The IT Boom and Other Unintended Consequences of Chasing the American Dream

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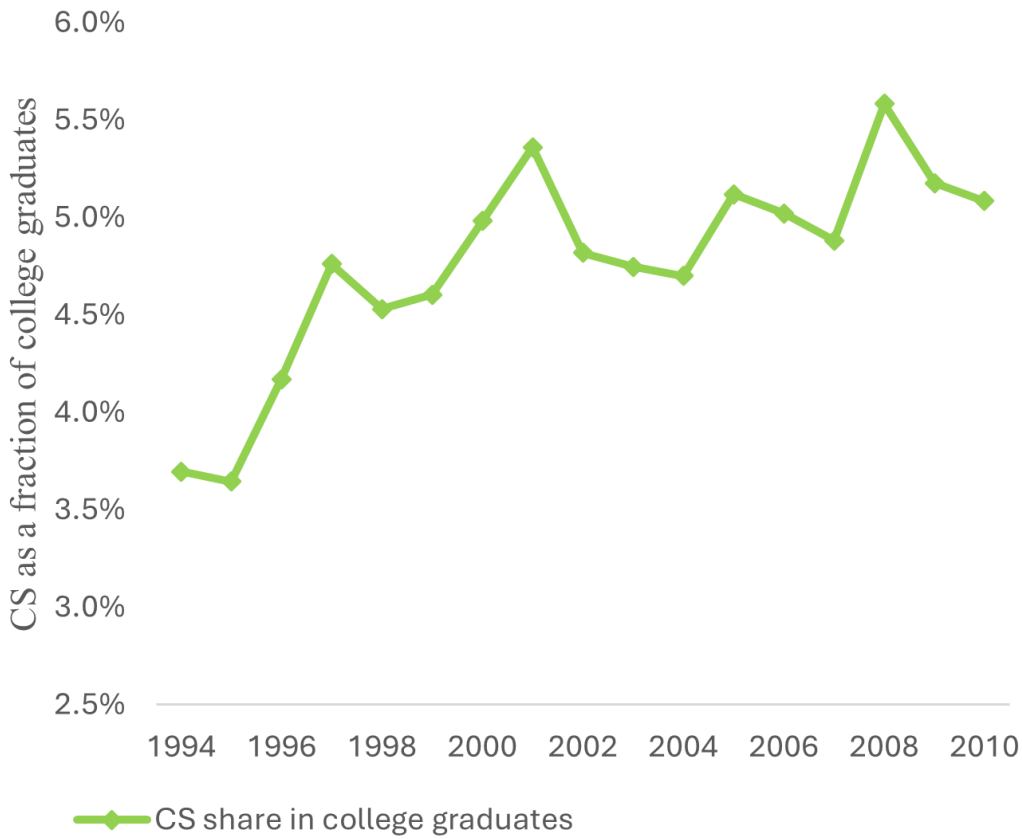
Innovation Boom in US IT and Immigration

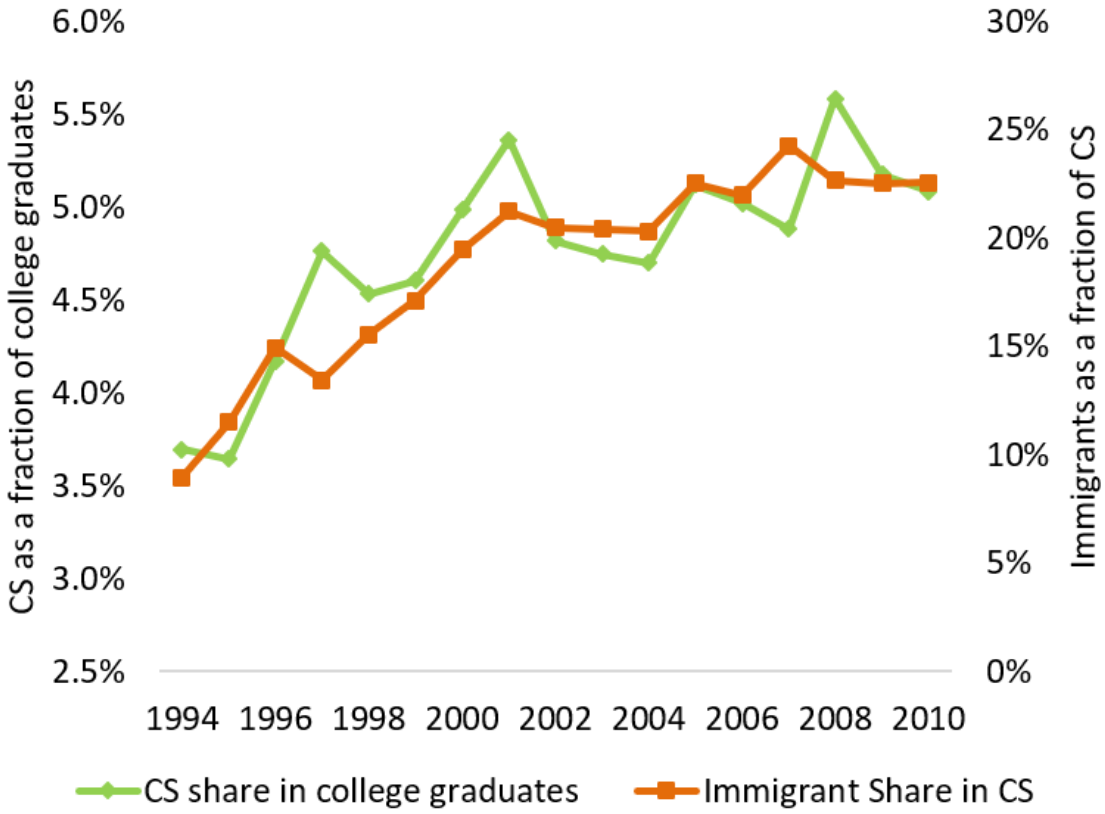
US Computer Scientists as % of College Grads



- CS fastest growing occupation in 1990s (and expected to stay fastest growing) (BLS 1996)

Innovation Boom in US IT and Immigration

US Computer Scientists as % of College Grads + Immigrants in CS



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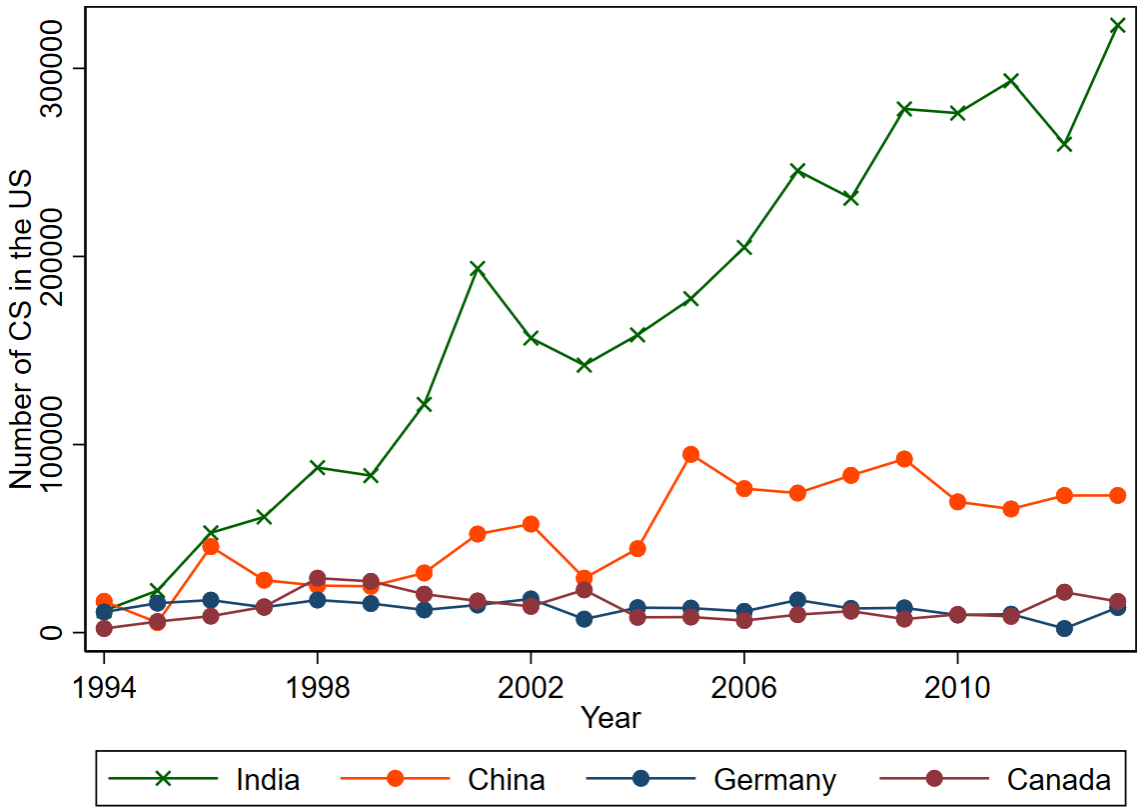
CS Immigration Driven By India

Foreign-born CS workers in the US by Country



- By 2014, more than 70% of H-1Bs went to Indians
- And 86% of all CS H-1Bs went to Indians (5% to China)

Raises Expected Wage Premium for CS in India

Relative Wages CS to non-CS for Indians

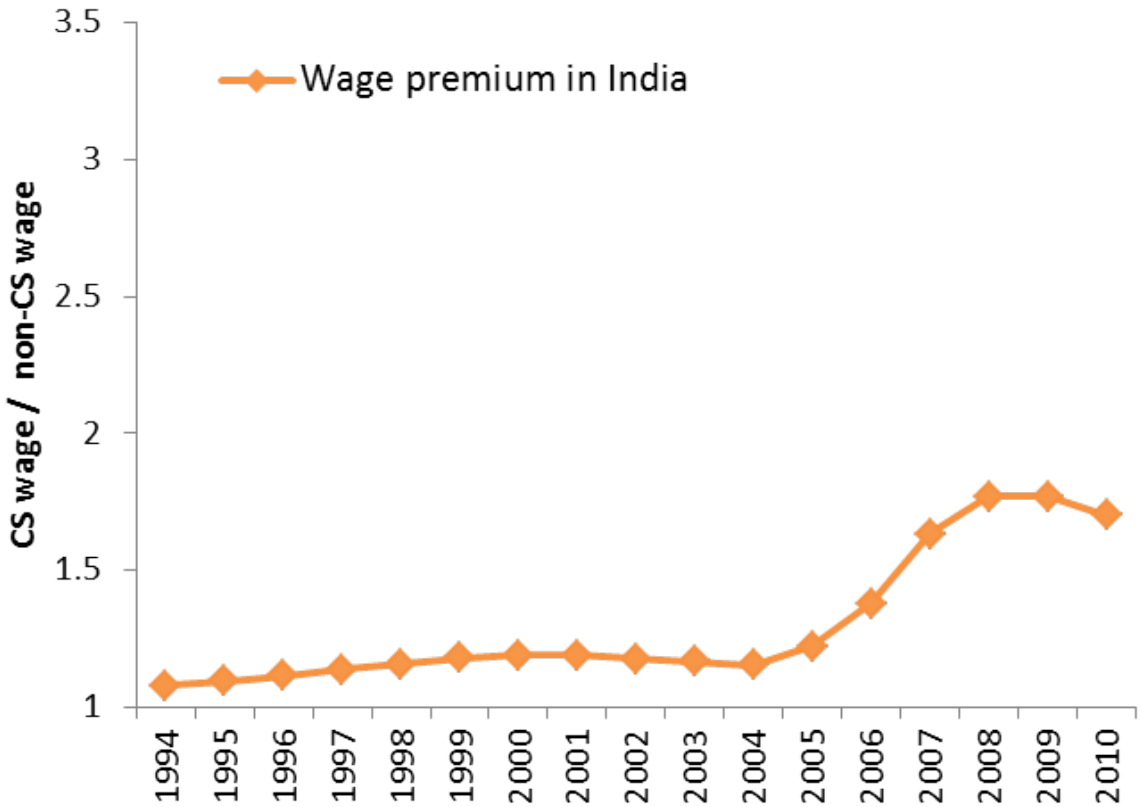


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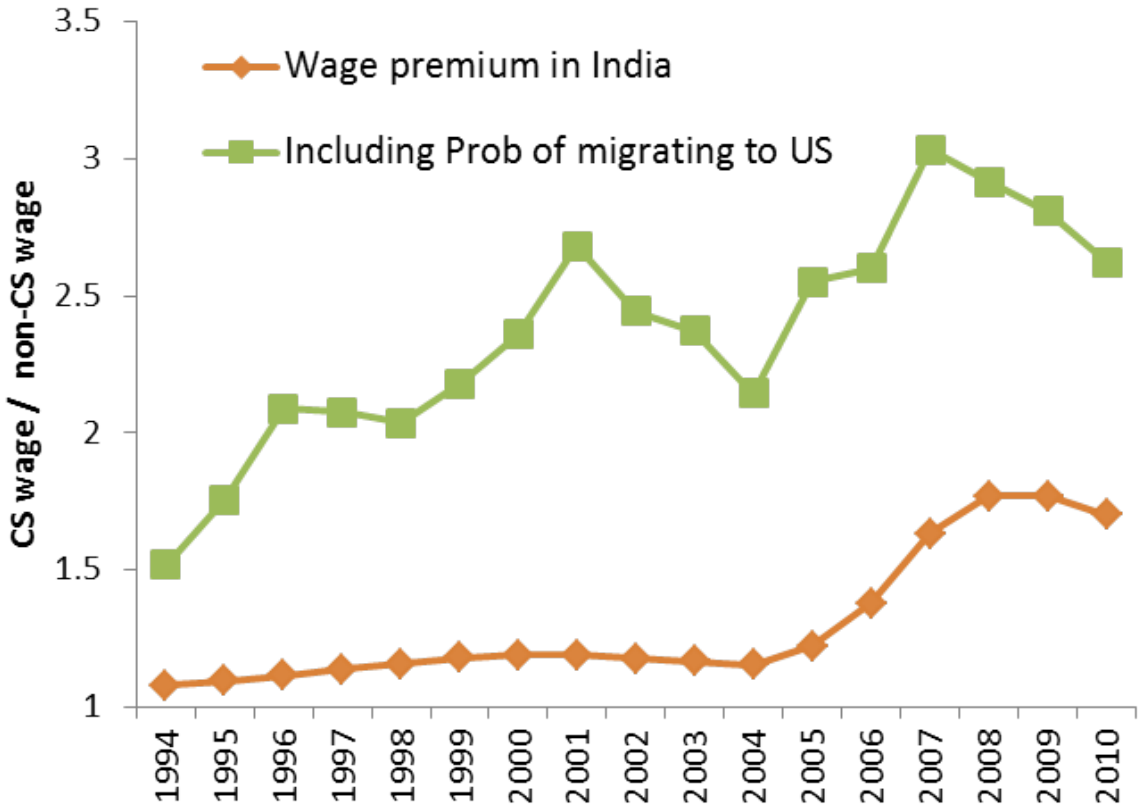
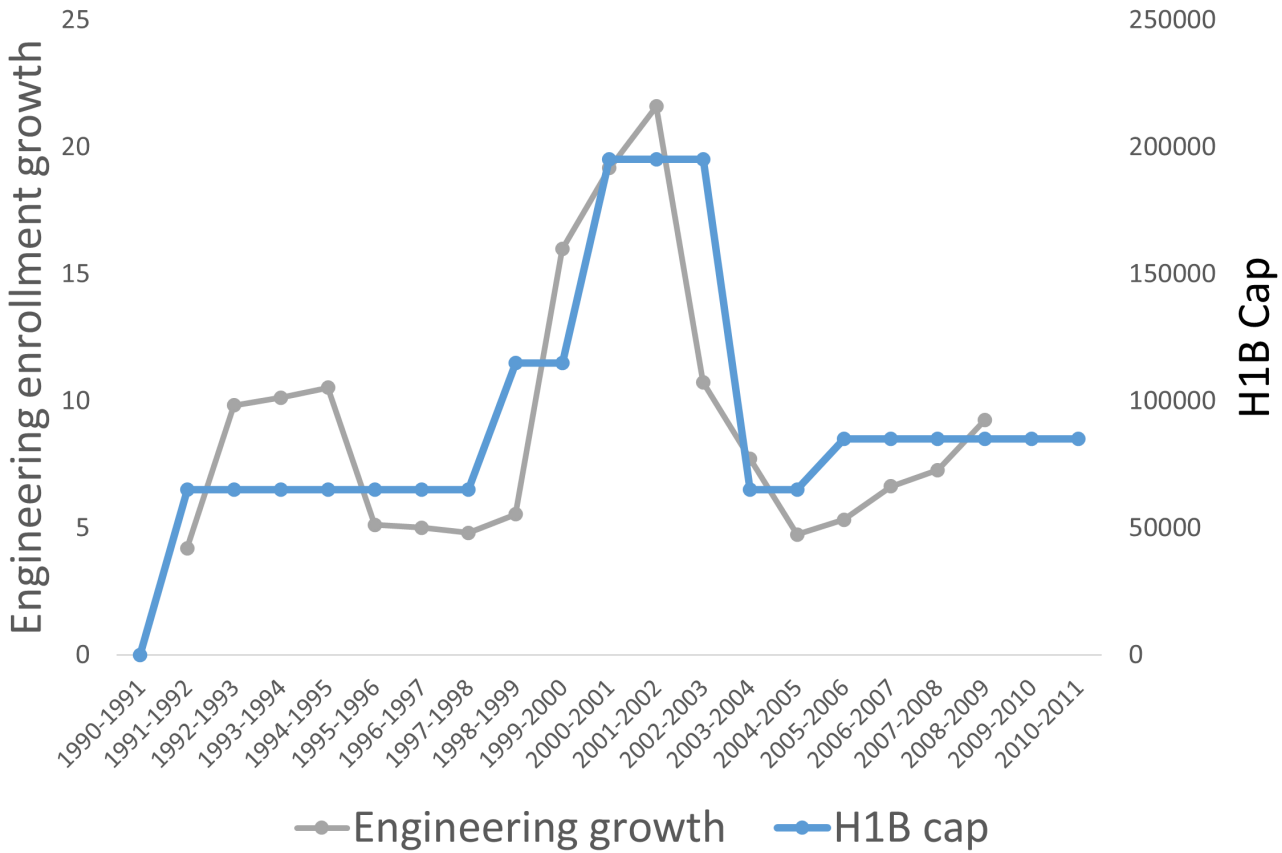
Figure: Relative Wages CS to non-CS for Indians



- In 2010 CS wage is $\approx$ 4 times higher in the US
- and $\approx$ 10% of Indian CS work in the US

Indian students enrolled in Engineering/CS



- *"growth (in training and degrees) was driven by larger salaries in the IT industry abroad"* (Bhatnagar 2005)
- (since few domestic IT jobs in 90s)

Brain Gain and Circulation

1. But H-1Bs capped – not all workers can go abroad.

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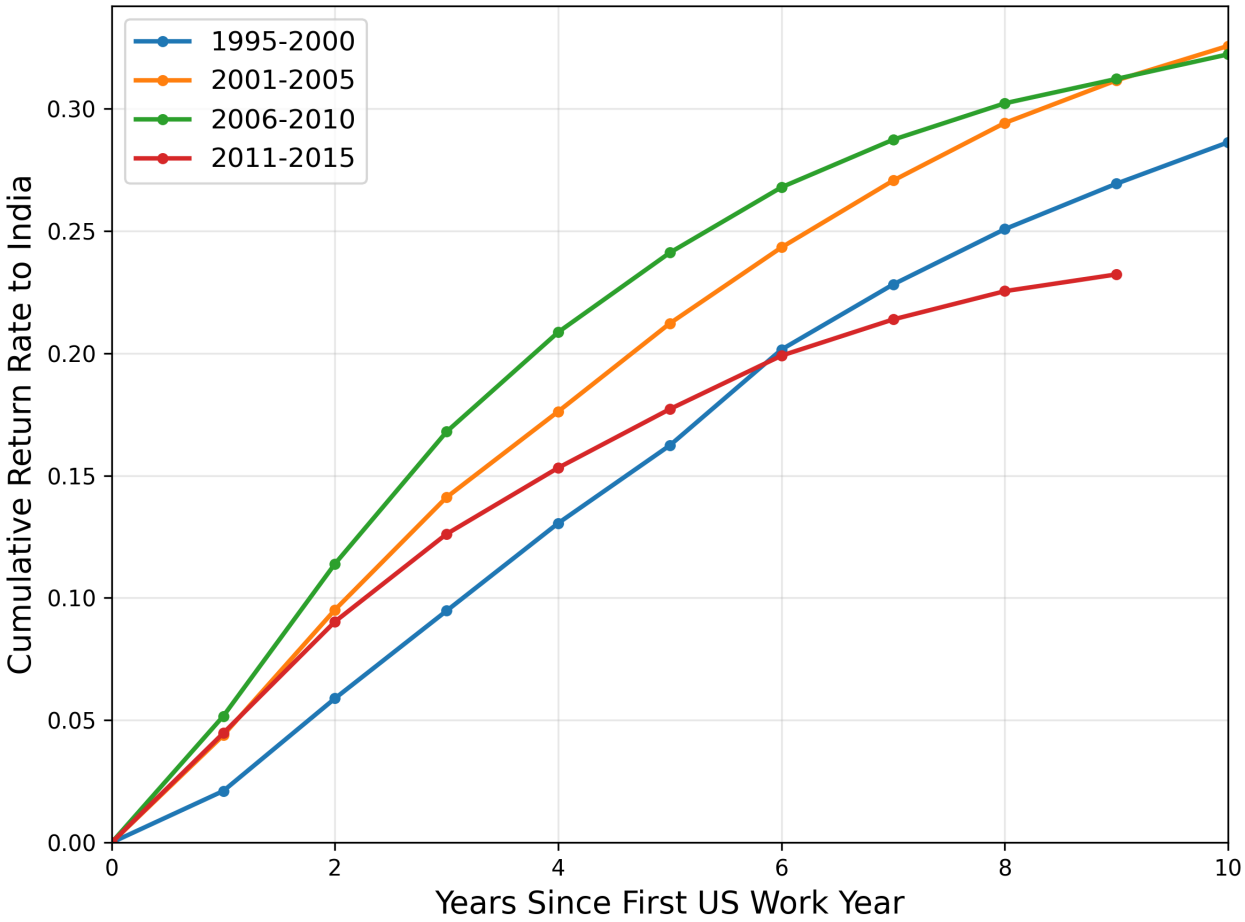

- In 6 years, >20% return

Boom in Indian IT firms

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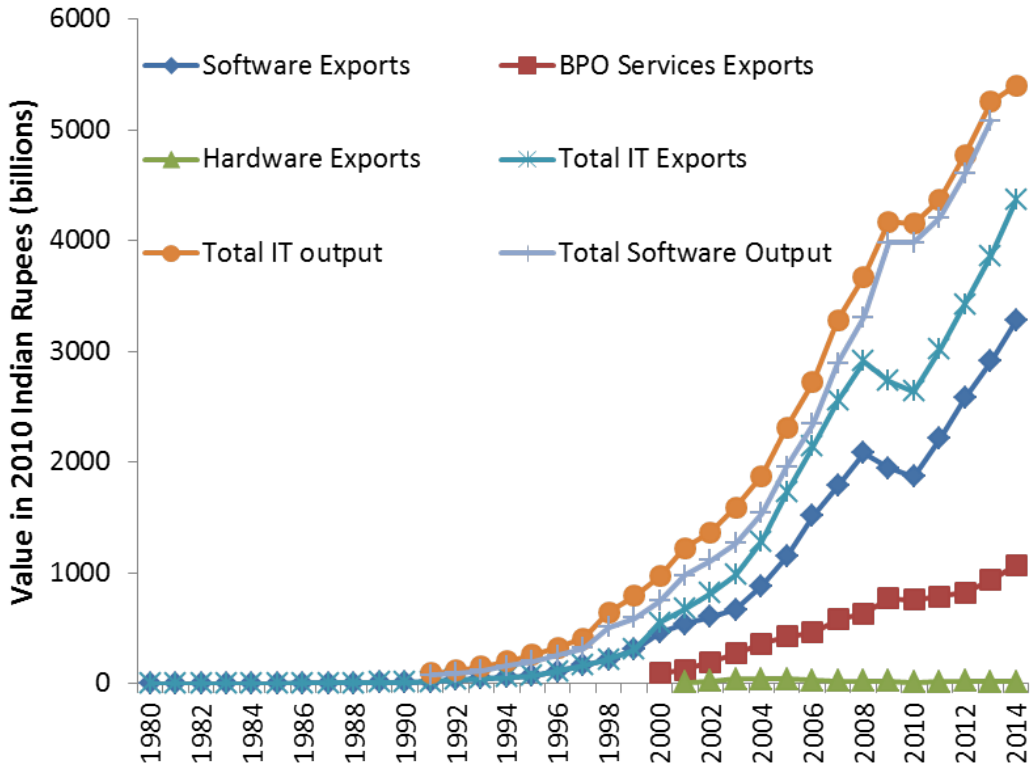
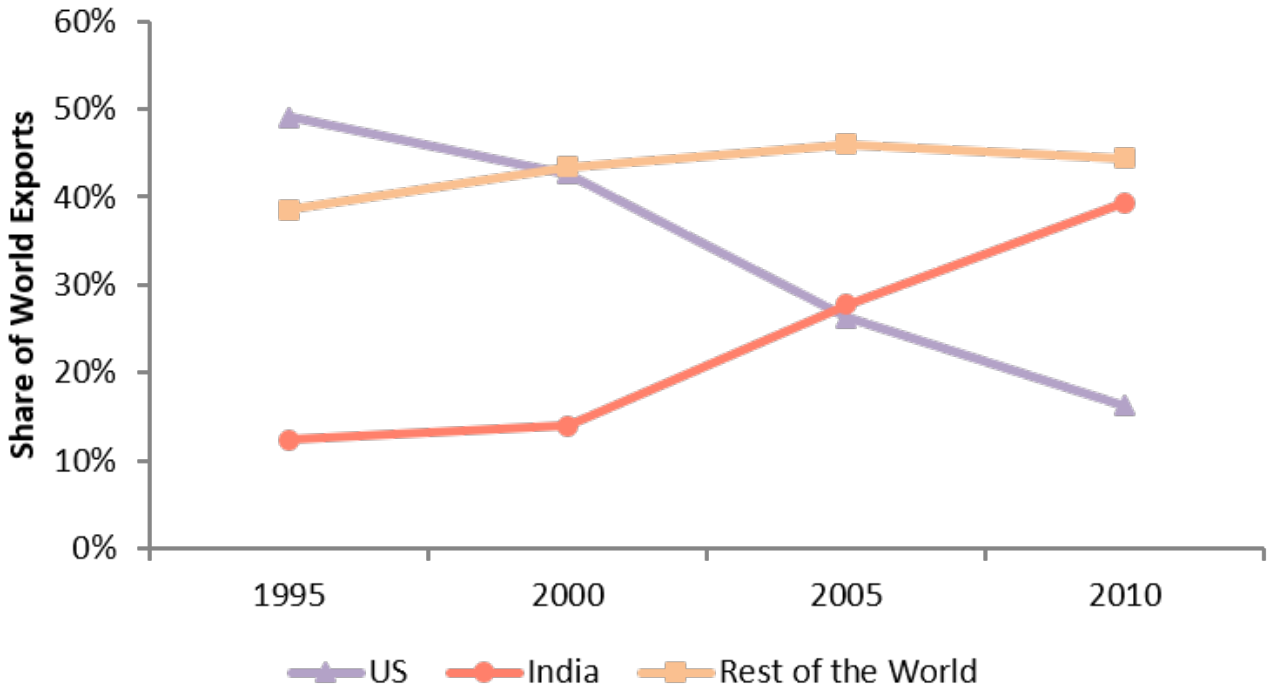
IT Sector Output in India



India Becomes Major Exporter of IT

Share of IT Exports: US, India and Rest of the World



- India overtakes the US in 2005 as an exporter of IT

What role did Immigration play in the spread of this tech boom to the other side of the world?

This Paper

- Evidence of 'brain-gain' driven by migration prospects
  - Prob(migration) affects India's Major & Occupation choice
  - IV: variation in H-1B cap + baseline occu/major shares

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- Build 3 country, 2 sector, quantitative GE model
  (di Giovanni et. al. 2015, Desmet et. al. 2018, Llull 2018, Burstein et. al. 2019, Colas 2019, Caliendo et. al. 2020, Monras 2020)
  - Dynamic occupational choice: CS vs Other.
  - Indians: uncertain on migration when choosing major
  - Migrants can return once visas expire ('brain circulation')
  - Innovation in CS

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- Results:
  - Immigration raised welfare and IT output in US & India
  - Endogenous labor supply is key to quantify welfare:
    Else... Brain Drain → Lower welfare in India

Combine two new datasets

- Enrollment: Universe of accredited Indian colleges
  - Digitize govt reports by school-field-year
- Migration and Workers: Universe of LinkedIn profiles
  - Occupation choice of workers in India LinkedIN vs ACS

US migration prospects and major choice in India

- Some school-majors more alumni in the US → Should respond more to changes in H-1B cap

US migration prospects and major choice in India

- Some school-majors more alumni in the US → Should respond more to changes in H-1B cap
- Leverage H-1B cap changes over time (t)
  - + school (s), field (f) exposure. H-1B cap
  - Mig exposure$_{s,f}$ = $\frac{\text{N grads from s,f before 2000 in US}}{\text{Enrollment in s,f in 2000}}$
  - Mig Dd$_t$ isolates demand from the US (e.g., policy changes)

$$Ln(\text{Students}_{s,f,t}) = \beta_1 \left(\text{Mig Dd}_t \times \text{Mig exposure}_{s,f}\right) + \underbrace{\delta_{sf}}_{\text{school-field FE}} + \underbrace{\delta_{st}}_{\text{school-time FE}} + \underbrace{\delta_{frt}}_{\text{field-region-time FE}} + \underbrace{\epsilon_{srft}}_{\text{Residual}}$$

Effect of H-1B cap on Enrollment in Majors

	Log(Enrolled)				Log(Passed Exams)			
Mig Exp X Log(H-1B Cap)	0.174***	0.121***			0.172***	0.125***		
	(0.0639)	(0.0447)			(0.0643)	(0.0348)		
Mig Exp X Log(Non-Indians)			0.139***	0.0976***			0.139***	0.102***
			(0.0494)	(0.0343)			(0.0489)	(0.0258)
Observations	8,421	7,649	8,421	7,649	8,421	7,649	8,421	7,649
R-squared	0.914	0.950	0.914	0.950	0.874	0.920	0.874	0.920
School-by-Field FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Field-by-Year FE	Yes	No	Yes	No	Yes	No	Yes	No
State-by-Year FE	Yes	No	Yes	No	Yes	No	Yes	No
Field-State-Year FE	No	Yes	No	Yes	No	Yes	No	Yes
School-Year FE	No	Yes	No	Yes	No	Yes	No	Yes

Alternative leads | Alternative shifters | State level

Occupation Choice & Migrant Demand

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- Divide Indian states on baseline (pre-1990) CS migration intensity to the US

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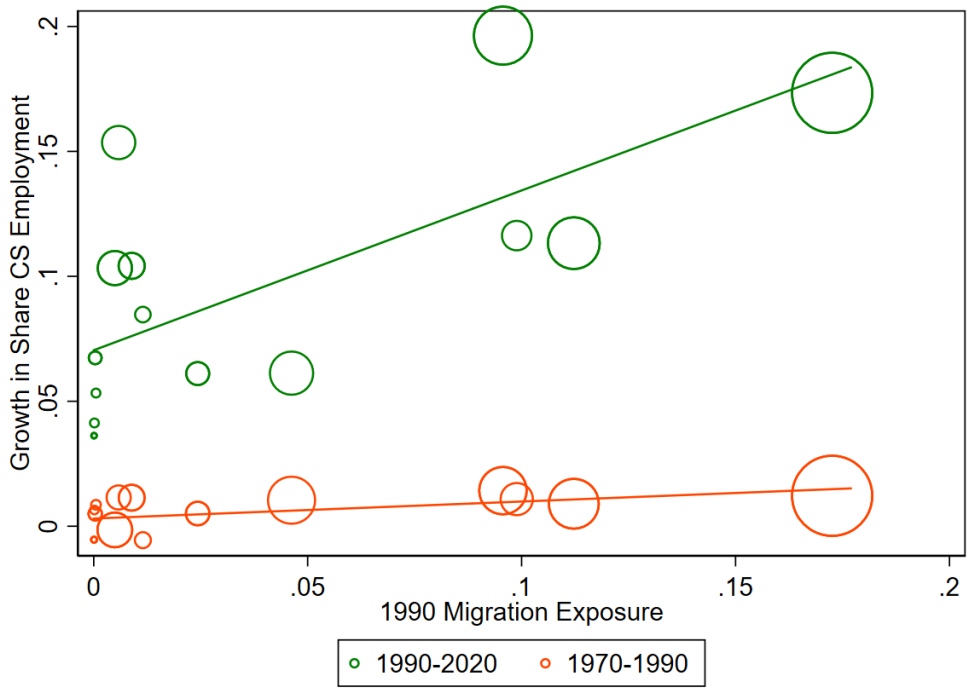
- Divide Indian states on baseline (pre-1990) CS migration intensity to the US
- Pre H-1B, no relationship.
- Post H-1B more growth in exposed states.



India Labor Response to Migration Opportunities

- Did migration to US impact occupational choice in India?
- Variation across time t, occs o & regions r in India

$$Ln(\text{N}_{ort}) = \beta_2 \left(\text{Mig exposure}_{or} \times \text{Mig Dd}_{ot}\right) + \delta_{or} + \delta_{rt} + \delta_{ot} + \epsilon_{ort}$$

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- A 'brain-gain' response. Event Studies Correlated Demand

	Log(Employment)					
	All	Young	Old	All	Young	Old
Mig Exp X Log(H-1B Cap)	0.00778**	0.0187***	0.000675			
	(0.00373)	(0.00580)	(0.00204)			
Mig Exp X Log(Non-Indians)				0.0524***	0.101***	0.00509**
				(0.00955)	(0.0126)	(0.00226)
Observations	283,133	89,533	45,287	234,369	77,682	35,930
R-squared	0.987	0.977	0.982	0.990	0.981	0.985
State-by-Occ FE	Yes	Yes	Yes	Yes	Yes	Yes
State-by-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Occ-by-Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Model Overview

Model Overview

Dynamic Labor Supply

- College-major and Occupation choice: CS vs. Other
- Uncertainty on migration when choosing → "brain gain".

Product Market and Labor Demand:

- (1) US, (2) India, (3) Rest of World
- 2 Sectors: (1) Final Goods, and (2) IT Good
- CS generate innovation spillover on technology

Dynamic Labor Supply

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- Occupation Choice:
  - Dynamic, occupation (o) choice thereafter

$$V^o_{t,a} = \max_o \Big\{ \underbrace{w^o_t \varepsilon^o_i}_{\text{current wage}} + \underbrace{\chi(a) \times \mathbb{1}(o_t \neq o_{t-1})}_{\text{switching cost}} + \underbrace{\zeta_o}_{\text{Occ. Avg taste}} + \underbrace{\beta \mathbb{E}_t[V^o_{t+1,a+1}]}_{\text{future payoffs}} + \underbrace{\sigma \eta^o_{i,t}}_{\text{preferences}} \Big\}$$

  - Heterogeneous preferences ($\eta_{i,t}$) and abilities (ε^o_i)
  - Switching costs vary by age a
  - Occupation-switching mitigates wage impacts

Drivers of Brain Gain and Brain Circulation

- Timing: Choose occupation in India in $t \rightarrow$ If CS, draw immigration probability $p_{t+1} \rightarrow$ If selected, migrate and work in $t+1$

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- Timing: Choose occupation in India in $t \rightarrow$ If CS, draw immigration probability $p_{t+1} \rightarrow$ If selected, migrate and work in $t+1$
- Migration Probability: depends on cap and CS ability $\rightarrow$ positive selection
- Return migrants are different (brain circulation)
  - 15-24% return by 6 years
  - Returning can be endogenous decision based on preferences
  - Not perfect substitutes with non-migrants
  - Return migration: has ambiguous effects on India

Production

- 2 Sectors: (1) Final Goods, and (2) IT Goods
- US, India, Rest of World: export/import all varieties

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- CS innovation spillover on IT technology
- IT good is intermediate good in Final output
  - Growth and innovation in IT affects downstream sectors

Equilibrium Back

Labor Demand

- Nested composite of 3 CES nests:
  1. Graduates vs non-grads
  2. CS grads vs non-CS grads
     - As CS workforce increases, demand for complements rise
     - Sector- and Skill-biased technical change over time
  3. In India: return CS vs non-migrant CS
  3. In US: immigrant CS vs native CS

First Estimate Fundamental Elasticities

1. India's labor supply response to migration opportunity
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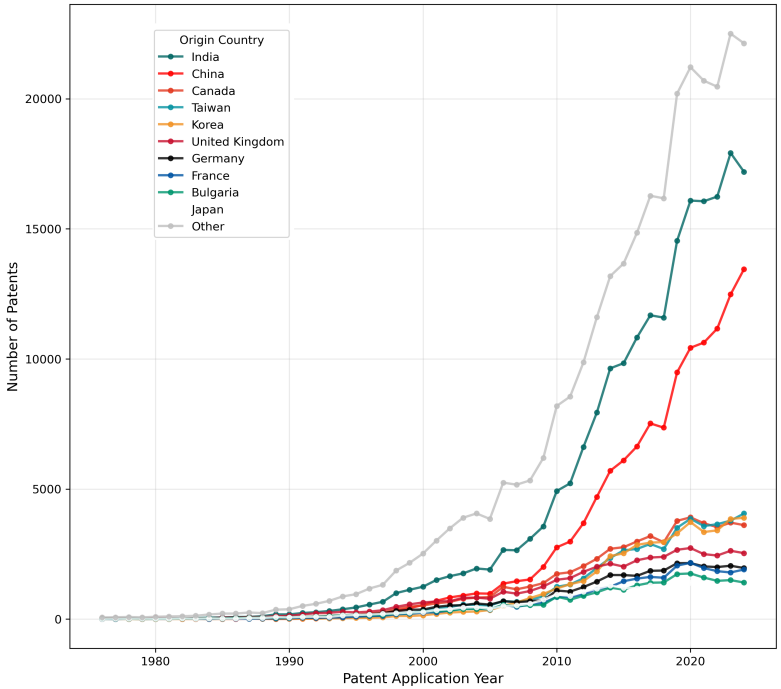
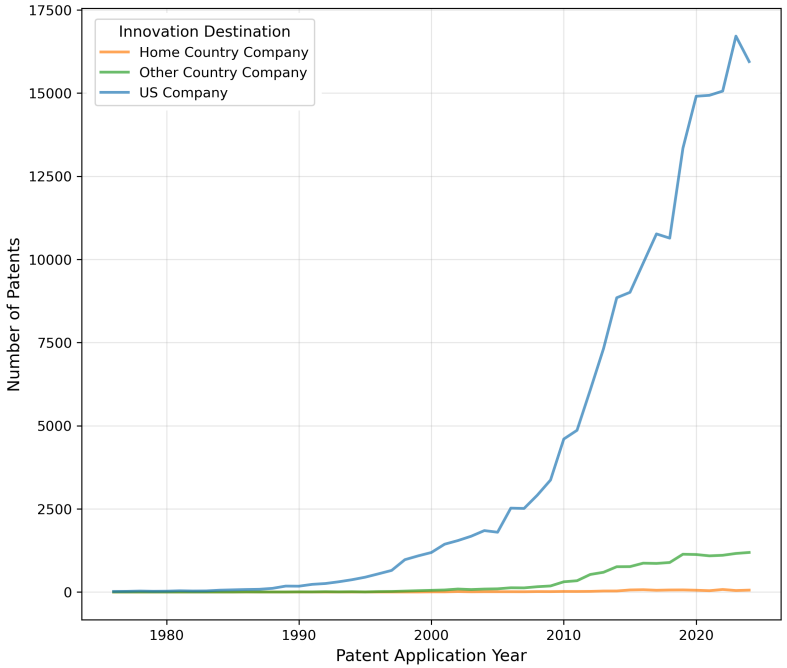
2. Computer Science innovation elasticity:
   - Estimate impact on patents Results
   - Leverage: (1) Immigrants concentrated in CS, (2) H-1B cap
3. Labor supply elasticity (wrt wages)
   - Dynamic: Long run v Short run elasticity
   - SMM Identification Details

Immigrant Patents Driven by Indians

(a) Patents By Country



(b) Assignees



Back

SMM Identification

1. India's labor supply response to migration opportunity
   - Estimated using shift-share ✓
2. Computer Science innovation elasticity: $T_k = T(CS_k)$
   - Estimate impact on patents ✓
3. Labor supply elasticity (wrt wages)
   - Dynamic: Long run v Short run elasticity Details
   - "Innovation Shocks" shift out labor demand: 'Trace out' labor supply curve

Impact of Migration: Ambiguous Predictions

- Effects on the sending country: India
  - Brain-drain vs Brain-gain (skill acquisition) and
  - Brain-circulation: return migrants

  (Stark 2009, Easterly & Nyarko 2009, Abarcar & Theoharides 2020)

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- Effects on the receiving country: US
  - Immigrants expand IT sector vs Production shifting abroad
  - Deteriorate terms of trade: IT exports cheaper (Krugman 1979, Davis & Weinstein 2002, Acemoglu, Gancia & Zilibotti 2015)

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- Effects on workers in both countries
  - More CS (lower wages) vs more innovation (higher wages)
  - For non-CS: more demand (higher wages) vs more switching into non-CS (lower wages)

    (Borjas 1999, Kerr & Lincoln 2010, Hunt & Gauthier-Loiselle 2010, Peri et. al. 2015, Doran et. al. 2017, Bound Khanna & Morales 2017)
  - Consumers: better off from lower prices, more productivity

Impact of Migration in 2010

	Baseline	No occupational choice	
		In both countries	In India only
Wages			
US CS workers	-0.64%		
India CS workers	-12.27%		
Occupational Choice			
US CS (native plus immigrant)	2.88%		
US CS workers	-3.89%		
India CS workers	42.23%		
IT production			
US IT output	1.06%		
India IT output	25.02%		
Welfare			
Welfare of US natives	0.043%		
Welfare in India	0.066%		

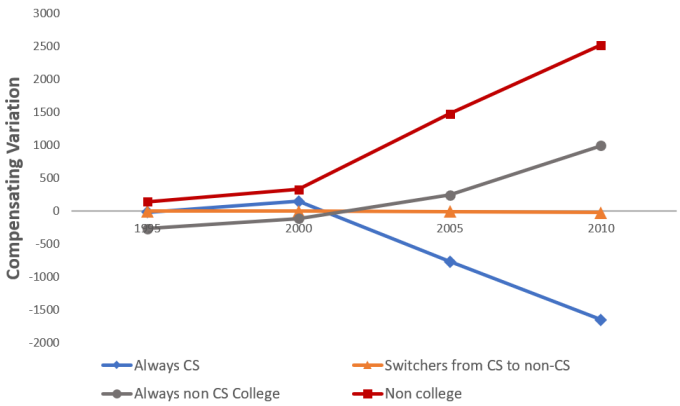
Impact of Migration in 2010

		No occupational choice	
	Baseline	**In both countries**	**In India only**
Wages			
US CS workers	-0.64%	-2.40%	-0.54%
India CS workers	-12.27%	1.31%	1.47%
Occupational Choice			
US CS (native plus immigrant)	2.88%	6.72%	3.16%
US CS workers	-3.89%	-	-3.60%
India CS workers	42.23% -	-	
IT production			
US IT output	1.06%	3.84%	2.21%
India IT output	25.02%	-10.41%	-10.17%
Welfare			
Welfare of US natives	0.043%	0.061%	0.045%
Welfare in India	0.066%	-0.055%	-0.053%

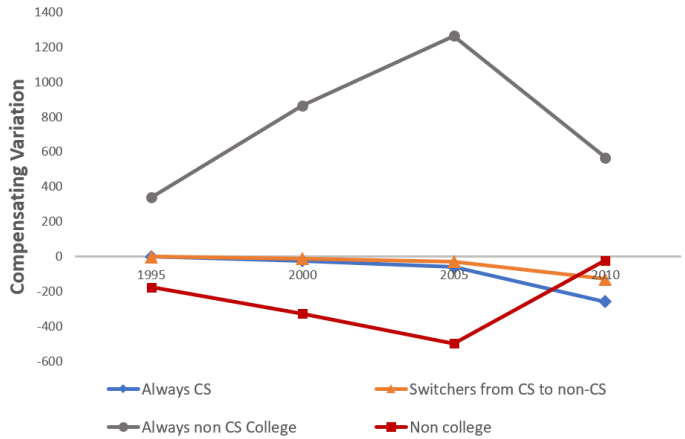
- Brain Gain > Brain Drain: If can't switch occupations India CS / IT can't grow; US IT output will rise

Distributional Welfare (USD mn)

(a) US native Workers



(b) Workers in India



Mechanisms

- Return Migration: Results
  1. Bring back tech knowhow and enlarge Indian IT sector.
  2. But lowers gains from migration – less 'brain gain'.

- Innovation Spillover: Results
  1. Key for India's welfare gain.

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- Innovation Spillover: Results
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- Trade and Remittances: Results
  1. Lower trade costs: more shift in IT production to India
  2. Remittances shift where income is spent

- Alternative counterfactuals:
  1. Vary cap-size – results are non-linear but monotonic Results
  2. Restrictions in later years: different consequences Results

US Immigration Policy Partly Affected Structural Change in India

- Halving H-1B migration reduces welfare by 0.15%
  - $55K per migrant
  - $13K goes to US workers; $1.1K to Indian non-migrants
- Distributional consequences of migration:
  - In US and India, native computer scientists wages lower
  - Non-CS better off from immigration.
- Important to model occupational switching, trade, innovation, price changes, wage expectations....
- Endogenous skill acquisition key to quantify gains

Thank You!