Do brain drain and poverty result from coordination failures?

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Endogeneity of the brain drain

Brain drain: high-skill people flee their own country. Main factors:

- poverty, instability, fractionalization ... (Docquier et al.)
- income differentials (Grogger and Hanson)
- importance of the skill premium home and abroad (Rosenzweig)

In this literature, economic characteristics of countries are treated as exogenous (or instrumented in empirical papers)

Endogeneity of economic performances

Brain drain (BD) affects human capital accumulation and economic development at origin

- early literature shows that brain drain reduces human capital (Bhagwati and Hamada)
- literature in the 90s shows that this is worsened if human capital induces externalities (endogenous growth)
- new literature highlights some beneficial effects of the BD (Beine et al.)

In this literature, emigration probability is exogenous - the endogeneity of the emigration rate is ignored

Possibility of multiple equilibria

Considering the two literatures together, $\exists$ vicious circles:
Poverty at home $\rightarrow$ flight of the most skilled
Brain drain $\rightarrow$ poverty at home

Vicious circles open the possibility of multiple equilibria

1. All the skilled have flew and the country is poor
2. All the skilled decided to stay and the country is developed

Reasons ? strategic complementarity between the emigration decision of the skilled: if the neighbor emigrates, it is better for me to emigrate too.

Consequence: expectations matter

Some examples of massive BD

Massive BD waves

- (out) Iran after 1979
- (out) Easter Europe after WWII
- (in) Ireland in the 1980s

But stronger BD can be found in small islands

Can a "high brain drain-high poverty" situation be the result of a coordination failure?

Example: Trinidad and Tobago

Average skill ratio (H/L) in high-income countries: 0.243 in 2000

Trinidad and Tobago:
Skilled to unskilled ratio population (bef. migration): 0.226
Brain drain: 79.03%
Productivity relative to developed: 44.3%

But if:

Brain drain: 0.01%
Productivity relative to developed: 68.3%

Would that be an equilibrium ?

What we do

A Theory

Endogenize human capital accumulation, migration and productivity.

Possibility of multiple equilibria

Identifying country-specific parameters

In 15 percent of developing countries (representing about 50 percent of small states), poverty and high brain drain are worsened by a coordination failure.

Technology

In each developing country:

$$Y_t = A_t \left(\omega L_t + H_t \right)$$

Note: high elasticity of substitution between L an H needed to match data on skill premium.

Skilled to unskilled ratio:

$$k_t \equiv \frac{H_t}{L_t}$$

Lucas-type externality:

$$A_t = A k_t^{\alpha}$$

Individual migration choice

Log utility
Income abroad: $\bar{A}$
Cost of migration for an individual: $\tilde{\varepsilon}_i$

all individuals with migration costs below a critical value find it optimal to emigrate. The critical value is given by

$$\varepsilon_t \equiv \ln \bar{A} - \ln A - \alpha \ln k_t$$

decreasing with the skill-ratio k_t

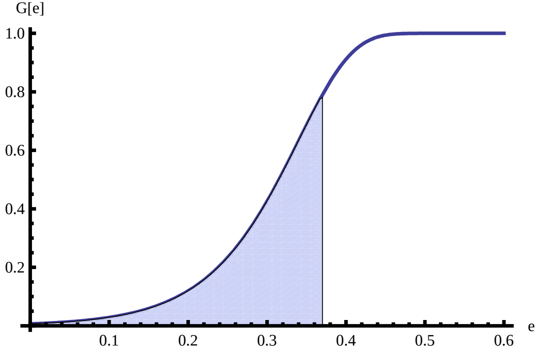
Individual migration choice

Heterogeneous migration costs $\sim$ distribution function $G(\tilde{\varepsilon})$

We will use Gumbel, Logistic and Normal

Country-specific parameters $m \in \mathbb{R}$ (location) and $b > 0$ (scale)

Example for Trinidad and Tobago:



Population dynamics

$$k_t = z_t \left[1 - G(\varepsilon_t)\right]$$

k_t: after-migration skill-ratio ;
z_t: skill-ratio in the ex-ante (before-migration) native labor force

Population levels of the two groups:

$$\begin{aligned} Z^s_{t+1} &= n^s Z^s_t \left[1 - G(\varepsilon_t)\right] + q\, n^u Z^u_t \\ Z^u_{t+1} &= (1 - q) n^u Z^u_t \end{aligned}$$

Assumption: high-skill workers educate all their children whereas low-skill workers only educate a fraction $q \in (0, 1)$ of them.

Population dynamics (2)

Resulting difference equation of the first-order:

$$z_{t+1} = Z^s_{t+1}/Z^u_{t+1} = \frac{1 - G(\varepsilon_t)}{1 - q} n \, z_t + \frac{q}{1 - q}$$

differential fertility: $n = n^s/n^u$

Inter-temporal equilibrium

Definition

Given an initial skilled to unskilled ratio $\bar{z}_0 > 0$, an inter-temporal equilibrium with migration is a vector of skilled to unskilled ratios $\{z_t\}_{t\geq 0} \in \mathbb{R}_+^\infty$ and a vector of poverty indexes $\{\varepsilon_t\}_{t\geq 0} \in \mathbb{R}^\infty$ such that $z_0 = \bar{z}_0$ and $\forall t \geq 0$:

$$\varepsilon_t = \ln \bar{A} - \ln A \left[(1 - G(\varepsilon_t))\, z_t\right]^\alpha \equiv f(\varepsilon_t, z_t), \tag{1}$$

$$z_{t+1} = \frac{q}{1-q} + \frac{1 - G(\varepsilon_t)}{1-q} n\, z_t \equiv h(\varepsilon_t, z_t). \tag{2}$$

Incentive constraint

Two Assumptions on G, requiring migration to respond sufficiently fast to differential income for large differential

Lemma

Under Assumptions 1 and 2, for any level $z > \hat{z}$ there exists two values of ε, $s^{+}(z_t) > s^{-}(z_t)$, such that the incentive constraint

$$\varepsilon_t = \ln \bar{A} - \ln A\left[(1 - G(\varepsilon_t))\, z_t\right]^{\alpha} \equiv f(\varepsilon_t, z_t)$$

holds.

Hence, two levels of brain drain $G(s^{+}(z)) > G(s^{-}(z))$ are compatible with one z (for $z > \hat{z}$)

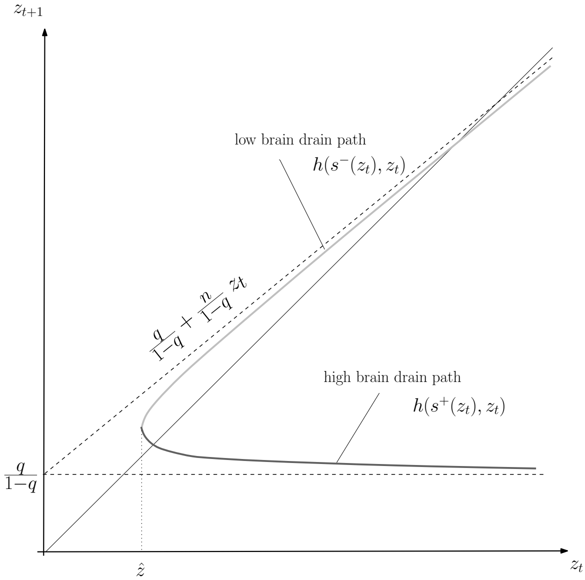
Dynamics

$$z_{t+1} = \frac{q}{1-q} + \frac{1-G(\varepsilon_t)}{1-q} n\, z_t \equiv h(\varepsilon_t, z_t)$$

At each t, there are therefore two values of z_{t+1} compatible with Equations (1)-(2). The dynamics can be written as:

$$z_{t+1} = \begin{cases} h(s^+(z_t), z_t) \\ \text{or} \\ h(s^-(z_t), z_t) \end{cases}$$

Drawing the dynamic relationship

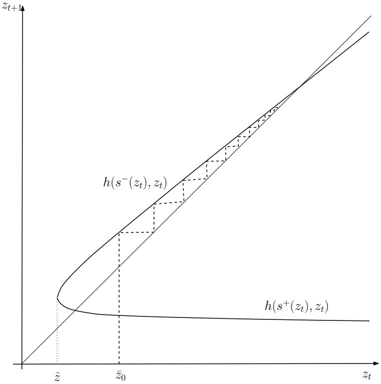


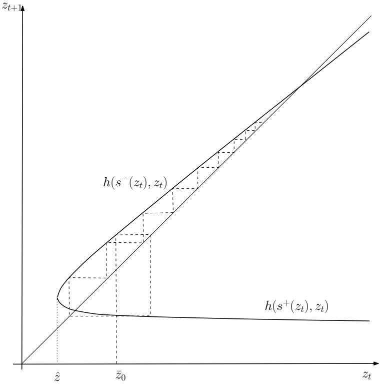
Indeterminacy

Some conditions for existence. If one equilibrium exists, an infinite number of equilibria exist

$$
\begin{array}{cccccccc}
 & & & & & & \nearrow & \dots \\
 & & & & & h(s^{-}(z_1^{+}), z_1^{+}) & \longrightarrow & \dots \\
 & & & & \nearrow & & & \\
 & & z_1^{+} = h(s^{-}(\bar{z}_0), \bar{z}_0) & & \longrightarrow & h(s^{+}(z_1^{+}), z_1^{+}) & \longrightarrow & \dots \\
 & \nearrow & & & & & \searrow & \dots \\
\bar{z}_0 & & & & & & & \\
 & \searrow & & & & & \nearrow & \dots \\
 & & z_1^{-} = h(s^{+}(\bar{z}_0), \bar{z}_0) & & \longrightarrow & h(s^{-}(z_1^{-}), z_1^{-}) & \longrightarrow & \dots \\
 & & & & \searrow & & & \\
 & & & & & h(s^{+}(z_1^{-}), z_1^{-}) & \longrightarrow & \dots \\
 & & & & & & \searrow & \dots
\end{array}
$$

Indeterminacy (2)





Data on the labor force by education level

The skill-ratio in the resident labor force is given by

$$k_{j,t} = \frac{H_{j,t}}{L^1_{j,t} + L^2_{j,t}}$$

The numbers of high-skill, low-skill and medium-skill resident workers $(H_{j,t}, L^1_{j,t}, L^2_{j,t})$ are available for each country j at time t from the Docquier, Lowell and Marfouk's database.

Return to one year of schooling $\in [0.07; 0.10]$ (Rosenzweig, 2007); low skilled have 15 years less and medium skilled have 6 years less than highly skilled. Hence, $\omega_1 = 0.6$ and $\omega_2 = 0.25$

Given GDP data, the productivity scale factor of country j is obtained as a residual:

$$A_{j,t} = \frac{Y_{j,t}}{\omega^1 L^1_{j,t} + \omega^2 L^2_{j,t} + H_{j,t}}$$

Calibration of α

$$A_t = A k_t^{\alpha}$$

We use data for 1990 and 2000.

Regressing $\ln A_{j,t}$ on $\ln k_{j,t}$ gives:

- $\alpha = 0.277$ using a large sample of developing countries (142 observations). Benchmark.
- $\alpha = 0.447$ using a larger sample of 195 developing and developed countries. Robustness.

Country fixed factor:

$$\ln A_j = \ln A_{2000,j} - 0.277 \times \ln k_{2000,j}$$

Calibration of q_j

Taking differential fertility $n = 0.605$ from Kremer and Chen

Dynamics of human capital:

$$z_{j,00} = \frac{nk_{j,75}}{1 - q_j} + \frac{q_j}{1 - q_j}$$

Solving for q_j yields:

$$q_j = \frac{z_{j,00} - nk_{j,75}}{1 + z_{j,00}}$$

Calibration of m_j and b_j

Need for two pairs (ε_j, G_j) to identify two parameters.

One is observed in 2000 ($\varepsilon_j \equiv \ln \bar{A} - \ln A - \alpha \ln k_j$)

In the benchmark, we assume that at the level of the US income (ε_{US}), the brain drain of each developing country would equal the US brain drain (G_{US}). (Robustness: same on Qatar)

This allows us to calibrate (m_j, b_j) as following (for Gumbel):

$$
\begin{aligned}
b_j &= \frac{\varepsilon_j - \varepsilon_{US}}{G^{-1}(G_j) - G^{-1}(G_{US})} \\
m_j &\equiv \varepsilon_j - b_j \times G^{-1}(G_j)
\end{aligned}
$$

Results

Numerical exercise conducted on 147 countries

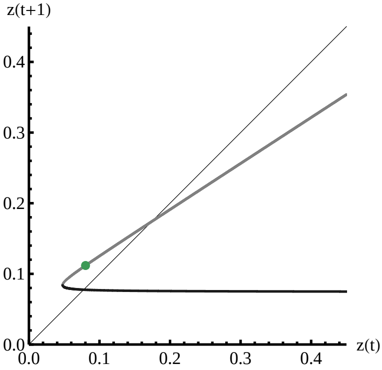
In 145 cases, two stable steady state equilibria: (ε^{-}, G^{-}) and (ε^{+}, G^{+})

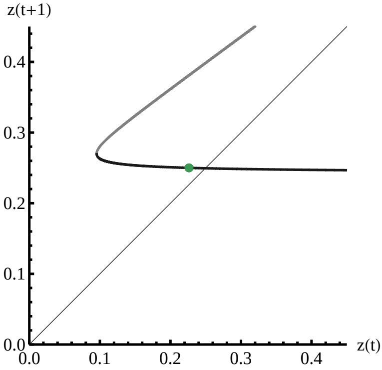
Exceptions:

- Croatia: (ε^{+}, G^{+}) is unstable
- St Kitts and Nevis: slope of oblique asymptote higher than 1

Identification of coordination failures

examples of Guatemala and Trinidad and Tobago





Results - large states ($>$ 2 millions inhab.)

- 103 countries are on the good path (ε^-, G^-):
  - we predict a significant decrease in the brain drain, provided that they remain on the same path
  - for 89 of them, the high brain drain path corresponds to $G^+ \simeq 1$
  - 14 of them face a risk of coordination failure ($G^+ \ll 1$): Mexico, Lebanon, Malaysia, Tunisia, etc.
- Only 2 cases are on the bad path (ε^+, G^+)
  - Jamaica: $G_{00}^{obs} = G_{00}^+ = 0.847$, $G_{ss}^+ = 0.863$ at the steady state, moving on the good path would give $G_{ss}^+ = 0.030$
  - Haiti: $G_{00}^{obs} = G_{00}^+ = 0.834$, $G_{ss}^+ = 0.860$ at the steady state, moving on the good path would give $G_{ss}^+ = 0.187$

Results - small states

- 22 small states on the good path
  - Brain drain is expected to decrease in these countries: average emigration rate of 29.6 percent in 2000, 23 percent in 2025, and 18.3 percent in the long-run.
  - 11 of them face a risk of coordination failure ($G^+ \ll 1$)
- 20 small states on the bad path in 2000
  - The skilled emigration rate will increase: average rate of 69.5 percent in 2000, 76.9 percent in 2025, and 75.9 percent in the long-run.

Selected cases of coordination failure

Country	z_{00}^{+}	G_{00}^{+}	z_{ss}^{+}	G_{ss}^{+}	z_{ss}^{-}	G_{ss}^{-}
Cape Verde	0.059	0.828	0.065	0.848	0.161	0.007
Cyprus	0.318	0.353	0.394	0.494	NA	0.000
Fiji	0.206	0.628	0.223	0.738	0.466	0.145
Guyana	0.388	0.894	0.411	0.904	1.966	0.032
Malta	0.168	0.585	0.193	0.641	NA	0.000
Mauritius	0.091	0.419	0.113	0.567	0.233	0.000
Saint Lucia	0.152	0.687	0.162	0.729	0.377	0.050
Samoa	0.291	0.735	0.313	0.796	0.722	0.171
Suriname	0.271	0.660	0.310	0.745	0.933	0.032
Tonga	0.313	0.757	0.338	0.804	0.897	0.125
Trinidad and Tobago	0.226	0.790	0.249	0.813	0.812	0.000

Robustess to identifying assumptions

Twelve variants:

- Lucas-type externality: $\overline{\alpha} = 0.447$ instead of $\underline{\alpha} = 0.277$
- Migration costs CDF: Logistic or Normal instead of Gumbel
- Parameters of CDF: based on Qatar ($\varepsilon_{Qat} = -0.382$ and $G_{Qat} = 0.023$) instead of US ($\varepsilon_{US} = -0.013$ and $G_{US} = 0.005$)

Identification	USA						Qatar					
$G(.)$	Gumbel		Logistic		Normal		Gumbel		Logistic		Normal	
α	$\underline{\alpha}$	$\overline{\alpha}$	$\underline{\alpha}$	$\overline{\alpha}$	$\underline{\alpha}$	$\overline{\alpha}$	$\underline{\alpha}$	$\overline{\alpha}$	$\underline{\alpha}$	$\overline{\alpha}$	$\underline{\alpha}$	$\overline{\alpha}$
Belize	×	×	×	×	×	×	×	×		×		×
Cape Verde	×	×	×	×	×	×	×	×	×	×	×	×
Dominica	×	×	×	×	×	×	×	×		×		×
Fiji	×	×		×		×		×				
Gambia		×		×								
Grenada	×	×	×	×	×	×	×	×	×	×	×	×
Guyana	×	×	×	×	×	×	×	×		×		×
Haiti	×	×		×		×	×	×				
Jamaica	×	×	×	×	×	×	×	×		×		×
Kiribati				×								
Lebanon		×		×								
Mauritius	×	×	×	×	×	×		×		×		×
Micronesia		×		×								
Nauru		×		×								
Palau	×	×	×	×	×	×	×	×	×	×	×	
Saint Kitts & Nevis	×	×	×	×	×	×	×	×	×	×	×	
Saint Lucia	×	×	×	×		×		×		×		×
Saint Vinc & Gren	×	×	×	×	×	×	×	×	×	×	×	×
Samoa	×	×		×		×		×				
Seychelles	×	×	×	×	×	×	×	×		×		×
Suriname	×	×	×	×		×		×				
Tonga	×	×		×		×		×				
Tuvalu		×		×								
Antigua and Barb.	×	×	×	×	×	×	×	×		×		×
Bahamas		×		×								
Barbados	×	×	×	×	×	×	×	×		×		×
Cyprus	×	×	×	×	×	×		×		×		
Malta	×	×	×	×	×	×	×	×	×	×	×	
Trinidad and Tob.	×	×	×	×	×	×	×	×	×	×	×	×
Coordination failures	22	28	18	29	16	22	15	22	7	17	7	17

Robustness to brain gain channel

Newer literature: migration prospects stimulate human capital formation

OLS regression: $q = q_0 + 0.095\ G \equiv q(G)$

We have $k_{ss} = \frac{(1-G)\cdot q(G)}{1-q(G)-n(1-G)}$

Optimal brain drain is positive in 64 cases:

$$\left[\frac{\partial k_{ss}}{\partial G}\right]_{G=0} > 0 \Leftrightarrow q_0 < 0.039$$

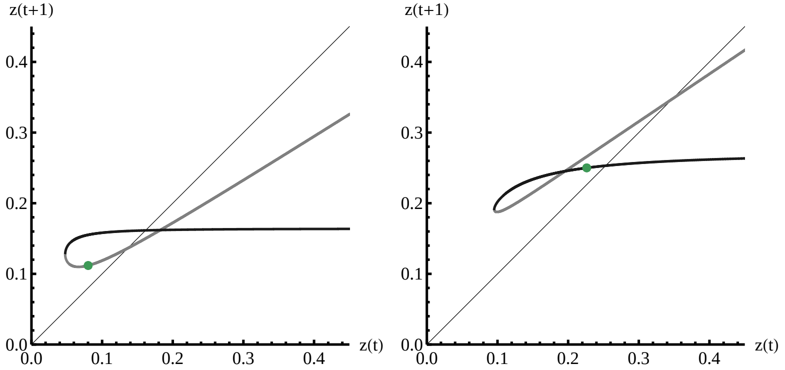
Optimal brain drain $G^* \simeq 0.411 - 10.12\ q_0$ if $q_0 < 0.039$

Robustness to brain gain channel (2)

Solving the model with endogenous q...

- Modifies shape of dynamic correspondences
- Gives $G^* > G_{ss}$ in 57 cases (all are on the low brain drain path)
- Does not modify the number of coordination failures
- No case for which G_{ss}^+ gives more domestic human capital (k_{ss}) than G_{ss}^-

Guatemala and Trinidad and Tobago



Conclusion

A theoretical model with indeterminacy brought to data.

Indeterminacy roots in the vicious cycle: brain drain-poverty

Results: 22 countries (including 20 small states) suffer from a coordination failure.

By repatriating highly skilled natives working abroad, they would reach a productivity level inciting high-skill workers to stay and generating more human capital accumulation.

This represents 15 percent of the sample, but 47.6 percent of countries with less than 2 million inhabitants.

Results are fairly robust to identifying assumptions and brain gain channel

Assumption 1

Assumption

The distribution function of migration costs satisfies[1]

$$G'(x) = o\left(\exp\left(-x/\alpha\right)\right) \quad \textit{when} \quad x \to +\infty$$

It requires migration to respond sufficiently fast to differential income for large differential

Satisfied for $G(\varepsilon)$ Normal with positive mean, or Gumbel with positive location. If $G(\varepsilon)$ logistic, holds provided that the scale b is larger than α.

[1] $o()$ means little-o of (Landau notation).

Further assumption

Assumption

The distribution function of migration costs is such that there is a unique ε satisfying

$$1 - G(\varepsilon) - \alpha G'(\varepsilon) = 0.$$

Not crucial but greatly simplifies the analysis

Existence

Proposition

Under Assumptions 1 and 2 an inter-temporal equilibrium exists under the following conditions.

When $h(\hat{\varepsilon}, \hat{z}) > \hat{z}$, *if* $z_0 > \hat{z}$, *an equilibrium exists.*

When $h(\hat{\varepsilon}, \hat{z}) < \hat{z}$,

- *if* $h(s^-(z), z) < z$ *forall* $z > 0$, *no equilibrium exists.*
- *if there exists* $\tilde{z} > 0$ *such that* $h(s^-(\tilde{z}), \tilde{z}) < \tilde{z}$ *and if* $z_0 \geq \underline{z}$, *where* $\underline{z}$ *is the smallest steady state of the dynamics* $z_{t+1} = h(s^-(z_t), z_t)$, *an equilibrium exists.*

"Stability" of the Nash equilibrium (1)

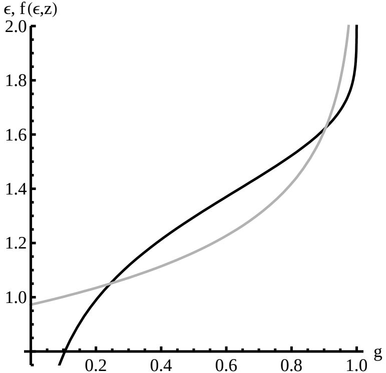
Trembling-hand perfect Nash equilibrium (Selten)

Robustness to the possibility that some players may make small mistakes

Used to select among multiple Nash equilibria

The right equilibrium is not trembling hand perfect

If one additional person migrates, gains are higher than costs for others



"Stability" of the Nash equilibrium (2)

But that selection is not robust to assumptions

Instead of following Lucas (1988), let us adopt Azariadis and Drazen (1990) view

Let A_t be a step function of k_t: both equilibria are now "stable"

Indeed technological level will not change with the mistake of one person

Same argument if institutional levels depend on skill ratio