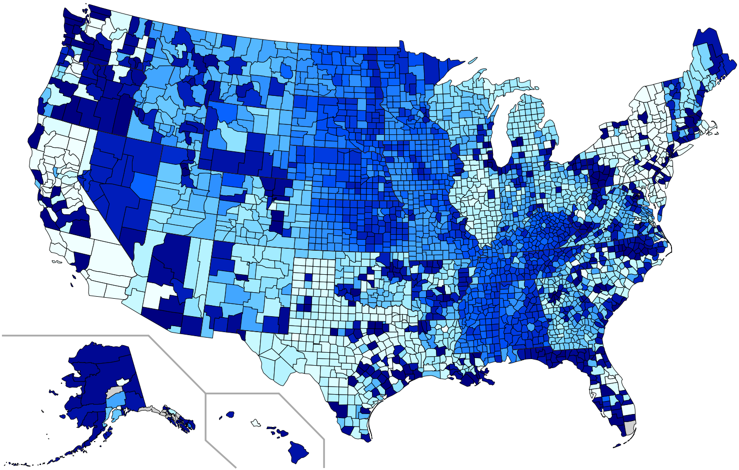
	$Immigration^{t}_{o,d}$				
	(1)	(2)	(3)	(4)	(5)
$\hat{A}^{1975}_{o,d} \times \tilde{I}^{1980}_{o,-r(d)}$	0.0036***	0.0036***	0.0035***	0.0035***	0.0035***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$\hat{A}^{1980}_{o,d} \times \tilde{I}^{1985}_{o,-r(d)}$	0.0016***	0.0016***	0.0016***	0.0016***	0.0016***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$\hat{A}^{1985}_{o,d} \times \tilde{I}^{1990}_{o,-r(d)}$	0.0018***	0.0018***	0.0018***	0.0018***	0.0018***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$\hat{A}^{1990}_{o,d} \times \tilde{I}^{1995}_{o,-r(d)}$	0.0005***	0.0005***	0.0005***	0.0005***	0.0005***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$\hat{A}^{1995}_{o,d} \times \tilde{I}^{2000}_{o,-r(d)}$	0.0004***	0.0004***	0.0004***	0.0004***	0.0004***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$\hat{A}^{2000}_{o,d} \times \tilde{I}^{2005}_{o,-r(d)}$	0.0002***	0.0002***	0.0002***	0.0002***	0.0002***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$\hat{A}^{2005}_{o,d} \times \tilde{I}^{2010}_{o,-r(d)}$	0.0002***	0.0002***	0.0002***	0.0002***	0.0002***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$I^{t}_{Euro,d}$				0.0109***	
				(0.0031)	
$I^{t}_{o,-r(d)} \frac{I^{t}_{Euro,d}}{I^{t}_{Euro}}$					0.3913**
					(0.1558)
N	3,583,881	3,583,881	3,583,881	3,583,881	3,583,881
R^2	0.656	0.657	0.709	0.709	0.709
Distance, Latitude Diff.	no	yes	yes	yes	yes
Region-Country FE	no	no	yes	yes	yes
County-Continent FE	no	no	yes	yes	yes
Time FE	no	no	yes	yes	yes

Notes: Standard errors are clustered by country.

Return Add'l Slides

Step 3: Immigration Shock $\hat{I}_d^{1980}$

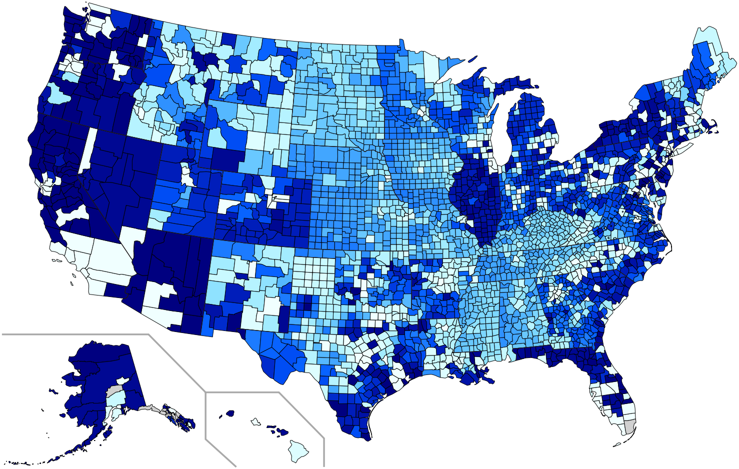
Conditional on County and State-Time Fixed Effects



Later Years | Return | Add'l Slides

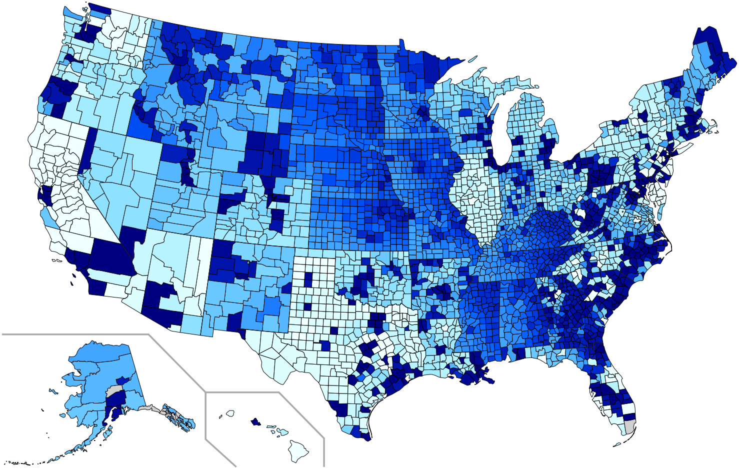
Immigration Shock $\hat{I}_d^{1985}$

Conditional on County and State-Time Fixed Effects



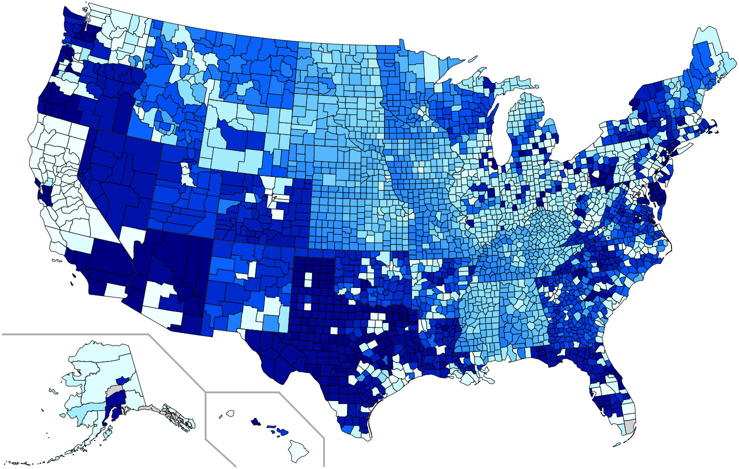
Immigration Shock $\hat{I}_d^{1990}$

Conditional on County and State-Time Fixed Effects



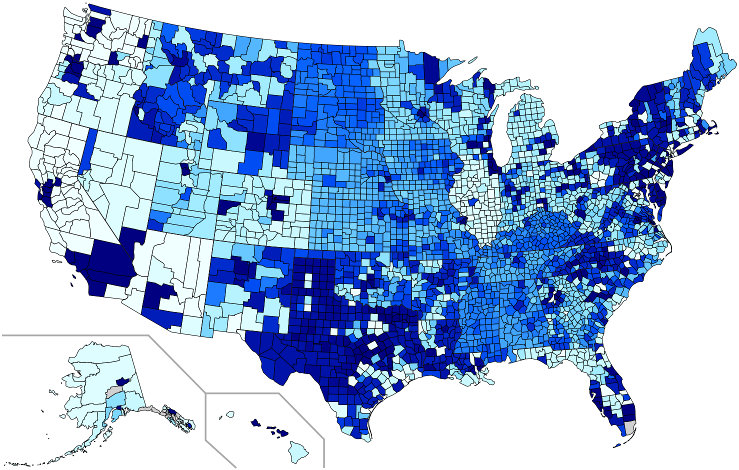
Immigration Shock $\hat{I}_d^{1995}$

Conditional on County and State-Time Fixed Effects



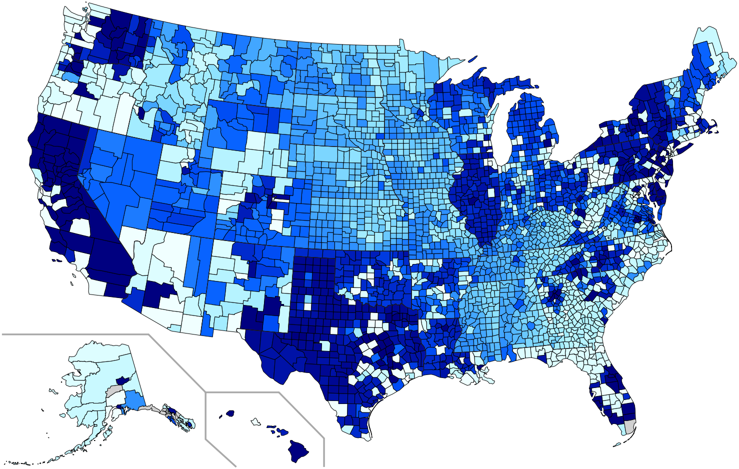
Immigration Shock $\hat{I}_d^{2000}$

Conditional on County and State-Time Fixed Effects



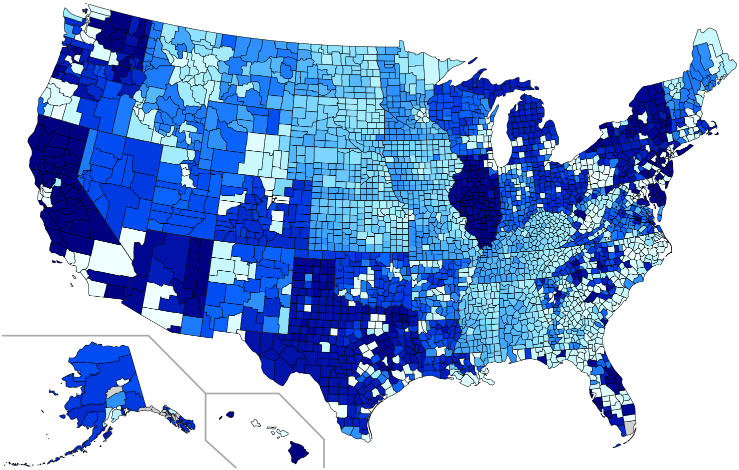
Immigration Shock $\hat{I}_d^{2005}$

Conditional on County and State-Time Fixed Effects



Immigration Shock $\hat{I}_d^{2010}$

Conditional on County and State-Time Fixed Effects



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First-stage: County-Level Population Change

	Δ *Population*$_d^t$		
	(1)	(2)	(3)
Immigration Shock ($\hat{I}_d^t$)	1.897***	1.888***	2.081***
	(0.181)	(0.186)	(0.263)
N	18,846	18,840	18,846
R^2	0.324	0.340	0.804
Geography FE	State	State	County
Time FE	Yes	Yes	Yes
State-Time FE	No	Yes	No

Notes: Standard errors are clustered by state.

Return Add'l Slides

Robustness: Alternative Instruments

	5-Year Difference in Patenting per 100,000			
	(1)	(2)	(3)	(4)
	Leave-Out Correlated Counties	*Leave-Out Own Continent*	*Ancestry in 1975 only*	*Stop Push-Pull in 1960*
Adão et al. (2019) First Stage	3.8	27.4	24.5	
False Rejection Rate (%)		*Overreject*	*Overreject*	
$\text{Immigration}_{d,t}$	0.202**	0.161	0.163	
	(0.084)	(*0.075*)	(*0.071*)	
N	18846	18846	18846	
First Stage F-Stat	656	695	361	
Geography FE	State	State	State	State
Time FE	Yes	Yes	Yes	Yes

Notes: Standard errors are clustered by state.

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Robustness: Instrument Construction

	Δ^{5yr} Patent Flows Per Capita		
Specification:	*Predicted Ancestry Shares (Baseline)*	*Realized Immigration Shares (Card, 2001)*	*Realized Ancestry Shares*
	(1)	(2)	(3)
Adão et al. (2019) First Stage False Rejection Rate (%)	3.8	27.4 *Overreject*	24.5 *Overreject*
$\text{Immigration}_{d,t}$	0.202** (0.084)	0.161 (0.075)	0.163 (0.071)
N	18846	18846	18846
First Stage F-Stat	656	695	361
Instrument Functional Form:			
Instrumented Ancestry	Yes	No	No
Push Factor Leave-Out	Yes	No	No
Controls:			
Geography FE	State	State	State
Time FE	Yes	Yes	Yes

Notes: Standard errors are clustered by state.

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Robustness: Specific Countries

	Difference in Patenting per 100,000 People Post-1980				
	Mexico	*China*	*India*	*Philippines*	*Vietnam*
	(1)	(2)	(3)	(4)	(5)
Panel A: Excluding Given Country					
Immigration_d^t	0.091***	0.123***	0.122***	0.122***	0.122***
	(0.028)	(0.046)	(0.045)	(0.044)	(0.045)
N	18,846	18,846	18,846	18,846	18,846
First Stage F-Stat	666	1,576	1,267	1,261	1,179
AR Wald F-Test p-value	0.003	0.015	0.014	0.014	0.014
Panel B: Including Only Given Country					
Immigration_d^t	0.125***	0.089***	0.145***	0.140**	0.125*
	(0.047)	(0.028)	(0.039)	(0.054)	(0.069)
N	18,846	18,846	18,846	18,846	18,846
First Stage F-Stat	2,094	535	318	22	2
AR Wald F-Test p-value	0.015	0.003	0.001	0.000	0.148
Controls:					
Geography FE	ST	ST	ST	ST	ST
Time FE	yes	yes	yes	yes	yes

Notes: Standard errors are clustered by state.

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Robustness: Additional Controls

	5-Year Difference in Patents per 100,000 People for 1980 to 2010				
	(1)	(2)	(3)	(4)	(5)
Immigration_d^t	0.122***	0.125**	0.125***	0.106**	0.090**
	(0.045)	(0.048)	(0.045)	(0.040)	(0.036)
Population Density (1970)		-0.001			
		(0.001)			
Patents per 1,000 People (1975)			-3.377		
			(2.313)		
Share High School Education (1970)				51.754***	
				(10.186)	
Share 4+ Years College (1970)					178.858***
					(25.375)
N	18,846	18,840	18,840	18,846	18,846
First Stage F-Stat	911	2,062	920	945	1,017
AR Wald F-Test p-value	0.014	0.016	0.014	0.018	0.021
Geography FE	State	State	State	State	State
Time FE	Yes	Yes	Yes	Yes	Yes

Notes: Standard errors are clustered by state.

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Second Stage: Population Growth and Innovation

	5-year Difference in Patenting per 100,000 People Post-1980		
	(1)	(2)	(3)
Δ Population$_d^t$	0.129***	0.125***	0.090***
	(0.039)	(0.041)	(0.020)
N	18,846	18,840	18,846
First Stage F-Stat	110	103	63
AR Wald F-Test p-value	0.010	0.016	0.000
Specification	IV	IV	IV
Geography FE	State	State	County
Time FE	yes	yes	yes
State-Time FE	no	yes	no

Notes: Standard errors are clustered by state.

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Growth Model Parameters

	Difference in Patenting per 100,000 People Post 1980		*IHS of Patenting Post 1975*
	(1)	(2)	(3)
Immigration_d^t	0.115***	0.598***	
	(0.040)	(0.105)	
$\text{sq}(\text{Immigration}_d^t)$		-0.001***	
		(0.000)	
$\text{IHS}(\text{Immigration}_d^t)$			1.723***
			(0.111)
N	18,846	18,846	21,987
First Stage F-Stat (first coefficient)	911	95	94
First Stage F-Stat (second coefficient)		11231	
AR Wald F-Test p-value	0.010	0.000	0.000
Geography FE	State	State	State
Time FE	Yes	Yes	Yes

Notes: Standard errors are clustered by state.

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Dynamic Effect of Immigration

	Difference in Patenting per 100,000 People			
	ΔPat_{t-2}^{t-1}	ΔPat_{t-1}^{t}	ΔPat_{t-1}^{t+1}	ΔPat_{t-1}^{t+2}
	(1)	(2)	(3)	(4)
$Immigration_d^t$	-0.104	0.116***	0.414***	0.448**
	(0.064)	(0.026)	(0.128)	(0.216)
N	15,705	18,846	15,705	12,564
First Stage F-Stat	80	85	11	7
AR Wald F-Test p-value	0.061	0.000	0.002	0.004
Controls:				
Geogrpahy FE	county	county	county	county
Time FE	yes	yes	yes	yes

Notes: Standard errors are clustered by state.

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Origin Countries, Destination Counties, and Ancestry

Origin Countries

- Immigrants come from $o = 1, ..., O$ origin countries.
- The size of the immigration flows grows at constant rate $n > 0$, and origins are subject to iid push shocks

$$I_{o,t} = (1+n)^t e^{\nu_{o,t}}, \ \ \nu_{o,t} \sim N(0, \sigma_\nu^2).$$

Destination Counties

- There are $d = 1, ..., D$ potential destination counties.
- Origin-specific ancestry A accumulates within each county via immigration I and domestic migration M:

$$A_{o,d,t+1} = A_{o,d,t}(1-\mu) + I_{o,d,t} + \sum_{d'=1}^{D} M_{o,d',d,t}.$$

- Total labor aggregates across origins: $L_{d,t} = \sum_o A_{o,d,t}$.

Immigrants Choose Destinations

Immigrants i from origin o evaluate expected utility from each destination d

$$\mathbb{E}_t \left[W_{d,t+1}^{\lambda} \left(\frac{A_{o,d,t+1}}{A_{o,t+1}} \right)^{1-\lambda} \right] e^{-\tau_{o,d,t}} \eta_{i,d,t},$$

with preferences depending upon

- the expected wage in d, $W_{d,t+1}$,
- the expected ancestry from their own origin o in d, $A_{o,d,t+1}$,
- an iid migration cost shock $\tau_{o,d,t} \sim N(0, \sigma_\tau^2)$, and
- an iid migrant taste shock $\eta_{i,d,t} \sim Frechet(\theta)$.

The resulting share of immigration flows in each county follows

$$\frac{I_{o,d,t}}{I_{o,t}} = \frac{\left(E_t \left[W_{d,t+1}^{\lambda} \left(\frac{A_{o,d,t+1}}{A_{o,t+1}} \right)^{1-\lambda} \right] \right)^{\theta} e^{-\theta \tau_{o,d,t}}}{\sum_k \left(E_t \left[W_{k,t+1}^{\lambda} \left(\frac{A_{o,k,t+1}}{A_{o,t+1}} \right)^{1-\lambda} \right] \right)^{\theta} e^{-\theta \tau_{o,k,t}}}.$$

Current residents receive a moving shock with probability μ and solve a similar domestic migration problem pinning down $M_{o,d',d,t}$.

Counties Produce Goods & Ideas

Freely traded numeraire final goods output $Y_{d,t} = Z_{d,t} Q_{d,t} L^{\alpha}_{Y,d,t}$ in each county d depends on

- persistent county-level TFP shocks
  $\ln Z_{d,t} = \rho \ln Z_{d,t-1} + \epsilon_{d,t}, \;\; \epsilon_{d,t} \sim N(0, \sigma^2_{\epsilon})$,
- county-level idea stocks $Q_{d,t}$ linked to new idea flows $N_{d,t}$

$$Q_{d,t} = Q_{d,t-1} + N_{d,t},$$

- and labor $L_{Y,d,t}$ used in goods production.

Production of new ideas $N_{d,t} = L^{\gamma}_{N,d,t} Q^{1-\gamma}_{d,t-1}$ in d depends on

- research labor used in ideas production $L_{N,d,t}$, and
- the existing idea stock $Q_{d,t-1}$.

Equilibrium

Equilibrium in the model involves a range of forces including

1. labor market clearing within counties driven by the wage $W_{d,t}$,
2. researcher demand $L_{N,d,t}$ driven by a patent/idea price $p_{d,t}$,
3. endogenous immigration driven by wages and ancestry,
4. endogenous domestic migration driven by wages and ancestry, and
5. stochastic fluctuations around a balanced growth path driven by population growth at rate n.

Note that we do not consider idea flows in our baseline, but we analyze a full-idea spillovers case in the paper with little impact on the short-run link between immigration and innovation.

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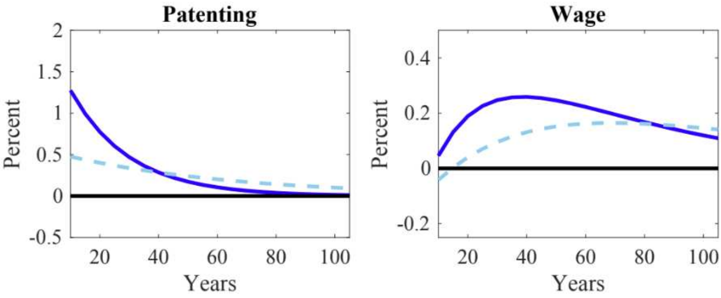
What Do Immigration Shocks Do?



- An immigration shock increases the supply of labor available for innovation, pushing up patenting and eventually the wage.
- Sign of initial wage response governed by γ.
- Identify γ by targeting the causal effect of immigration on patenting found in the data.

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Estimate the Model Targeting our IV Coefficient

Panel A: Moments	Data	Model
IV coeff., patenting$_{d,t}$ on immigration $I_{d,t}$	1.723 (0.112)	1.710
Std. deviation, o immigration $I_{o,t}$	0.406 (0.028)	0.386
Std. deviation d immigration $I_{d,t}$	0.179 (0.011)	0.167
Std. deviation, o-d immigration $I_{o,d,t}$	0.072 (0.012)	0.112
Autocorrelation, output per capita $Y_{d,t}/L_{d,t}$	0.954 (0.007)	0.963
Autocorrelation, patenting$_{d,t}$	0.894 (0.009)	0.869
Panel B: Estimated Parameters	**Symbol**	**Value**
Elasticity, patenting to labor	γ	0.795 (0.038)
Autocorrelation, county TFP	ρ	0.856 (0.018)
Std. deviation, county TFP shocks	σ_ϵ	0.019 (0.005)
Std. deviation, immigration push shocks	σ_ν	0.577 (0.051)
Std. deviation, bilateral immigration shocks	σ_τ	0.535 (0.045)

- Key result: local elasticity of patenting to research labor: 0.795.

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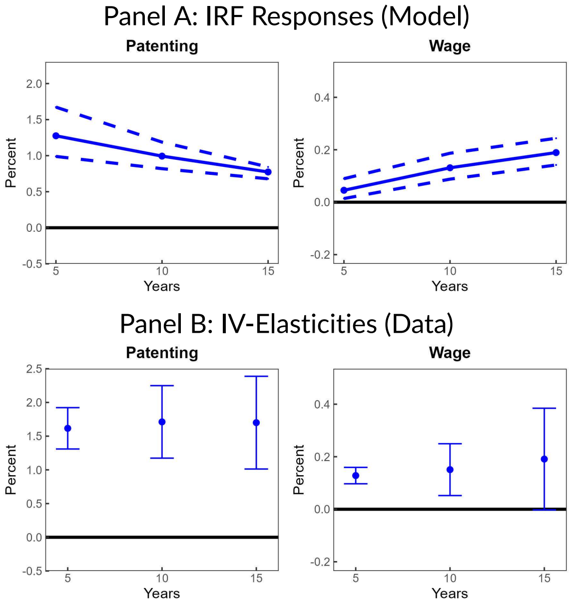
Dynamic Responses to Immigration



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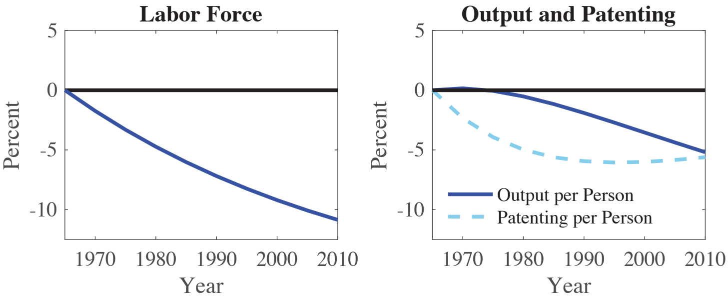
Immigration's Aggregate Impact



US immigration averaged around 1/6th of population growth after the liberalizing 1965 Immigration & Nationality Act. The model reveals lower innovation and income without this contribution.

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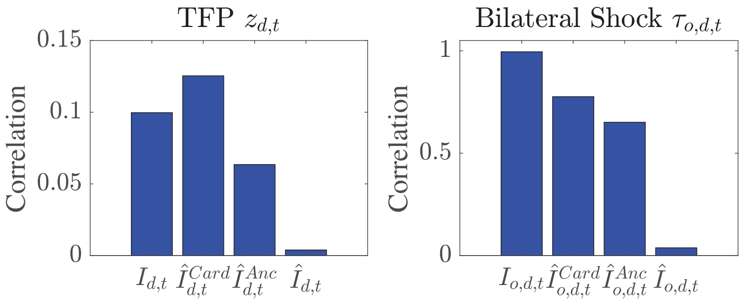
TFP, Bilateral Shocks, and Instrumental Variables



The instrument construction "works" in the model. Our exclusion restriction holds, marking improvement over baseline Card as well as cruder versions of our instrument.

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