International Trade, Immigration and Macroeconomic Dynamics

Chujian Shao

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Introduction

- A large empirical literature studies the relationship between immigration and international trade, yet the evidence remains mixed and difficult to interpret.
- Previous studies (Heckscher-Ohiln model or heterogeneous-firm trade model) lack a unified dynamic general-equilibrium framework that jointly accounts for labor mobility, firm dynamics, and trade.
- The macroeconomic implications of immigration policy for trade, firm establishment and production remain poorly understood.

Objective: This paper develops a two-country dynamic stochastic general equilibrium model with heterogeneous firms, endogenous firm entry, and endogenous labor migration to study:

1. How international trade and cross-country migration interact dynamically through wages, firm entry, and exporter selection
2. How changes in migration barriers affect macroeconomic outcomes in labor-sending and labor-receiving countries
3. The role of the extensive margins of production and exports in shaping cross-country migration incentives and trade dynamics

Key findings from the model

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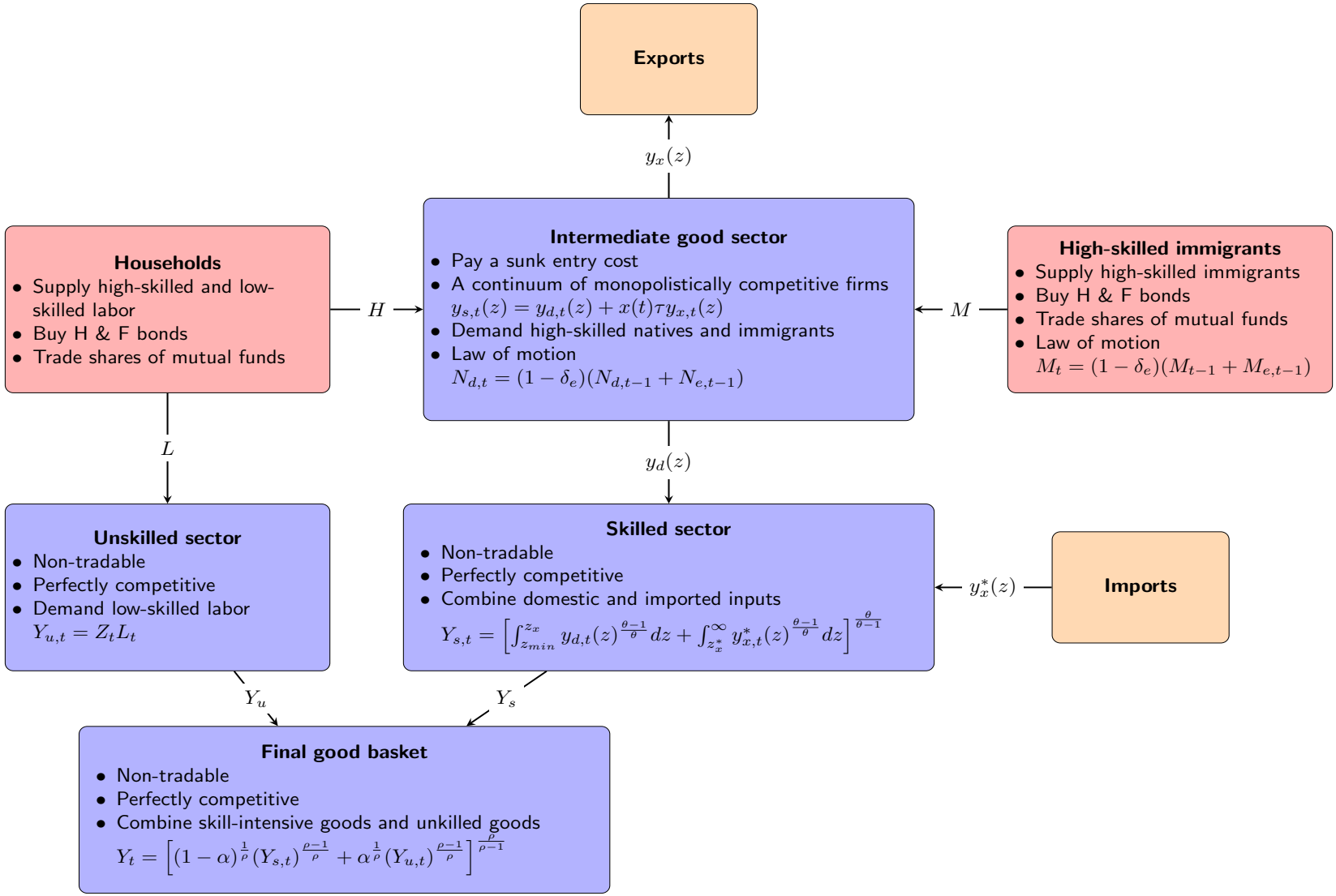
  - Trade integration narrows wage differentials and dampens incentives for labor migration.
  - The labor-receiving country benefits from labor inflows, while its business-cycle responses are less sensitive to migration frictions.
- Firm dynamics (entry and exporter selection) are central to understanding how macro shocks translate into trade, labor flows, and welfare.
  - Without firm entry, macro shocks generate weak migration responses.
  - Without exporter selection, trade and migration responses can be over-amplified.

Literature and contribution

- Trade and factor mobility
  - Mundell(1957), Markusen (1983), Wong (1986), Rauch (1991), Hatton and Williamson (2005, 2006), Iranzo and Peri (2009)
  - **Contribution: the DSGE framework clarifies mechanisms (wages, entry, exporter selection) and traces transitional paths that static models and reduced-form regressions cannot uniquely identify.**
- Macroeconomic consequences of immigration
  - Mandelmann and Zlate (2012), Weiske (2017), Furlanetto and Robstad (2019), Smith and Thoenissen (2018)
  - **Contribution: document asymmetric effects across labor-sending and labor-receiving countries, as well as across high- and low-skilled households**
- The extensive margins of production and trade
  - Melitz (2003), Ghironi and Melitz (2005), Alessandria and Choi (2007), Bilbiie et al (2012), Jaef and Lopez (2014), Gourio et al (2016)
  - **Contribution: emphasize the roles of firm dynamics in shaping labor mobility and trade flows**

Model overview



This paper focuses on high-skilled immigration because of its significant growth in recent years and its central role in shaping firm establishment.

◂ Households ◂ Final ◂ Firm entry ◂ Intermediate ◂ Additional equations

Model calibration

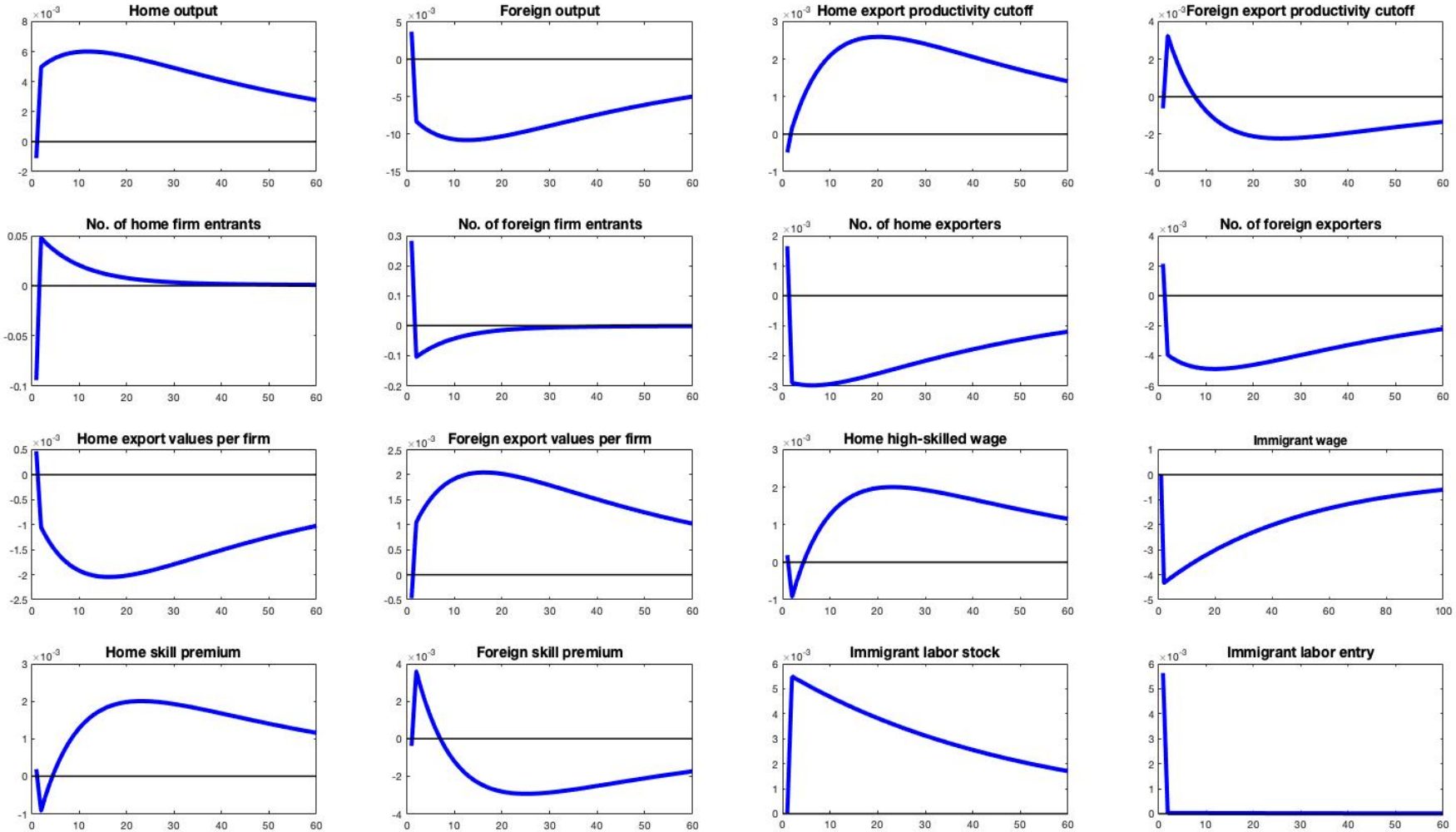
- High-skilled U.S. immigrants mainly come from several developing countries, including Mexico, China, India, Philippines and Vietnam. I construct an aggregate of these five countries as a foreign economy.
- The model is calibrated to the home (U.S.) and foreign economy (a bunch of less developing countries) during the period 2004-2018. Periods are interpreted as years.
- Parameter values are chosen from the literature and to match features of macroeconomic data of these two economies.

◂ Calibration table

Main implications of lower emigration cost f_m

- **Direct policy effect:** lower f_m raises immigrant entry and stock immediately.
- **Wage channel:** labor supply expands $\Rightarrow$ wages fall on impact; then recover as output and labor demand rise.
- **Firm dynamics:** lower costs and larger market raise expected profits $\Rightarrow$ entry spikes; competition gradually erodes profits.
- **Trade margins:** the number of home exporters and exports per firm decline immediately.
  - Domestic reallocation: larger home market shifts sales toward domestic demand.
  - Exporter selection: export cutoff can tighten in the short run, pushing marginal exporters out.
- **Interpretation:** a migration-policy shock changes wages, firm entry, and market size simultaneously, reshaping export profitability and causing firms to reallocate toward domestic sales, which implies a short-run contraction in exports.

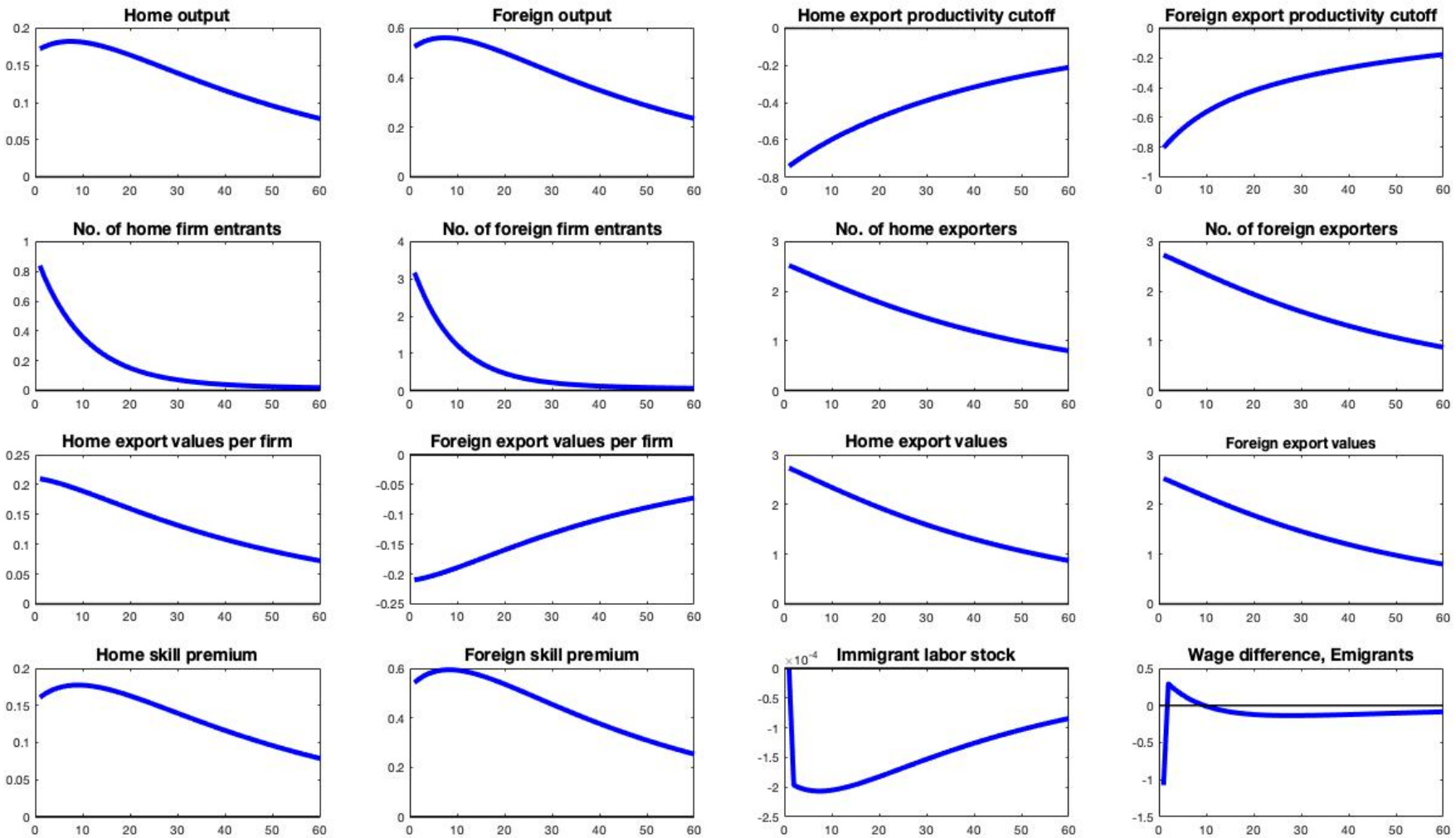
Negative emigration cost f_m shock



Main implications of lower trade costs (iceberg τ)

- **Direct trade effect:** exporting becomes more profitable $\Rightarrow$ export cutoff falls, increasing (i) # exporters (extensive margin) and (ii) exports per exporter (intensive margin).
- **Labor demand channel:** export expansion raises labor demand $\Rightarrow$ wages rise; entry increases but moderates as costs and competition rise.
- **Migration response is endogenous:** with f_m unchanged, trade integration raises wages in both countries and can narrow expected wage differentials, reducing the incentive for labor migration and leading to weak or declining immigrant entry.
- **Interpretation:** migration-policy easing can reduce exports in the short run (reallocation + selection), whereas trade liberalization raises exports directly, and reduces cross-country labor movement.

Negative trade cost τ shock



◂ Analytical solution

Home vs. Foreign effects

Shock	Home (Labor-Receiving)	Foreign (Labor-Sending)
Migration cost ↓ (f_m)	Labor supply ↑; output/entry ↑; wages ↓→↑; exports ↓	Labor supply ↓; wages ↑; output/entry ↓; exports ↓
Trade cost ↓ (τ)	Export profits ↑; entry ↑; labor demand ↑; wages ↑; migration weak	Export demand ↑; entry ↑; labor demand ↑; wages ↑; migration incentives ↓

Key insight

Migration-policy easing shifts labor toward Home (benefiting Home and straining Foreign), whereas trade integration raises exporting opportunities and output for both countries and narrows wage gaps, limiting skilled labor outflows from Foreign.

Alternative models

Key features of the model: firm heterogeneity, endogenous firm entry, and endogenous labor migration

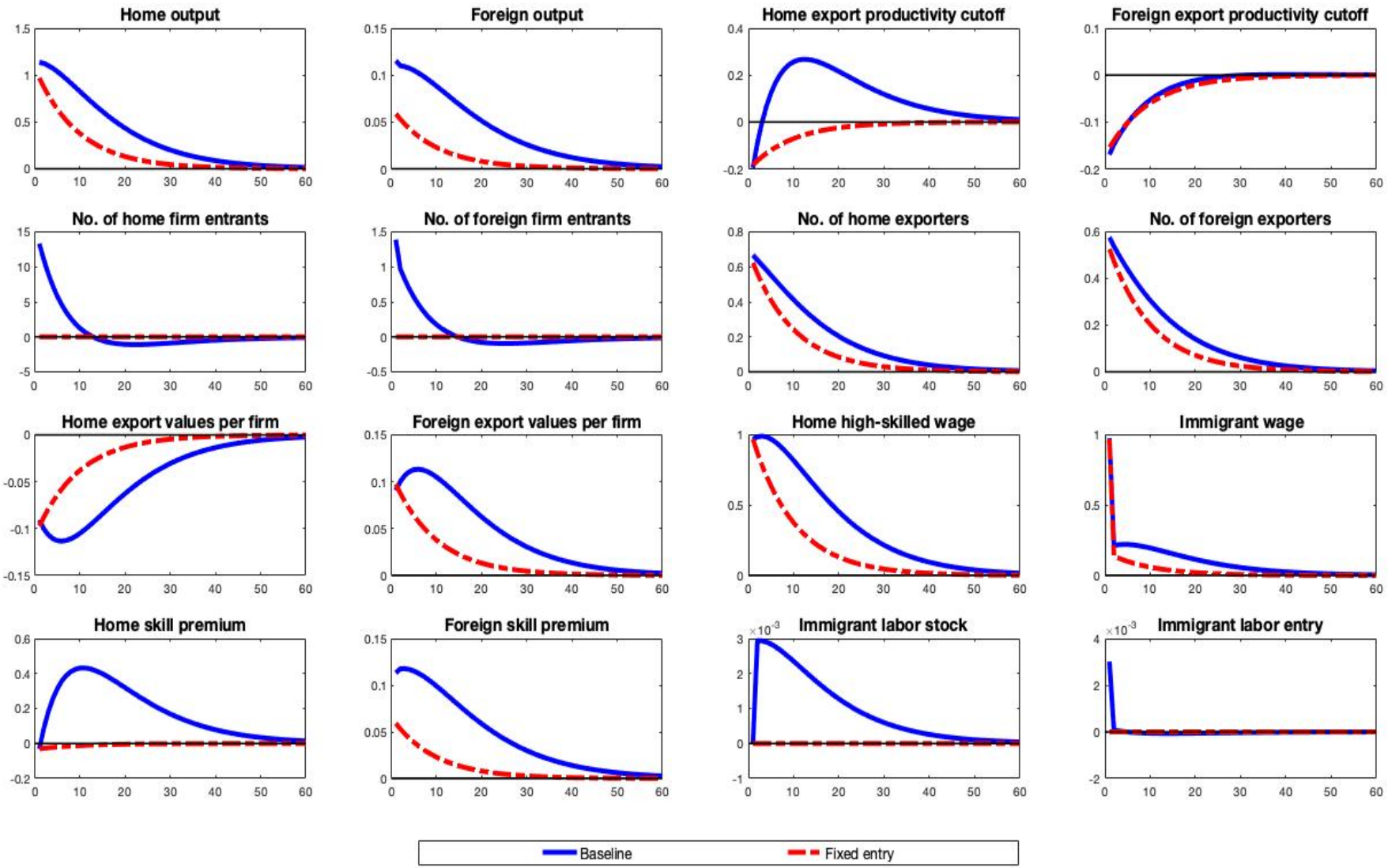
- Fixed entry
  - The stock of firms is constant
  - $f_{e,t} = f_e + \eta_e[exp(N_{e,t} - \bar{N}_e) - 1]$
- Fixed cutoff
  - The export productivity cutoff is fixed
  - $f_{x,t} = f_x + \eta_x[exp(z_{x,t} - \bar{z}_x) - 1]$
- Labor immobility
  - The labor immigration channel is shut down

Key findings: alternative models

- Firm entry as a bridge between macro shocks and migration
  - Absent endogenous firm entry, productivity shocks generate much weaker labor-market and migration responses, underscoring the role of firm creation in shaping international labor flows.
- Fixed cutoff over-amplifies trade and migration responses
  - Endogenous export cutoffs offset productivity gains by tightening selection; fixing the cutoff removes this offset and produces a larger export boom and a stronger migration response.
- Labor mobility mainly reshapes the sending country's cycle
  - Foreign outcomes are much more sensitive to migration than Home outcomes under a Home productivity shock.

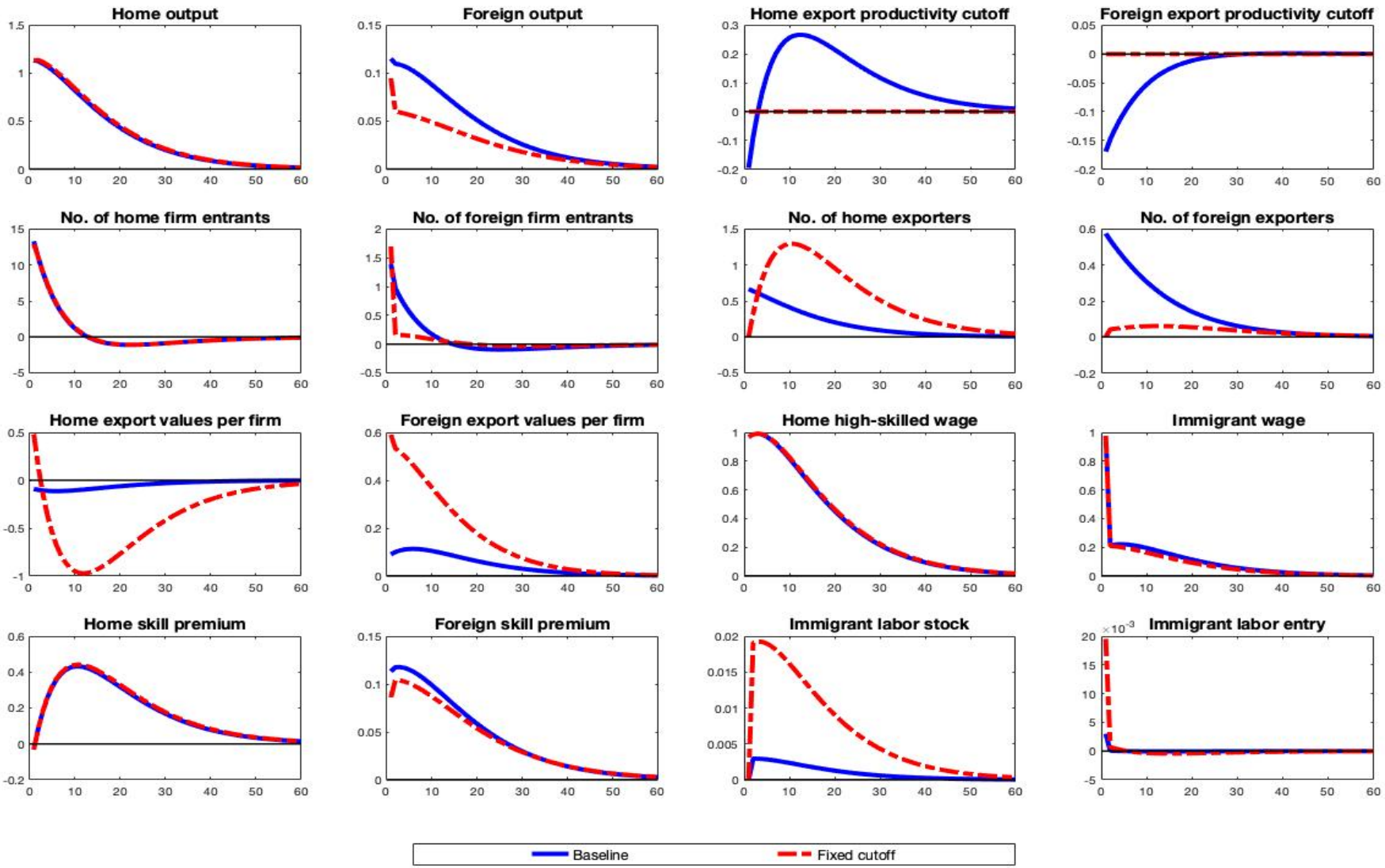
◂ Fixed entry ◂ Fixed cutoff ◂ No immigration ▸ Skip

Positive home productivity Z shock



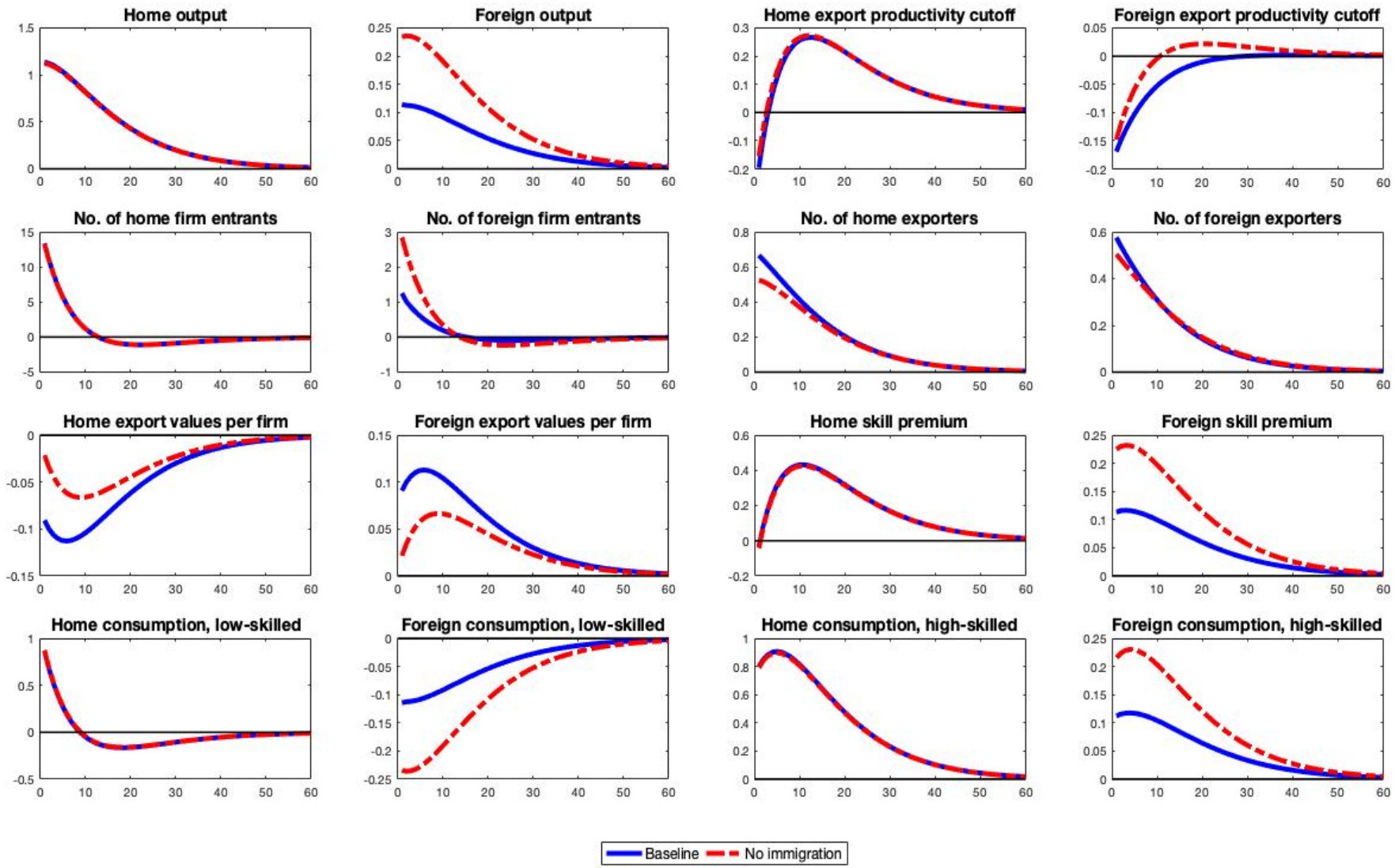
◂ Analytical solution ◂ Back

Positive home productivity Z shock



◂ Back

Positive home productivity Z shock



◂ Back

Welfare implications of immigration

The long-run welfare gain or loss of each type of households in two countries from a 50% decrease in sunk emigration costs (loosening the immigration policy) is calculated as the percentage change (Δ) in steady-state consumption of the baseline model that would leave households indifferent between the initial policy and the new policy.

$$\frac{1}{1-\beta}U[(1+0.01\Delta)c_j, j] = E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} U(c_{j,t}, j_t), \quad \forall j \in \{h, l\}$$

	Home, high-skilled	Home, low-skilled	Foreign, high-skilled	Foreign, low-skilled
Baseline	0.0277	-0.0194	-0.0294	0.0323
Fixed cutoff	0.0344	-0.0244	-0.0708	0.0423

Note: Values are in percent. Under the special case with fixed entry, the values of Δ are close to zero so there are no welfare gains or loses of all types of households.

Model sensitivity

Table 1: Business cycle statistics, data vs model

	Volatility %		Correlation with Y		International correlation		Correlation with M	
	Data	Model	Data	Model	Data	Model	Data	Model
Y	1.59	1.53	1	1	0.28	0.27	0.24	0.46
C	0.97	1.19	0.68	0.98	0.43	0.27	0.22	0.51
N_d	0.89	1.26	0.44	0.37	n/a	0.24	0.24	0.46
N_e	4.94	6.67	0.54	0.89	n/a	0.24	0.43	0.28
Y^*	2.71	1.39	0.28	0.27	0.28	0.27	-0.27	-0.39
C^*	2.64	1.20	0.28	0.27	0.43	0.27	-0.19	-0.41
M	0.80	0.17	0.24	0.46	n/a	n/a	1	1

Note: For the data, variables are converted in natural logs and expressed in deviations from a Hodrick-Prescott trend. Following Ravn and Uhlig (2002), I set the HP smoothing parameter to be 6.25 for annual data.

Conclusion

- This paper develops a two-country DSGE model featuring heterogeneous firms, endogenous firm entry, and endogenous labor migration.
- This paper contributes to the trade literature, which abstracts cross-country labor mobility, and the immigration literature by studying the macroeconomic consequences of immigration and exploring the roles of firm dynamics in shaping cross-country labor migration incentives.
- Key model implications:
  - Trade integration can dampen migration incentives by narrowing wage differentials, while immigration shocks reshape trade through firm reallocation and exporter selection.
  - Migration policy changes have asymmetric macroeconomic and welfare effects across sending and receiving countries, as well as across skill groups.
  - Firm dynamics serve as a key propagation channel, linking productivity, trade and migration shocks to labor demand, trade intensive and extensive adjustments, and welfare outcomes.

Appendix slides

Home households

The home economy consists of a continuum of two types of infinitely lived households, supplying units of high-skilled and low-skilled labor, with relative size γ and $1-\gamma$.

$$\max_{(c_{j,t},j_t,b_{j,t+1},\varphi_{j,t+1})} E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t}\{lnc_{j,\tau} - \frac{\chi_j}{1+\mu} j_\tau^{1+\mu}\}$$

subject to

$$w_{j,t}j_t + (1+r_t)b_{j,t} + (1+r_t^*)Q_t b_{*j,t} + (\tilde{v}_t + \tilde{\pi}_t)N_{d,t}\varphi_{j,t} + T_{j,t} =$$

$$c_{j,t} + \tilde{v}_t(N_{d,t}+N_{e,t})\varphi_{j,t+1} + b_{j,t+1} + Q_t b_{*j,t+1} + \frac{\zeta}{2}(b_{j,t+1})^2 + \frac{\zeta}{2}Q_t(b_{*j,t+1})^2$$

$j \in (h,l)$ denotes the household type
χ_j is the weight on the disutility from labor
$1/\mu \geq 0$ is the Frisch elasticity of labor supply
$\tilde{v}_t$ is the average market value of firms
$\varphi_{j,t}$ is the share holdings on mutual fund of $N_{d,t}$ firms held by household j
$\tilde{\pi}_t$ is the dividends received by households
$N_{d,t}$ is the number of firms
$N_{e,t}$ is the number of new entrants
Q_t is the real exchange rate
$\frac{\zeta}{2}(b_{j,t+1})^2$ is the quadratic adjustment cost
T is the rebate of the cost of adjusting bond holdings to households

◂ Back

Foreign households

- The foreign economy consists of a continuum of two types of infinitely lived households, supplying units of high-skilled and low-skilled labor indexed by $j_t^* \in (h_t^*, l_t^*)$, with relative size $\gamma*$ and $1 - \gamma*$.

- Following Mandelman and Zlate (2012), I assume labor immigration is endogenous and foreign labor demand is also always positive.

- Some household members m_t choose to work abroad, so the remaining foreign high-skilled in a household are $\xi_t^* = h_t^* - m_t$.

- With an exogenous return shock with probability δ_m, the law of motion for the stock of high-skilled immigrant labor is

$$m_t = (1 - \delta_m)(m_{t-1} + m_{e,t-1})$$

◂ Back

Foreign households

The foreign high-skilled household's budget constraint is:

$$\begin{aligned}
&\boldsymbol{w^*_{h,t}(h^*_t - m_t) + w_{m,t}Q_t^{-1}m_t} + (\tilde{v}^*_t + \tilde{\pi}^*_t)N^*_{d,t}\varphi^*_{h,t} \\
&+ (1 + r^*_t)b^*_{*h,t} + (1 + r_t)Q_t^{-1}b^*_{h,t} + T^*_{h,t} = \\
&c^*_{h,t} + \boldsymbol{f_{m,t}m_{e,t}} + \tilde{v}^*_t(N^*_{d,t} + N^*_{e,t})\varphi^*_{h,t+1} \\
&+ Q_t^{-1}b^*_{h,t+1} + b^*_{*h,t+1} + \frac{\zeta}{2}(b^*_{*h,t+1})^2 + \frac{\zeta}{2}Q_t^{-1}(b^*_{h,t+1})^2
\end{aligned}$$

- $w^*_{h,t}(h^*_t - m_t)$: wage income earned by high-skilled non-emigrants in the foreign country
- $w_{m,t}Q_t^{-1}m_t$: high-skilled emigrant wage income expressed in units of the foreign final good
- A sunk emigration cost for high-skilled labor is defined as $f_{m,t}$ units of the foreign final good

Back

Foreign households

- The first order condition with respect to new high-skilled emigrants $m_{e,t}$:

$$f_{m,t} = \sum_{\tau=t+1}^{\infty} \left[\beta(1-\delta_m)\right]^{\tau-t} E_t \left[\frac{c^*_{h,t}}{c^*_{h,\tau}} d_{m,\tau}\right]$$

where $d_{m,t} = w_{m,t} Q_t^{-1} - w^*_{h,t}$ as the wage difference between the immigrant wage in home and the high-skilled wage in foreign expressed in units of the foreign final good.

- In equilibrium, the sunk emigration cost equals the emigration benefit.

- Changes in immigration policies are reflected by shocks $\varepsilon_t^{f_m}$ to the level of the sunk emigration cost f_m, so $f_{m,t} = \varepsilon_t^{f_m} f_m$.

Back

Final good sector

The representative final good producer under perfect competition combines the sectoral basket of skill-intensive goods $Y_{s,t}$ and unskilled goods $Y_{u,t}$ to produce final goods Y_t.

$$Y_t = \left[(1-\alpha)^{\frac{1}{\rho}} (Y_{s,t})^{\frac{\rho-1}{\rho}} + \alpha^{\frac{1}{\rho}} (Y_{u,t})^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}$$

$$\max_{Y_{s,t}, Y_{u,t}} P_t Y_t - P_{s,t} Y_{s,t} - P_{u,t} Y_{u,t}$$

$$Y_{s,t} = (1-\alpha) \left[\frac{P_{s,t}}{P_t} \right]^{-\rho} Y_t = (1-\alpha) \rho_{s,t}^{-\rho} Y_t$$

$$Y_{u,t} = \alpha \left[\frac{P_{u,t}}{P_t} \right]^{-\rho} Y_t = \alpha \rho_{u,t}^{-\rho} Y_t$$

$$P_t = \left[(1-\alpha)(P_{s,t})^{1-\rho} + \alpha (P_{u,t})^{1-\rho} \right]^{\frac{1}{1-\rho}}$$

where $\frac{P_{s,t}}{P_t} = \rho_{s,t}$ and $\frac{P_{u,t}}{P_t} = \rho_{u,t}$.

Unskilled sector

The unskilled good producer in the perfectly competitive market has the following production function:

$$Y_{u,t} = Z_t L_t$$

$$\max_{L_t} \rho_{u,t} Y_{u,t} - w_{l,t} L_t$$

$$\rho_{u,t} = w_{l,t} / Z_t$$

Skilled sector

The skill-intensive good in the home country aggregates domestic and imported inputs in Armington form:

$$Y_{s,t} = \left[\underbrace{\int_{z_{min}}^{z_x} y_{d,t}(z)^{\frac{\theta-1}{\theta}} dz}_{z \in \Omega_{d,t}} + \underbrace{\int_{z_x^*}^{\infty} y_{x,t}^*(z)^{\frac{\theta-1}{\theta}} dz}_{z \in \Omega_{x,t}^*} \right]^{\frac{\theta}{\theta-1}}$$

$$\max_{y_{d,t}(z), y_{x,t}^*(z)} P_{s,t} Y_{s,t} - \int_{z \in \Omega_{d,t}} P_{d,t}(z) y_{d,t}(z) \mathrm{d}z - \int_{z \in \Omega_{x,t}^*} P_{x,t}^*(z) y_{x,t}^*(z) \mathrm{d}z$$

$$y_{d,t}(z) = \left[\frac{P_{d,t}(z)}{P_{s,t}} \right]^{-\theta} Y_{s,t} = (1-\alpha) \left[\frac{P_{d,t}(z)}{P_{s,t}} \right]^{-\theta} \left[\frac{P_{s,t}}{P_t} \right]^{-\rho} Y_t$$

$$y_{x,t}^*(z) = \left[\frac{P_{x,t}^*(z)}{P_{s,t}} \right]^{-\theta} Y_{s,t} = (1-\alpha) \left[\frac{P_{x,t}^*(z)}{P_{s,t}} \right]^{-\theta} \left[\frac{P_{s,t}}{P_t} \right]^{-\rho} Y_t$$

$$P_{s,t} = \left[(P_{d,t})^{1-\theta} + (P_{x,t}^*)^{1-\theta} \right]^{\frac{1}{1-\theta}}$$

◂ Back

Firm entry and export decision

- As in Ghironi and Melitz (2005), after paying the sunk entry cost, each firm is randomly assigned an idiosyncratic productivity z from a common distribution $G(z)$ with the support interval $[z_{min}, \infty)$.
- The law of motion for the total number of firms is $N_{d,t} = (1 - \delta_e)(N_{d,t-1} + N_{e,t-1})$.
- In equilibrium, firm entry takes place until the expected value of the average firm is equal to the sunk entry cost measured in units of the final good: $\tilde{v}_t = f_{e,t}$.
- Exporting is costly, involving a per-unit melting-iceberg trade cost $\tau_t \geq 1$ and a per-period fixed cost $f_{x,t}$ measured in units of final goods.
- Firms export if and only if there is a positive export profit. The export productivity cutoff is: $z_{x,t} = \inf\{z : \pi_{x,t} > 0\}$

Back

Intermediate good sector

Firms are differentiated by their productivity z, and they employ high-skilled labor to produce intermediate goods.

$$
\begin{aligned}
y_{s,t}(z) &= Z_t z \left[\lambda m_t(z)^{(\sigma-1)/\sigma} + (1-\lambda) h_t(z)^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)} \\
&= y_{d,t}(z) + x_t \tau_t y_{x,t}(z)
\end{aligned}
$$

Z_t is the aggregate productivity in the home country.
$m_t(z)$ is the demand for high-skilled immigrants.
$h_t(z)$ is the demand for high-skilled natives.
σ is the elasticity substitution between high-skilled natives and immigrants.
λ is the weight of high-skilled immigrants.
x_t is an indicator function that captures the export status.
τ_t is iceberg trade costs.
$y_{d,t}(z)$ is the variety produced and sold in the domestic market.
$y_{x,t}(z)$is the variety produced in the domestic market and sold abroad.

Intermediate good sector

The profit maximization problem for a domestic producer to produce intermediate goods:

$$\max_{\xi_t(z),\rho_{d,t}(z),\rho_{x,t}(z)} \rho_{d,t}(z)y_{d,t}(z) + x_t Q_t \rho_{x,t}(z) y_{x,t}(z) - (w_{h,t}\phi_{h,t} + w_{m,t}\phi_{m,t})\xi_t(z) - x_t f_{x,t}$$

subject to

$$y_{d,t}(z) + x_t \tau_t y_{x,t}(z) = Z_t z \Phi_t \xi_t(z)$$
$$y_{d,t}(z) = (1-\alpha)\rho_{d,t}(z)^{-\theta} \rho_{s,t}^{\theta-\rho} Y_t$$
$$y_{x,t}(z) = (1-\alpha^*)\rho_{x,t}(z)^{-\theta} \rho_{s,t}^{*\,(\theta-\rho)} Y_t^*$$

$\phi_{m,t}$ and $\phi_{h,t}$ are the within-firm share of high-skilled immigrants and natives respectively.
Φ_t is defined as a CES aggregate of the share of high-skilled natives and immigrants.
$\xi_t(z)$ is the firm's total high-skilled labor demand in the home country.
Relative prices are $\frac{P_{d,t}(z)}{P_t} = \rho_{d,t}(z)$, $\frac{P^*_{x,t}(z)}{P_t} = \rho^*_{x,t}(z)$ and $\frac{P_{s,t}}{P_t} = \rho_{s,t}$.

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Additional equations – intermediate good

- Given the production function, the optimal combination of high-skilled home and immigrant labor is chosen by each firm.

$$\min_{h_t(z),m_t(z)} w_{h,t}h_t(z) + w_{m,t}m_t(z)$$

subject to

$$y_{s,t}(z) = Z_t z \left[\lambda m_t(z)^{(\sigma-1)/\sigma} + (1-\lambda)h_t(z)^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)}$$

- The firm's relative demand for high-skilled immigrants and natives:

$$\frac{m_t(z)}{h_t(z)} = \left(\frac{\lambda}{1-\lambda}\right)^{\sigma} \left(\frac{w_{m,t}}{w_{h,t}}\right)^{-\sigma}$$

- The demand for natives relative to immigrants in a given skill level is inversely related to the relative wage with elasticity σ.

Additional equations – intermediate good

- Within-firm share of high-skilled immigrants and natives are respectively

$$\phi_{m,t} = \frac{\lambda^{\sigma} w_{m,t}^{-\sigma}}{\lambda^{\sigma} {w_{m,t}}^{-\sigma} + (1-\lambda)^{\sigma} {w_{h,t}}^{-\sigma}}$$

$$\phi_{h,t} = \frac{(1-\lambda)^{\sigma} w_{h,t}^{-\sigma}}{\lambda^{\sigma} {w_{m,t}}^{-\sigma} + (1-\lambda)^{\sigma} {w_{h,t}}^{-\sigma}}$$

- Define Φ_t as a CES aggregate of the share of high-skilled natives and immigrants

$$\Phi_t = \left[\lambda \phi_{m,t}^{(\sigma-1)/\sigma} + (1-\lambda)\phi_{h,t}^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)}$$

Additional equations – intermediate good

- The prices set by a domestic producer for its sales in the home country and the foreign market are respectively

$$\rho_{d,t}(z) = \frac{P_{d,t}(z)}{P_t} = \frac{\theta}{\theta - 1} mc_t(z)$$

$$\rho_{x,t}(z) = \frac{P_{x,t}(z)}{P_t^*} = Q_t^{-1} \frac{\theta}{\theta - 1} \tau_t mc_t(z) = Q_t^{-1} \tau_t \rho_{d,t}(z)$$

where $mc_t(z) = \frac{w_{h,t}\phi_{h,t} + w_{m,t}\phi_{m,t}}{z Z_t \Phi}$

- Profits from domestic sales $\pi_{d,t}$ and from foreign sales $\pi_{x,t}$ are defined as

$$\pi_{d,t}(z) = \frac{1-\alpha}{\theta} [\rho_{d,t}(z)]^{(1-\theta)} \rho_{s,t}^{(\theta-\rho)} Y_t$$

$$\pi_{x,t}(z) = \frac{(1-\alpha^*) Q_t}{\theta} [\rho_{x,t}(z)]^{(1-\theta)} \rho_{s,t}^{*\,(\theta-\rho)} Y_t^* - f_{x,t}$$

- Demand for high-skilled labor units is

$$\xi_t(z) = \frac{(1-\alpha)(\rho_{d,t})^{-\theta}(\rho_{s,t})^{\theta-\rho} Y_t}{z_{d,t} \Phi_t Z_t} + \frac{(1-\alpha^*)\tau_t(\rho_{x,t})^{-\theta}(\rho_{s,t}^*)^{\theta-\rho} Y_t^*}{z_{x,t} \Phi_t Z_t}$$

Back

Additional equations – foreign firms

- A foreign producer with an idiosyncratic productivity z produces intermediate goods under monopolistic competition.

$$y^*_{s,t}(z) = Z^*_t z \xi^*_t(z) = y^*_{d,t}(z) + x(t)^* \tau^*_t y^*_{x,t}(z)$$

where $\xi^*_t = h^*_t - m_t$ denotes as the high-skilled non-emigrants in the foreign country

- Under the skill-intensive sector, foreign perfectly competitive producers combine intermediate inputs from both home and foreign according to

$$Y^*_{s,t} = \left[\int_{z^*_{min}}^{z^*_x} y^*_{d,t}(z)^{\frac{\theta-1}{\theta}} dz + \int_{z_x}^{\infty} y_{x,t}(z)^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}}$$

- Under the unskilled sector, foreign perfectly competitive producers employ low-skilled labor to produce unskilled goods.

$$Y^*_{u,t} = Z^*_t L^*_t$$

Back

Additional equations – average productivity

As in Ghironi and Melitz (2005), assuming the firm-specific labor productivity draws z are Pareto-distributed with C.D.F $G(z) = 1 - (z_{min}/z)^{\kappa}$ and P.D.F. $g(z) = \kappa z_{min}^{\kappa}/z^{\kappa+1}$, so the two average productivity levels are:

$$\tilde{z}_{d,t} = \left(\int_{z_{min}}^{\infty} z^{\theta-1} dG(z) \right)^{\frac{1}{\theta-1}} = \nu z_{min}$$

$$\tilde{z}_{x,t} = \frac{1}{1 - G(z_{x,t})} \left(\int_{z_{x,t}}^{\infty} z^{\theta-1} dG(z) \right)^{\frac{1}{\theta-1}} = \nu z_{x,t}$$

where parameters $\nu \equiv \left(\frac{\kappa}{\kappa-(\theta-1)} \right)^{1/(\theta-1)}$ and $\kappa > \theta - 1$.

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Additional equations – average profit and price

- The total average profit of firms producing tradable varieties in the home country can be expressed as:

$$N_{d,t}\tilde{\pi}_t = N_{d,t}\tilde{\pi}_{d,t} + N_{x,t}\tilde{\pi}_{x,t}$$

- Average price level of skilled-intensive sector is

$$P_{s,t} = \left[N_{d,t}\tilde{P}_{d,t}^{1-\theta} + N_{x,t}^{*}\tilde{P}_{x,t}^{*\,1-\theta}\right]^{\frac{1}{1-\theta}}$$
$$(\rho_{s,t})^{1-\theta} = N_{d,t}(\tilde{\rho}_{d,t})^{1-\theta} + N_{x,t}^{*}(\tilde{\rho}_{x,t}^{*})^{1-\theta}$$

- The aggregate price index in the home country is affected by the prices of domestically produced skilled-intensive and unskilled-intensive goods.

$$1 = (1-\alpha)(\rho_{s,t})^{1-\rho} + \alpha(\rho_{u,t})^{1-\rho}$$

where $\rho_{u,t} = w_{l,t}/Z_t$.

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Additional equations – home labor MC condition

- High-skilled labor market clearing condition in the home economy is given as

$$\begin{aligned}\Xi_t =& \gamma h_t + \gamma^* m_t \\ =& \frac{(1-\alpha)(\tilde{\rho}_{d,t})^{-\theta}(\rho_{s,t})^{\theta-\rho} Y_t N_{d,t}}{\tilde{z}_{d,t}\Phi_t Z_t} \\ &+ \frac{(1-\alpha^*)\tau(\tilde{\rho}_{x,t})^{-\theta}(\rho^*_{s,t})^{\theta-\rho} Y^*_t N_{x,t}}{\tilde{z}_{x,t}\Phi_t Z_t}\end{aligned}$$

- High-skilled native and immigrant labor market clearing conditions are

$$\begin{aligned} H_t =& \gamma h_t \\ =& \phi_{h,t}\Xi_t \end{aligned} \qquad \begin{aligned} M_t =& \gamma^* m_t \\ =& \phi_{m,t}\Xi_t \end{aligned}$$

- Low-skilled labor market clearing condition: $L_t = (1-\gamma) l_t = \alpha \rho_{u,t}^{-\rho} Y_t / Z_t$.

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Additional equations – foreign labor MC condition

- High-skilled labor market clearing conditions in the foreign economy is given as

$$\begin{aligned}\Xi_t^* &= \gamma^*(h_t^* - m_t) \\ &= \frac{(1-\alpha^*)(\tilde{\rho}_{d,t}^*)^{-\theta}(\rho_{s,t}^*)^{\theta-\rho}Y_t^* N_{d,t}^*}{\tilde{z}_{d,t}^* Z_t^*} \\ &\quad + \frac{(1-\alpha)\tau^*(\tilde{\rho}_{x,t}^*)^{-\theta}(\rho_{s,t})^{\theta-\rho}Y_t N_{x,t}^*}{\tilde{z}_{x,t}^* Z_t^*}\end{aligned}$$

- Low-skilled labor market clearing condition: $L_t^* = (1-\gamma^*)l_t^* = \alpha {\rho_{u,t}^*}^{-\rho} Y_t^*/Z_t^*$.

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Additional equations – bond MC condition

- Home bond market clearing condition:

$$B_{h,t} + B_{l,t} + B^*_{h,t} + B^*_{l,t} = B_t + B^*_t = 0$$

- Foreign bond market clearing condition:

$$B^*_{*h,t} + B^*_{*l,t} + B_{*h,t} + B_{*l,t} = B^*_{*t} + B_{*t} = 0$$

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Additional equations – balance of international payments

The balance of international payments indicates that the trade balance and income from bond investment equal to the changes in bond holdings:

$$TB_t + r_t^b B_t + r_t^{b*} Q_t B_{*,t} = (B_{t+1} - B_t) + Q_t(B_{*,t+1} - B_{*,t})$$

where the trade balance is
$TB_t \equiv N_{x,t}(1-\alpha^*)(\tilde{\rho}_x)^{1-\theta}(\rho_{s,t}^*)^{\theta-\rho} Y_t^* Q_t - N_{x,t}^*(1-\alpha)(\tilde{\rho}_x^*)^{1-\theta}(\rho_{s,t})^{\theta-\rho} Y_t$

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Additional Equations – resource constraint

- The resource constraint in the home country:

$$Y_t = C_{h,t} + C_{l,t} + C_{m,t} + N_{e,t} f_{e,t} + N_{x,t} f_{x,t}$$

- The resource constraint in the foreign county:

$$Y_t^* = C_{h,t}^* + C_{l,t}^* - Q_t^{-1} C_{m,t} + N_{e,t}^* f_{e,t}^* + N_{x,t}^* f_{x,t}^* + f_{m,t} M_{e,t}$$

- Aggregate output in home: $GDP_t = Y_t + TB_t$
- Aggregate output in foreign: $GDP_t^* = Y_t^* + TB_t^*$

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Analytical Solution

Let $\Lambda_t \equiv \phi_{h,t} w_{h,t} + \phi_{m,t} w_{m,t}$ as the weighted average high-skilled labor costs in home. The log-linearization of the immigrant demand function:

$$\mathsf{M_t} = \underbrace{\phi_{\mathsf{m,t}}}_{\text{Immigrant share}} + \underbrace{\mathsf{N_{d,t}}}_{\text{The stock of home firms}} + \underbrace{\frac{(\theta-1)C}{D}(\mathsf{Z_t} - \mathsf{Z_t^*})}_{\text{Difference of aggregate productivity}}$$

$$- \underbrace{\left(\frac{(\theta-1)C\tilde{\mathsf{z}}^*_{\mathsf{x,t}}}{D} + \frac{\kappa \tilde{\mathsf{z}}^{-\kappa}_{\mathsf{x,t}}}{D}\right)}_{\text{Average export productivity cutoffs}} + \underbrace{\frac{C(\mathsf{Q_t} + \mathsf{f}^*_{\mathsf{x,t}} - \mathsf{f}_{\mathsf{x,t}} + (\theta-1)\tau_t)}{D}}_{\text{Trade costs}}$$

$$- \underbrace{\left(\frac{(\theta-1)C + D}{D}\right)\Lambda_t + \frac{(\theta-1)C(\mathsf{w}^*_{\mathsf{h,t}} + \Phi_t)}{D}}_{\text{Wage difference of high-skilled labor across countries}}$$

where $A \equiv \left(\frac{w_h^* \Phi}{\Lambda}\right)^{\theta-1}$, $\Psi \equiv ((\nu)^{\theta-1-\kappa} Q)\frac{f_x^* \tau^{\theta-1}}{f_x}$, $B \equiv \frac{(\theta-1)\nu^{\theta-1+\kappa}}{\Lambda}$, $C \equiv \Psi A \left(\frac{Z}{Z^* \tilde{z}_x^*}\right)^{\theta-1}$ and $D \equiv \left(\Psi A \left(\frac{Z}{Z^* \tilde{z}_x^*}\right)^{\theta-1} + \left(\frac{1}{\tilde{z}_x}\right)^{\kappa}\right)$. ◂ Z ◂ Tau

Calibration

Parameters	Values	Sources or targets
Discount factor	$\beta = 0.96$	Literature, 4 % interest rate
Elasticity of substitution across input varieties	$\theta = 3.8$	Ghironi and Melitz (2005)
Elasticity of substitution across skill-intensive and unskilled goods	$\rho = 0.5$	Mendoza (1991)
Pareto distribution	$\kappa = 3.4$	Ghironi and Melitz (2005)
Probability of firm exit	$\delta_e = 0.025$	Ghironi and Melitz (2005)
Probability of immigrant return	$\delta_m = 0.1$	Center for Immigration Studies (2011)
Elasticity of substitution between high-skilled natives and immigrants	$\sigma = 20$	Ottaviano and Peri (2012)
Weight of high-skilled immigrants	$\lambda = 0.185$	LEHD, Kerr et al. (2015)
Share of unskilled goods in home	$\alpha = 0.79$	U.S. Bureau of Labor Statistics
Share of unskilled goods in foreign	$\alpha^* = 0.85$	The World Bank and other sources
Size of high-skilled labor in home	$\gamma = 0.46$	The World Bank
Size of high-skilled labor in foreign	$\gamma^* = 0.16$	The World Bank
Disutility from high-skilled labor in home	$\chi_h = 0.42$	Skill premium 1.81 (US)
Disutility from low-skilled labor in home	$\chi_l = 0.50$	Skill premium 1.81 (US)
Disutility from high-skilled labor in foreign	$\chi_h^* = 0.45$	Skill premium 2.43 (foreign economies)
Disutility from low-skilled labor in foreign	$\chi_l^* = 0.55$	Skill premium 2.43 (foreign economies)
Elasticity of labor supply	$1/\mu = 1$	Farhat (2009)
Quadratic adjustment cost	$\zeta = 0.0025$	Stationary bond holding
Iceberg trade cost	$\tau = 1.3$	The World Bank, trade share 28% of GDP
Fixed cost of exporting in home	$f_x = 0.04$	The World Bank, U.S. export share 12% of GDP
Fixed cost of exporting in foreign	$f_x = 0.025$	The World Bank, U.S. import share 16% of GDP
Sunk entry cost in home	$f_e = 1$	Zlate (2016)
Sunk entry cost in foreign	$f_e = 4$	Zlate (2016)
Sunk emigration cost	$f_m = 2.25$	Share of high-skilled immigrants, 7.5%

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