Reading group

The Global Race for Talent: Brain Drain, Knowledge Transfer, and Growth

Prato (2022)

Working paper

Presented by Duong Tung Bui *(Univ of Western Ontario)*

November 1, 2025

1. Introduction
2. Model
3. Data
4. Empirical facts
5. Quantitative analysis
6. Conclusion

Motivation

- Migration of high-skilled workers creates various negative and positive effect to the economy
  - For the origin country, fear of "brain drain" and the benefit of cross-country knowledge transfer by emigrants
  - For host country, immigrant bring valuable talent, but they might displace native workers?
- Policy-related questions:
  - What are the aggregate implications of migration on the countries of origin and destination?
  - What determines the decisions of individuals to migrate?
  - How do individuals form their collaboration and interaction networks?
  - What is the role of policy in shaping these individual-level decisions and aggregate outcomes?

Research question and Innovation

Research question: Impact of international migration on the allocation of talent, innovation, and knowledge transfer across countries

Innovation: Introduces a two-country general equilibrium model of innovation-based endogenous growth. The novelties of the model include

- Migration decision are micro-founded and shape migration flows, innovation and talent allocation
- Inventors accumulate human capital by learning from others within endogenous interaction network, which vary across countries

Related literature and Contribution

Endogenous growth focusing on individuals: (Lucas and Moll (2014), Akcigit et al. (2018), Akcigit et al. (2020))

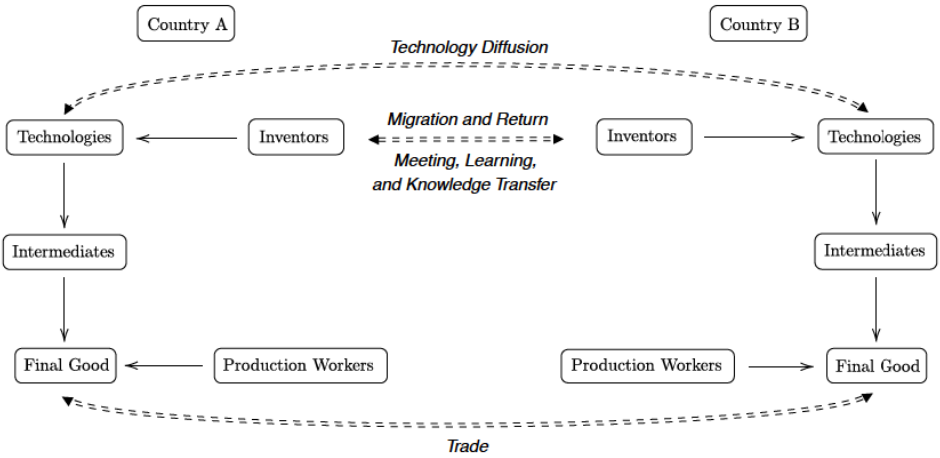
- Agents in the economy can increase their productivity through interactions with others, which often draws from a exogenous or endogenous distribution.
- This paper contributes through introducing (i) endogenous international migration and (ii) endogenous interaction networks and knowledge spillovers within and across countries

Link between innovation, migration, and growth: (Kerr and Lincoln (2010), Borjas and Doran (2012), Foley and Kerr (2013), Bernstein et al. (2018))

- Most focuses on the effect of immigration on the receiving country.
- This paper makes contribution by additionally emphasizing the effect of emigration on the sending country

Overview

Figure 1: Summary of the Model



Setup

Two countries context

- Individuals are born as either **Production workers** or **Inventors**.
- **Inventors**: 4 types differing by cross-country mobility. ▸ Details
    - Have ex ante heterogeneous talent z, which evolves through interaction and learning. ▸ Details
    - Produce new technologies and ideas.
    - Choose to move based on talent, foreign productivity differentials, and global conditions. ▸ Details

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  - Produce new technologies and ideas.
  - Choose to move based on talent, foreign productivity differentials, and global conditions. ▸ Details
- **Intermediate-good monopolists** enhance product quality by: ▸ Details
  - Buying technology from local inventors.
  - Benefiting from exogenous spillovers from more productive countries.
- **Final goods** are competitively produced from labor and intermediate goods, and traded internationally. ▸ Details

Inventors and Production worker Setup

- Country $c \in \{A, B\}$. Total individuals in the economy: $L_c + I_c = 1$, each has survival rate δ
- **Inventors of each type** $j \in \{AA; AB; BB; BA\}$ with the 1st letter denotes country of origin, and 2nd one denotes country of residence
- The endogenous **mass of local inventors** in country c: $\mu_{Ac} + \mu_{Bc} = I_c$
- Talent $z \sim$ Parato dist $\hat{F}_c(z)$. Foreign productivity shock $\epsilon \sim$ exogenous dist $\Upsilon_c(\epsilon)$.
- **Inventors produce technology** q_t with linear production function:

$$q_t(z_t, \epsilon_t) = \begin{cases} z_t & \text{if local (living in country of origin)} \\ \max\{z_t + \epsilon_t, 1\} & \text{if migrant (living abroad).} \end{cases}$$

- Let $F_{j,t}(q)$ and F_c denote the endogenous distributions of innovation bundles by type j and country c at time t.

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Inventor - Interactions and Learning

Talent z evolve endogenously as the result of interactions and learning.

- Inventor have **random meetings** with prob λ
- When an inventor with talent and bundle $(z, q) \geq 0$ meets another with $(\hat{z}, \hat{q}) \geq 0$, **talents evolve** according to the following learning function

$$z_t = z_{t-1}\hat{q}_{t-1}^{\eta} \quad \text{and} \quad \hat{z}_t = \hat{z}_{t-1}q_{t-1}^{\eta},$$

  with $\partial^2 z_t / \partial z_{t-1}\partial\hat{q}_{t-1} > 0$
- Conditional on having a meeting, the probability of an individual of **type** i **meeting an individual of type** j:

$$\psi_{i,j,t} = \frac{\mu_{j,t}}{\sum_{j' \in \mathcal{J}} \mu_{j',t}}\xi_{i,j} \quad \text{for } i \neq j$$

  The set of probabilities $\{\psi_{i,j}\}$ captures the endogenous interaction network in the global economy, $\xi_{i,j}$ captures meeting frictions across any two types.

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Inventor - Migration Decision

- **Migration and return problem** for an inventor with country of origin A (same for origin B):

$$W_{AA}(z,\epsilon,t) = \max\{V_{AA}(z,\epsilon,t),\ V_{AB}(z,\epsilon,t) - \underbrace{\kappa \bar{A}_A(t)}_{\text{Fixed cost of migration}}\},$$

$$W_{AB}(z,\epsilon,t) = \max\{V_{AB}(z,\epsilon,t),\ V_{AA}(z,\epsilon,t)\}.$$

with

$$V_{AA}(z,\epsilon,t) = \underbrace{\pi_A(z,t)}_{\text{Inventor's profits}} + \beta\delta \int_{-\infty}^{\infty} \Big(\lambda \sum_j \psi_{AA,j,t} \int_1^{\infty} \underbrace{W_{AA}(z\hat{q}^{\eta},\epsilon',t+1)}_{\substack{\text{Continuation value after meeting} \\ \text{an inventor of type } j}} dF_{j,t}(\hat{q})$$

$$+ (1-\lambda) W_{AA}(z,\epsilon',t+1) \Big) d\nu_{\epsilon'|\epsilon}.$$

- $V_{AB}(z,\epsilon,t)$ share similar form but differ in (i) **profit** $\pi_B(z+\epsilon,t)$, (ii) **productivity differential** ϵ, (iii) **probabilities of interacting with different inventor** $\psi_{AB,j}$. These differences corresponds to 3 reasons why inventors migrate in this model

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Production of final good

- In each country c, **competitive final good** producer that maximize profit

$$\max_{L_c, k_{j,c}} Y_{c,t} - w_c L_c - \int_0^1 p_{j,c,t} k_{j,c,t} dj \quad \text{s.t} \quad Y_{c,t} = \frac{1}{1-\alpha} (L_c)^{\alpha} \int_0^1 (A_{j,c,t})^{\alpha} (k_{j,c,t})^{1-\alpha} dj$$

This problem delivers the following demand curve for intermediate input k_j

$$P_{j,c} = (L_c)^{\alpha} (A_{j,c})^{\alpha} (k_{j,c})^{-\alpha} \quad (1)$$

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$$P_{j,c} = (L_c)^\alpha (A_{j,c})^\alpha (k_{j,c})^{-\alpha} \quad (1)$$

- Each **intermediate monopolist** maximizing profit with marginal cost $1-\alpha$

$$\Pi_{j,c} = \max_{k_{j,c}, P_j} \{P_{j,c} k_{j,c} - (1-\alpha) k_{j,c}\}, \quad \text{subject to (1).}$$

and the optimal profit is: $\Pi_{j,c} = \alpha L_c A_{j,c}$.

- **Aggregate productivity** in economy c, $\bar{A}_c = \int_0^1 A_{j,c} dj$. It follows that the equilibrium workers' wage and aggregate output are linear in aggregate productivity:

$$w_c = \frac{\alpha}{1-\alpha} \bar{A}_c, \quad Y_c = \frac{1}{1-\alpha} L_c \bar{A}_c.$$

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Market for ideas

Intermediate-goods monopolists improve the quality of their product by:

1. **Purchase technologies from local inventors**
   - Quality increase by step size $q\bar{A}$
   - The number of matches and the **probability of technology-purchasing** for firm is the same since number of intermediate firm $IF_c = 1$

$$x_{c,t} = (\mu_{Ac,t} + \mu_{Bc,t})^{\nu} (IF_c)^{1-\nu} = \frac{x_{c,t}}{IF_c} = (\mu_{Ac,t} + \mu_{Bc,t})^{\nu}$$

   - **Technology-selling probability** for inventors:

$$(\mu_{Ac,t} + \mu_{Bc,t})^{\nu-1} = \frac{x_{c,t}}{\mu_{Ac,t} + \mu_{Bc,t}}$$

   with $\nu < 1$ capturing the crowding out effect

2. **Receive exogenous spillover from frontier country**
   - **Spillover rate** is $\tilde{\sigma}_{c,t} = \sigma \max\{\bar{A}_{c,t} - \bar{A}_{-c,t}, 0\}$

Market for ideas (Con't)

Thus, the **value of owning a product line** with quality $A_{j,c,t}$, denoted by $J(A_{j,c,t}, t)$, is:

$$J(A_{j,c,t}, t) = \Pi_{j,c,t} + \frac{1}{1+r}\left[x_{c,t}\left(\int_1^\infty \left(\underbrace{J(A_{j,c,t} + \tilde{\sigma}_{c,t} + q\bar{A}_{c,t+1}, t+1) - p_{j,c,t+1}(q)}_{\text{Purchase tech with cost } p_{j,c(q)}} \right) dF_c(q) \right.\right.$$

$$\left.\left. + (1 - x_{c,t}) \underbrace{J(A_{j,c,t} + \tilde{\sigma}_{c,t}, t+1)}_{\text{Exogenous tech spillover}} \right)\right].$$

The **profits of an inventor** with talent z working in country c:

$$\pi_c(z,t) = (\mu_{Ac} + \mu_{Bc})^{\nu-1} p_{c,t}(q(z))$$

Back

Again, the innovation in this model is:

1. Migration decision are micro-founded and shape migration flows, innovation and talent allocation
   - Inventor migrate because of (i) **profit** $\pi_B(z+\epsilon, \mu_{j,c}, q)$, (ii) **productivity differential** ϵ, (iii) **probabilities of interacting with different inventor** $\psi_{i,j}(\mu_{j,c})$
   - Migration affect share of different inventor type $\mu_{j,c}$, which then probability of firm matching with an inventor $x_{c,t}$
   - Migration also affect talent z, and then technological bundle $q(z)$, and then productivity $A_{j,c}$
   - So on and so forth
2. Inventors accumulate human capital z by learning from others within endogenous interaction network $\psi_{i,j}(\mu_{i,j})$, which vary across countries

Balanced growth path

1. **Equilibrium in idea market**: Ideas valued by discounted profits; symmetric across intermediate sectors

$$p_{j,c,t} = p_{c,t} = \frac{1+r}{r} \underbrace{\alpha L_c \bar{A}_{c,t}}_{=\Pi_c}$$

2. **Migration decisions in equilibrium**: Migration is time-invariant. This means when both countries' technology and wages grow at the same constant rate, inventors have no further incentive to relocate.

Balanced growth path

3. **Evolution of aggregate productivity in equilibrium**: aggregate productivity grows at the same rate in each country:

$$g_A = g_B = g = \max\{\iota_A, \iota_B\}$$

and the productivity gap is constant and equal to:

$$a = \begin{cases} \frac{\sigma}{\sigma+\iota_B-\iota_A} & \text{if } \iota_B > \iota_A \\ \frac{\sigma+\iota_A-\iota_B}{\sigma} & \text{if } \iota_B < \iota_A. \end{cases}$$

- Even if the laggard country (say, B) innovates more slowly, it still grows at the same rate as the frontier country (A)
- The gap in productivity levels remains constant over time — determined by the relative innovation rates and spillover rate.

Taxation and Migration policies

1. Taxes on inventors' profits

$$\pi_c(z,t) = (1-\tau_c)(\mu_{Ac}+\mu_{Bc})^{\psi-1} p_{c,t}(q(z)).$$

2. Immigration caps

- The country introduce a migration of at most $\hat{\mu}$ inventor with the probability of being allowed to move

$$m_t = \min\left\{\frac{\bar{\mu}}{\mu^*_{AB,t}}, 1\right\}.$$

where $\mu^*_{AB,t}$ is the mass of local inventors of origin A who want to move to B equal

$$\mu^*_{AB,t} = \iint \mathbf{1}\{V_{AB}(z,\epsilon,t) - \kappa \bar{A}_A(t) - V_{AA}(z,\epsilon,t) > 0\} g_{AA,t}(z,\epsilon)\, d\epsilon\, dz$$

- The continuation value for a local inventor born in A and living in A is

$$W_{AA}(z,\epsilon,t) = \max\{V_{AA}(z,\epsilon,t), m_t(V_{AB}(z,\epsilon,t) - \kappa \bar{A}_A(t)) + (1-m_t)V_{AA}(z,\epsilon,t)\}.$$

Application: Asymmetric Tax Rates

Setup:

- Two countries: A (low tax τ_A) and B (high tax τ_B).
- A has free immigration; B caps inflow at $\bar{\mu}$.
- Talent, preferences, and occupational structure are identical across countries.

Assumptions:

1. Identical exogenous characteristics: $I_A = I_B$, $\theta_A = \theta_B$, $\rho_A = \rho_B$, $\omega_A = \omega_B$.
2. Meeting frictions favor local and same-origin interactions; migrants meet locals at destination more easily.

Application: Asymmetric Tax Rates (Con't)

Key Results:

- **Migration thresholds (Prop. 5–6):**
  - Higher-talent inventors (z) more likely to move to low-tax B; return if productivity shock (ϵ) falls.
  - Lower-talent inventors remain home or return sooner.
- **Implication:**
  - Low taxes in B attract top talent $\rightarrow$ higher average talent and innovation.
  - High-tax A loses top inventors but gains through return migration.

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Data

Miguelez & Fink (2013) — World Intellectual Property Organization (WIPO): PCT patents

- Record inventors' nationality and residence.
- Used to measure aggregate migration flows.
- No individual-level information.

Coffano & Tarasconi (2014) — European Patent Office (EPO) patents

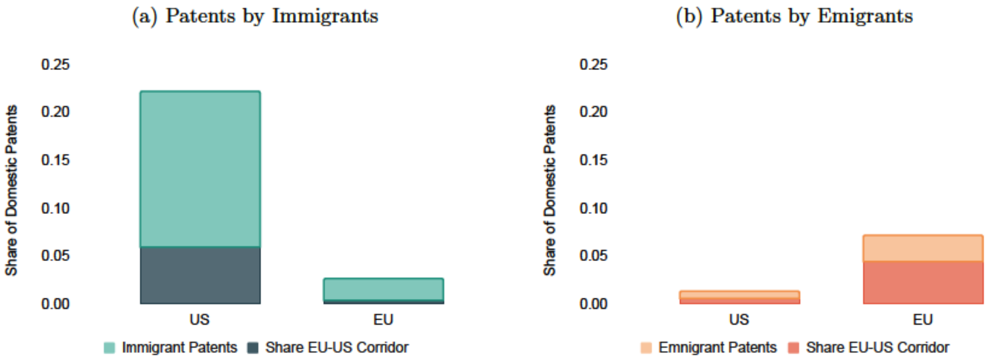
- Include inventor names, addresses, assignees, tech fields, and citations.
- Complement PCT data for individual-level analysis.

Key measures:

- **Individual migration:** based on tracking address changes across countries; inferring origin from name via name-based software (Namsor).
- **Productivity and Interactions:** based on patents, citations, and co-inventor records.

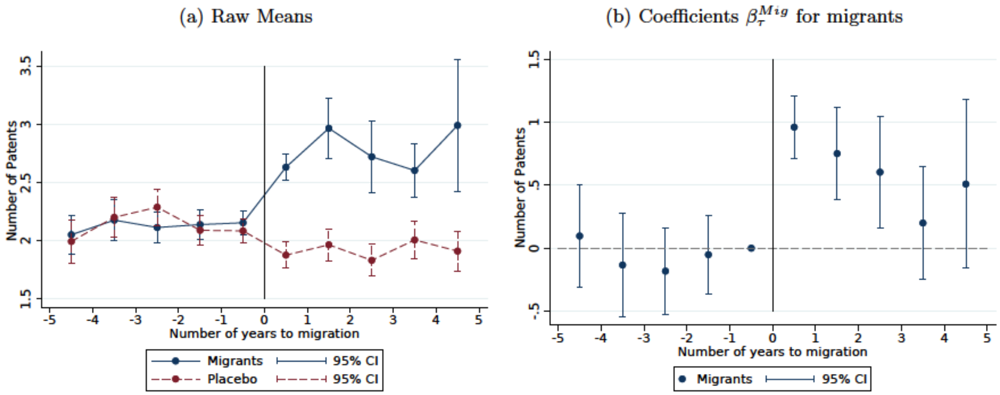
(i) Migration flows between the EU and the US are asymmetric

Figure 2: Immigration and Emigration of Inventors in US and EU, 2000-2010



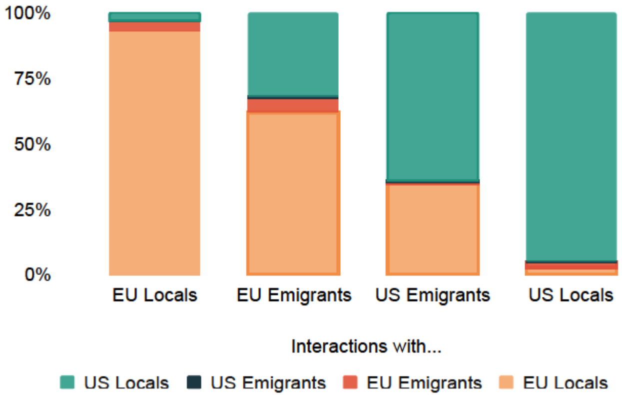
(ii) Migrants tend to become more productive after migration.

Figure 3: Patenting Activity by Migrant Inventors around Time of Migration



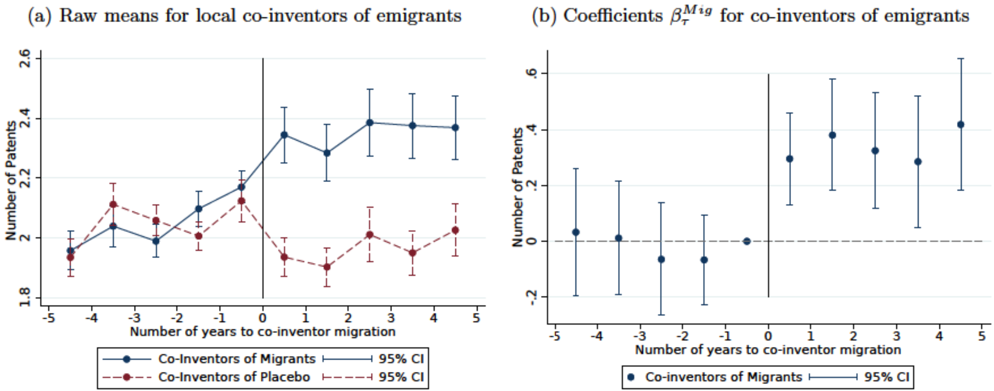
(iii) Collaboration networks are heterogeneous for locals and migrants and migrants continue working with inventors at origin after moving.

Figure 4: Interaction Networks



(iv) Local inventors tend to become more productive after a co-inventor emigrates

Figure 5: Patenting Activity by Co-inventors of Migrants around Time of Migration



Calibration

Goal: Quantify EU–US migration, innovation, and talent allocation by fitting the model to microdata.

Setup:

- EU → country A, US → country B.
- Equal talent distribution and R&D share across locations ($\theta_A = \theta_B$, $I_A = I_B$).
- 22 parameters calibrated using three steps.

Three-step calibration:

1. **External calibration:** Use literature values ($\beta = 0.97$, $r = 0.03$, $\delta = 0.95$, $\alpha = 0.11$, $\nu = 1$, $\tau_A = 0.4$, $\tau_B = 0.3$, $I_A = 0.01$).
2. **Direct match to data:** Six meeting-friction parameters ξ_{ij} fitted to inventor network data.
3. **SMM calibration:** Jointly estimate eight parameters ($\bar{\mu}, \kappa, \lambda, \eta, \sigma, \theta_A, \rho, \omega$) via simulated method of moments (SMM).

Quantifying the Importance of Knowledge Transfers

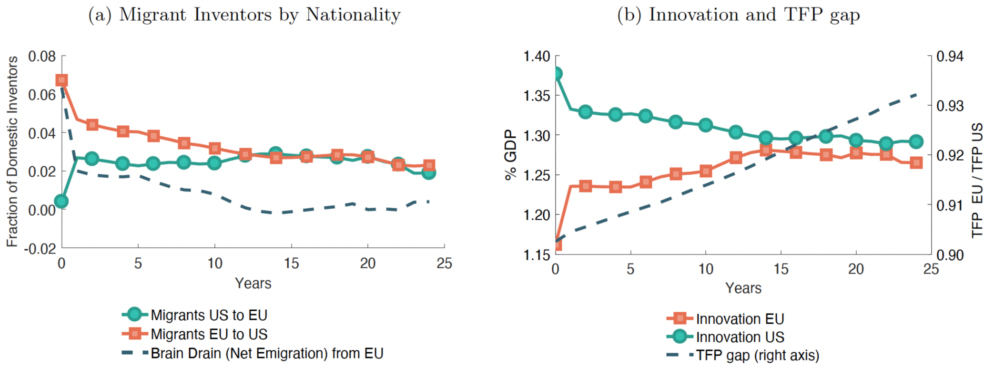
Answering this question by shutting off interactions across different groups of inventors; i.e., set $\xi_{i,j} = 0$ for all $i \neq j$

Table 6: Shutting Down International Knowledge Transfers

	Baseline	New	% Change
—Panel A. Innovation and Growth —			
Innovation EU	1.19%	1.08%	-9.2%
Innovation US	1.39%	1.48%	6.5%
Growth Rate	1.39%	1.48%	6.5%
TFP Gap	0.90	0.83	-8.2%
—Panel B. Migration Flows —			
EU-US Migrants	0.07	0.10	54.5%
US-EU Migrants	0.00	0.00	-100.0%
Return Share	0.10	0.03	-65.4%

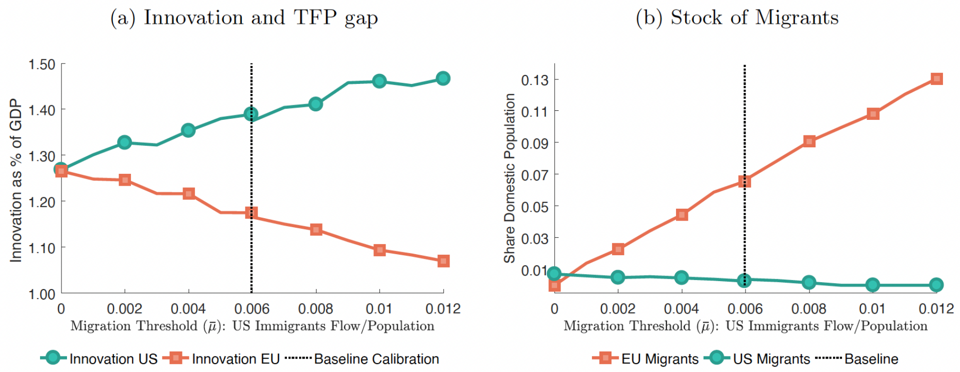
Policy exercise: Tax Cut for Foreign Inventors and Return Migrants in the EU

Figure 9: Tax Cut for Foreigners and Return Migrants in the EU: Migration and Innovation.



Changing Migration Limit in US

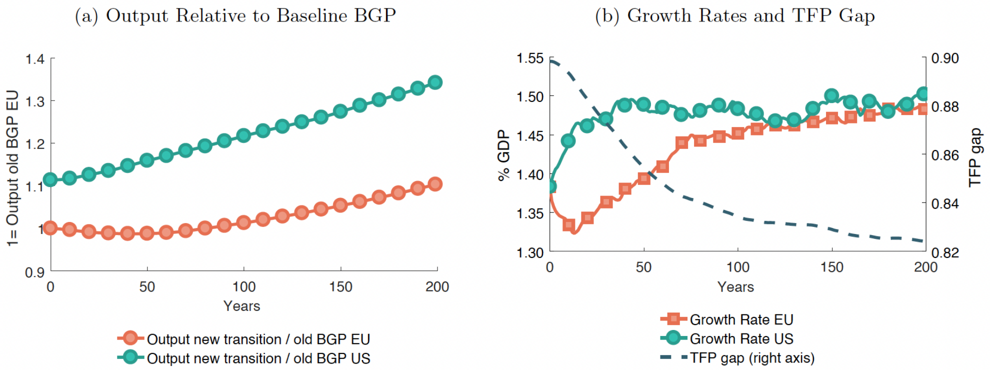
Figure 11: Counterfactual Change to US Immigration Threshold ($\bar{\mu}$): BGP Comparison



Changing Migration Limit in US (Con't)

Counterfactual increase of the migration threshold in the US from 0.006% to 0.012% of domestic inventors per year.

Figure 13: Counterfactual Increase of US Migration Threshold: Transitional Dynamics.



Conclusion

Main Findings:

- Inventor migration has both benefits and costs:
  - Migrants spread knowledge and raise innovation where they move.
  - But can create brain drain and displacement in origin countries.
- The paper builds an innovation-based GE model linking migration, interaction networks, and knowledge spillovers to patent data.

Policy Insights:

- **EU tax cuts** for foreign and return inventors:
  - Short run – attract talent, boost EU productivity and wages.
  - Long run – reduce global growth by limiting spillovers and diffusion.
- **US H1B expansion** raises productivity in both US and EU by reallocating talent efficiently and enhancing knowledge flows.

Thank You