Globalization? Trade War? A Counterbalance Perspective

Arthur Hu (Vanderbilt)

Xingwei Hu (IMF)

Hui Tong (IMF)
Outline

1. Objectives
2. Competitiveness
3. Bilateral Conflict
4. 2-Sided Bargaining
5. Economic Globalization
6. Empirical Studies
Outline

1. Objectives
2. Competitiveness
3. Bilateral Conflict
4. 2-Sided Bargaining
5. Economic Globalization
6. Empirical Studies
Competitive advantage also matters!

- Adam Smith: economy of scale.
- David Ricardo: comparative advantage.
- If all production factors were free of flow, then hopefully, the global GDP would be maximized.
- However, not all countries share the same well-off: some succeed over some time whereas others fail during the same period.
- They have to COMPETE for their own shares and, at the same time, COOPERATE to maximize the global GDP.
Empirical evidence from the past 50 years

- 2 trade wars between the top 2 economies
- Never-ending trade frictions here and there
- Ebbing and flowing globalization & protectionism among economic superpowers
  - UK’s Brexit in 2020
  - European Union and Euro
  - China’s entry into the WTO in 2001
  - North America Free Trade Agreement (NAFTA)
  - Trump administration’s exit from int’l organizations
Objectives of this research

- Quantify competitive advantage using a network counterbalance equilibrium
- Provide necessary conditions for globalization and trade wars
- Identify any country’s right targets for collaboration or conflict
- Derive a fair resolution for trade conflict and national bargaining power
- Evaluate the side effects of trade friction and globalization
Outline

1. Objectives
2. Competitiveness
3. Bilateral Conflict
4. 2-Sided Bargaining
5. Economic Globalization
6. Empirical Studies
International trade system as a game on network

Let there be $n$ countries in the system, labeled as $1, 2, \cdots, n$, and denote $\mathcal{N} = \{1, 2, \cdots, n\}$.

Denote the $n$-by-$n$ matrix $P = [P_{ij}]$ where $P_{ij}$ is the fraction of country $i$’s GDP, which exports to country $j$. 

A simple network of trade

3 country nodes: $i, j, k$

Directional edges for exports

Trade volumes not shown
To model the progress of country $i$’s production, we introduce the set function $v_i : 2^\mathcal{N} \rightarrow [0, 1]$ by

$$v_i(S) = \sum_{k \in S} P_{ik}$$

for any $S \subseteq \mathcal{N}$.

Then, $P_{ij}$ is $j$’s Shapley value (Shapley-Shubik power index) in the coalitional game $(\mathcal{N}, v_i)$.

Both the value and the power index are von Neumann-Morgenstern utility functions (Roth: Econometrica, 1977; JET, 1977).
Even though the final product bears the mark of being made in one country, its components or parts may come from elsewhere. One part may be made in a third country; a fourth country could provide the tools to make the part and another offers the raw material, etc.

\( P^2 \) is one-time transition of the power where

\[
\left[ P^2 \right]_{ij} = \sum_{k=1}^{n} P_{ik} P_{kj}.
\]

Similarly, we have \( P^3, P^4, \ldots \ldots \). In the limit, \( \lim_{t \to \infty} P^t \) has a constant vector, say \( \pi \), for all rows.
The counterbalance equilibrium of power

\( \pi \) also satisfies the counterbalance equilibrium

\[ \pi = \pi P, \]

as defined in Hu and Shapley (GEB, 2003).

The counterbalance:

\textbf{inflow} Country \( i \) absorbs power from all countries:

\[ \pi_i = \sum_{j=1}^{n} \pi_j P_{ji}; \]

\textbf{outflow} It also distributes its power to all countries:

\[ \pi_k = \pi_i P_{ik} + \sum_{j \neq i} \pi_j P_{jk}. \]

Counterbalanced systems: ecological system, USA’s government system, etc.
Mixed cooperative & noncooperative relations in $\mathcal{N}$

**Noncooperative:** As

$$\sum_{k=1}^{n} \pi_k = 1,$$

an increase of $\pi_j$ may imply a decrease of $\pi_i$. So, in theory, there are $n(n - 1)/2$ potential trade conflicts, either small or large, in the trade system.

**Cooperative:** By

$$\pi_i = \sum_{j=1}^{n} \pi_j P_{ji},$$

a rising $\pi_j$ increases $\pi_i$. Therefore, $i$ should help all other countries, including the poorest and the least competitive, to enhance their $\pi_j$. 
\( \pi_i \): country \( i \)'s competitive advantage

- Assume no bilateral trade deficit in this slide ONLY.
- Let \( \beta_i \) be the \( i \)th row of \( P \) — countries’s comparative advantage over country \( i \). Since all countries compete exporting to country \( i \), \( \beta_i \) is also the ranking score for competitiveness when \( i \) acts as the reference.
- Endogenously weight all \( \beta_i \): competitive countries have larger weights than less competitive ones. Say, \( w_i \) is the weight for \( \beta_i \). Then \( \sum_{i=1}^{n} w_i \beta_i \) measures the global competitiveness for all countries.
- Since \((w_1, \cdots, w_n)\) are already the competitiveness, 
\[
(w_1, \cdots, w_n) = \sum_{i=1}^{n} w_i \beta_i = (w_1, \cdots, w_n)P \text{ and } w_i = \pi_i.
\]
Outline

1. Objectives
2. Competitiveness
3. Bilateral Conflict
4. 2-Sided Bargaining
5. Economic Globalization
6. Empirical Studies
**dP_{ij} or dP_{ji}: country i’s potential action on j**

Before launching an attack on or collaboration with country j, country i expects the changes on its π_i.

**Gaming on P,**

- Say, i changes its exports to j by dP_{ij} or changes its imports from j by dP_{ji}.

- In retaliation for the dP_{ji} change on P_{ji}, country j changes P_{ij} by λ_{ji}dP_{ji}.

- In retaliation for the dP_{ij} change on P_{ij}, country j changes P_{ji} by λ_{ij}dP_{ij}.

- For consistency, λ_{ij}λ_{ji} = 1.
Response to the shock $dP_{ji}$ in the equilibrium $\pi = \pi P$

The effects on $\pi_i$ and $\pi_j$:

\[
\begin{align*}
\frac{d\pi_i}{dP_{ji}} &= \frac{- (\lambda_{ji} \pi_i - \pi_j) \tilde{1}' \left( I_{n-1} - Z_i \right)^{-1} \gamma_{ji}}{1 + \tilde{1}' \left( I_{n-1} - Z_i \right)^{-1} \alpha_i}, \\
\frac{d\pi_j}{dP_{ji}} &= \frac{(\lambda_{ji} \pi_i - \pi_j) \tilde{1}' \left( I_{n-1} - Z_j \right)^{-1} \gamma_{ij}}{1 + \tilde{1}' \left( I_{n-1} - Z_j \right)^{-1} \alpha_j},
\end{align*}
\]

and the effects of $dP_{ji}$ on other countries:

\[
\frac{d\pi_{-i}}{dP_{ji}} = (\lambda_{ji} \pi_i - \pi_j) \left( I_{n-1} - Z_i \right)^{-1} \left[ \gamma_{ji} - \frac{\tilde{1}' \left( I_{n-1} - Z_i \right)^{-1} \gamma_{ji}}{1 + \tilde{1}' \left( I_{n-1} - Z_i \right)^{-1} \alpha_i} \right] \alpha_i
\]
Identify the collaborators or competitors using $\frac{d\pi_i}{dP_{ji}}$.

- **No zero-sum game**: the gain and loss are not equal. Other countries share the discrepancy.

- If $\lambda_{ji} = \frac{\pi_j}{\pi_i}$, no changes on $\pi$ for any small $dP_{ji}$.

- If $\lambda_{ji} > \frac{\pi_j}{\pi_i}$, a negative $dP_{ji}$ increases $\pi_i$, i.e. $j$ is a competitor and $i$ should reduce $P_{ji}$.

- If $\lambda_{ji} < \frac{\pi_j}{\pi_i}$, a positive $dP_{ji}$ increases $\pi_i$, i.e., $j$ is a collaborator and $i$ should increase $P_{ji}$.

- Look for the best competitor or collaborator by choosing $j$ to minimize or maximize the derivatives in percentage: $\frac{d\log\pi_i}{d\log P_{ji}} = \frac{P_{ji}}{\pi_i} \frac{d\pi_i}{dP_{ji}}$. 
Outline

1. Objectives
2. Competitiveness
3. Bilateral Conflict
4. 2-Sided Bargaining
5. Economic Globalization
6. Empirical Studies
Net trade balance

■ Focus on two sides: countries $i$ and $j$.

■ A positive $dP_{ij}$ or $dP_{ji}$ creates jobs and capitalizes on the economy of scale.

■ Good trade balance also creates jobs, increase production scale, and expand comparative advantage.

■ **Zero-sum game** on bilateral net trade balance: one country’s net surplus equals the counterpart’s net deficit of the same amount.

■ For zero net trade balance: $\lambda_{ji} = \frac{g_j}{g_i}$ where $g_i$ is country $i$’s GDP.
Impossible Trilemma: $\pi_i \uparrow$, trade surplus, $dP_{ji} > 0$
Cooperative solutions for $\lambda_{ji}$

Under the veil of ignorance of other countries:

- When both $i$ and $j$ compete for competitiveness:
  \[ \lambda_{ji} = \frac{\pi_j}{\pi_i}. \]

- When both $i$ and $j$ compete for trade balance:
  \[ \lambda_{ji} = \frac{g_j}{g_i}. \]

- When one seeks for competitiveness while another for trade balance, we get the Nash bargaining solution [see next two slides]:
  \[ \lambda_{ji} = \sqrt{\frac{\pi_j g_j}{\pi_i g_i}}. \]
When $i$ seeks for $\pi_i \uparrow$ while $j$ for trade surplus

Nash Bargaining solution of $\lambda_{ji}$:

$$\text{argmax}_{\lambda_{ji}} \left\{ \left( \lambda_{ji} - \frac{g_j}{g_i} \right) \left( \lambda_{ij} - \frac{\pi_i}{\pi_j} \right) \bigg| \lambda_{ij} = \frac{1}{\lambda_{ji}} \right\} = \sqrt{\frac{\pi_j g_j}{\pi_i g_i}}.$$
When $i$ seeks for trade surplus while $j$ for $\pi_j \uparrow$

Nash Bargaining solution of $\lambda_{ji}$:

$$\arg\max_{\lambda_{ji}} \left\{ \left( \lambda_{ji} - \frac{\pi_j}{\pi_i} \right) \left( \lambda_{ij} - \frac{g_i}{g_j} \right) \bigg| \lambda_{ij} = \frac{1}{\lambda_{ji}} \right\} = \sqrt{\frac{\pi_j g_j}{\pi_i g_i}}.$$
Global bargaining power

Among the $n(n-1)/2$ potential trade conflicts, most countries would not choose to compete but cooperate.

In either Nash bargaining case, $\lambda_{ji} = \sqrt{\frac{\pi_{jg_j}}{\pi_{ig_i}}}$. So, we define $i$’s global bargaining power by

$$\sqrt{\pi_{ig_i}}.$$

- Result in a linear ordering of the countries.
- Consistent transitivity of Nash bargaining solutions: $\lambda_{jk} = \lambda_{ji}/\lambda_{ki}$ for any $i$.
- You may normalize it by: $\frac{\sqrt{\pi_{ig_i}}}{\sum_{j=1}^{n} \sqrt{\pi_{jg_j}}}$. 
Outline

1. Objectives
2. Competitiveness
3. Bilateral Conflict
4. 2-Sided Bargaining
5. Economic Globalization
6. Empirical Studies
Global integration or disintegration by changing $P_{ii}$

Before going further or less globalization, country $i$ considers the expected change on its $\pi_i$.

Gaming on $P$:

- Change $P_{ii}$ by $dP_{ii}$: $dP_{ii} < 0$ for further globalization while $dP_{ii} > 0$ for protectionism.

- No specific target country to cooperate or conflict with.

- Assume $dP_{ii}$ triggers proportional changes on all other elements in $P$. 
Response of $\pi$ w.r.t. $dP_{ii}$ in the equilibrium $\pi = \pi P$

Effects on $\pi_i$:

$$\frac{d\pi_i}{dP_{ii}} = -\frac{\vec{1}'_{n-1}(I_{n-1} - Z_i)^{-1}(\pi M_i)'}{1 + \vec{1}'_{n-1}(I_{n-1} - Z_i)^{-1}\alpha_i}$$

and effects on all other countries:

$$\frac{d\pi_{-i}}{dP_{ii}} = (I_{n-1} - Z_i)^{-1} \left[ (\pi M_i)' - \frac{\vec{1}'_{n-1}(I_{n-1} - Z_i)^{-1}(\pi M_i)'}{1 + \vec{1}'_{n-1}(I_{n-1} - Z_i)^{-1}\alpha_i} \right].$$
Globalization policy implications using $\frac{d\pi_i}{dP_{ii}}$

- Less globalization if $\frac{d\pi_i}{dP_{ii}}$ is significantly positive, say, $\frac{d\log \pi_i}{d\log P_{ii}} = \frac{P_{ii}}{\pi_i} \frac{d\pi_i}{dP_{ii}} > 1\%$.

- More globalization if it is significantly negative.

- In-between, look for best collaborators, regional trade agreements, or preferential trade agreements.

- The effects on other countries could be substantial.

- Optimal levels of globalization: over-globalized countries increase $P_{ii}$ by 1% while under-globalized reduce $P_{ii}$ by 1%. Continue this process until stable.
Outline

1. Objectives
2. Competitiveness
3. Bilateral Conflict
4. 2-Sided Bargaining
5. Economic Globalization
6. Empirical Studies
Data in the empirical studies

- 190 country members of IMF
- Twenty years from 2000 to 2019
- Exports data from UN’s ComTrade database
- Annual GDP for the countries and the years

Data already reflect political, territorial, ideological, cultural, war, national security, and other geopolitical considerations, as well as resource endowment, industrial distribution, location advantages, climate, and weather.
Estimated $\pi_i$ for China, Russia, and G7 Countries (2000-2019).
The combined $\pi_i$ for all other countries
### 1,000 $\times \frac{d\log \pi_i}{d\log P_{ji}}$ for years 2000 and 2017*

|   | CAN | CHN | DEU | FRA | GBR | ITA | JPN | RUS | USA  |
|---|-----|-----|-----|-----|-----|-----|-----|-----|------|
| CAN | 6.69 | 6.95 | 1.20 | .14 | 1.00 | .73 | .97 | 1.02 | 4.35 | 3.51 | 1.54 | 4.52 | 1.69 | .506 |
| CHN | -5.79 | 7.38 | -6.10 | -7.79 | -8.55 | -5.20 | -7.69 | -8.34 | -26.34 | -14.15 | -5.99 | 3.51 | -46.53 | -16.15 |
| DEU | -5.48 | 7.38 | -3.76 | 16.67 | -13.75 | -6.40 | -18.05 | -3.67 | -2.8 | 4.71 | 8.97 | 56.53 | -11.87 | -6.17 |
| FRA | 1.47 | 5.38 | 3.45 | 7.79 | 6.54 | 5.34 | 10.18 | 6.14 | 3.67 | 3.67 | 2.2 | 24.30 | -2.77 | -2.65 |
| GBR | -.72 | 2.08 | 2.69 | 8.50 | 10.18 | 5.7 | 1.3 | 7.22 | 4.43 | 6.62 | 6.12 | 26.59 | -2.89 | -2.83 |
| ITA | -2.35 | -1.16 | -2.59 | 5.28 | 1.3 | 0.18 | 31.77 | 2.41 | -.91 | 5.34 | 5.14 | 25.75 | -4.06 | -23.64 |
| JPN | -4.88 | -5.41 | -3.74 | 31.77 | .10 | -5.26 | -2.48 | -4.56 | -2.9 | -3.10 | -3.41 | 6.42 | -9.84 | -1.72 |
| RUS | -6.2 | -5.3 | -2.87 | -31.77 | -1.86 | -5.26 | -2.48 | -4.56 | -2.9 | -3.10 | -3.41 | 6.42 | -9.84 | -1.72 |
| USA | 15.90 | 64.43 | 10.99 | 12.68 | 12.13 | 31.29 | 70.09 | 24.53 | 56.82 | 25.75 | 6.42 | -2.07 | -1.72 | -1.72 |

* The numerators are for 2017 and the denominators for 2000.

- USA’s top target for conflict was CHN in 2017 & JPN in 2000.
- Any country would benefit from further collaboration with USA.
Normalized global bargaining powers (2000-2019)
1,000 \times \frac{d \log \pi_j}{d \log P_{ii}} \text{ for years 2000 and 2017}\*

|     | CAN  | CHN  | DEU  | FRA  | GBR  | ITA  | JPN  | RUS  | USA  |
|-----|------|------|------|------|------|------|------|------|------|
| CAN | 9.78 | 5.86 | 9.65 | 9.13 | -1.66| 11.18| 7.39 | 12.19| -17.81|
| CHN | -6.14| 3.48 |10.07 | 9.83 | 6.94 | 9.66 | 8.39 | 3.71 | -13.53|
| DEU | 4.14 |-427.81|17.38|18.44 |21.72 |16.12|14.56| -6.8 | 13.68 |
| FRA | 12.28|7.20  |-103.54|25.87 |8.36  |18.20|25.36| -8.71| 14.02 |
| GBR | -16.04|47.37 |90.31 |68.51 |78.00 |-14.27|14.84| -68.17| 18.12 |
| ITA | 13.68|9.23  |49.72 |-60.84|20.33 |40.20|19.50| 2.69  | 11.26 |
| JPN | 8.08 |7.19  |48.77 |-35.22|25.60 |35.32|12.97| -84.74|21.10 |
| RUS | -15.25|12.39 |15.73|13.97 |10.57|10.57|22.15| -8.01 | 8.87 |
| USA | 13.72|15.70 |12.39|13.97 |10.57|10.57|22.15| -8.01 | 8.87 |

* The numerators are for 2017 and the denominators are for 2000.

- **UK & USA advocated antiglobalization most in 2017.**
- **Japan would benefit most if USA went to antiglobalization in 2017. Canada would hurt most.**
## China-USA trade war since 2018

**Table:** Effects measured by $\frac{d \log \pi_k}{d \log P_{ji}}$

| Year | CAN | DEU | FRA | GBR | ITA | JPN | RUS | CHN | USA |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 2018 | -.023 | .010 | .006 | .003 | .009 | .016 | .018 | .109 | -.051 |
| 2019 | -.020 | .005 | .004 | .002 | .008 | .015 | .017 | .096 | -.044 |

* Country $i$ is for the USA and $j$ for China.

- The war did hurt China’s $\pi_j$; but the harm decreased from 2018 to 2019.

- It increased USA’s $\pi_i$ with a diminishing magnitude.

- Except for Canada, no third countries in the table benefited from the war. Japan and Russia suffered most.
Trade counterbalances cooperation and competition.