Mapping Globalization

Using Heatmaps to Explore Trade Networks

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Exploring Networks Without a Map

Patterns of trade among dyads often visualized using maps

Map based displays usually constrain amount of data we can plot & absorb

And hard to show direction of trade

Or make comparisons across years or transaction types

Alternative: move away from physical space

Plot a grid showing every country’s trade with every other country

This type of plot is known as an image plot
Global intensity of trade relations

Region color codes

East Asia  Europe  North America  Latin America  Southeast Asia

Global intensity of trade

4.27e−06  0.000512  0.00166  0.00301  0.00418  0.00601  0.00893  0.0368
Questions raised by image plots of trade data

How do we select the countries to plot?

How do we order the countries in rows and columns?

What data are we plotting exactly?

How do we turn those data into color (selecting bins)?
How do we select the countries to plot?

Lots of options

Need not choose the same countries for rows and columns

Examples here: $N$ largest importers and $M$ largest exporters
How do we order the countries?

Perhaps the key step

Alpha or random order will tend to hide interesting patterns

Solution: Plot “similar” rows and columns close to each other

Reveals clusters of traders and outliers from prevailing patterns of trade

We use cluster analysis to find which rows and columns cluster together

Heatmap: An image plot with rows & columns ordered by cluster analysis
What data are we plotting exactly?

How do we measure trading relationships?

Total dollars of trade between two countries?

Two problems with this:

1. Trade data is directional
   - US imports from China $\neq$ US exports to China

2. Big countries have much higher absolute levels of trade
   - Graphs will tend to highlight well-known relationships only
What data are we plotting exactly?

Option 1:

Measure trade from country $i$ to $j$ as a % of world trade

\[
\text{Global Intensity of Trade}_{i\rightarrow j} = \frac{\text{Imports}_{i\rightarrow j}}{\text{Imports}_{\bullet\rightarrow \bullet}}
\]

This gives us two complementary measures for any pair of countries

Solves problem 1 (directionality), not problem 2 (big countries dominate)
What data are we plotting exactly?

Option 2:

Measure trade as a % of imports (by the importer) and exports (by the exporter)

Gives greater weight as dyads become more “exclusive”

\[
\text{Dyadic Intensity of Trade}_{i \rightarrow j} = \frac{\text{Imports}_{i \rightarrow j}}{\text{Imports}_{\bullet \rightarrow j}} \times \frac{\text{Imports}_{i \rightarrow j}}{\text{Imports}_{i \rightarrow \bullet}}
\]

Solves problem 1; *partially* solves problem 2 (bigger countries have more “partners”)

### An example

<table>
<thead>
<tr>
<th>World Trade</th>
<th>Amount of Trade</th>
<th>Global Intensity of Trade</th>
<th>Sender’s Total Exports</th>
<th>Receiver’s Total Imports</th>
<th>Dyadic Intensity of Trade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexico → US</td>
<td>$100 m</td>
<td>0.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden → Finland</td>
<td>$1 m</td>
<td>0.001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>China → Italy</td>
<td>$1 m</td>
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<td>------------------------</td>
<td>--------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>Mexico → US</td>
<td>$100 m</td>
<td>0.1</td>
<td>$110 m</td>
<td>$200 m</td>
<td>0.455</td>
</tr>
<tr>
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<td>$1 m</td>
<td>0.001</td>
<td></td>
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<tr>
<td>Sweden → Finland</td>
<td>$1 m</td>
<td>0.001</td>
<td>$2 m</td>
<td>$1.5 m</td>
<td>0.333</td>
</tr>
<tr>
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<td></td>
<td></td>
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<tbody>
<tr>
<td>“= $1000 million”</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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Global intensity of trade relations

Region color codes

- **East Asia**
- **Latin America**
- **Southeast Asia**

Global intensity of trade

<table>
<thead>
<tr>
<th>Region</th>
<th>4.27e−06</th>
<th>0.000512</th>
<th>0.00166</th>
<th>0.00301</th>
<th>0.00418</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>North America</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>0.00512</td>
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Exporter

Importer

- **Canada**
- **Mexico**
- **Japan**
- **Hong Kong**
- **China**
- **France**
- **United Kingdom**
- **Germany**
- **Sweden**
- **Austria**
- **Switzerland**
- **Malaysia**
- **Singapore**
- **Taiwan**
- **South Korea**
- **Netherlands**
- **Spain**
- **Belgium—luxembourg**
- **Italy**

United States

- **Mexico**
- **Canada**
- **Japan**
- **Hong Kong**
- **China**
- **France**
- **United Kingdom**
- **Germany**
- **Sweden**
- **Austria**
- **Switzerland**
- **Malaysia**
- **Singapore**
- **Taiwan**
- **South Korea**
- **Netherlands**
- **Spain**
- **Belgium—luxembourg**
- **Italy**
Dyadic strength of trade relations

Region color codes

East Asia
Latin America
North America
Southeast Asia

Dyadic intensity of trade

3.97e−09 to 0.000295
0.000295 to 0.00183
0.00183 to 0.00513
0.00513 to 0.00851
0.00851 to 0.0141
0.0141 to 0.0238
0.0238 to 0.173

United States
Mexico
Canada
Hong Kong
China
Singapore
Malaysia
Japan
France
Germany
Taiwan
South Korea
Austria
Sweden
Netherlands
Spain
Switzerland
Italy
Belgium–luxembourg
United Kingdom

Exporter

Importer

United States
Mexico
Canada
Hong Kong
China
Singapore
Malaysia
Japan
France
Germany
Taiwan
South Korea
Austria
Sweden
Netherlands
Spain
Switzerland
Italy
Belgium–luxembourg
United Kingdom
How do we turn those data into colors?

We have our transformed trade data by dyad.

To plot it on a heatmap, we need to discretize it, or place it in “bins”

Choosing the cutpoints between bins affects what patterns will emerge from the data

Our dyadic trade data is strongly skewed:
Distribution of Dyadic Trade Intensity, 2001

Dyadic Trade Intensity

Frequency

0.00 0.05 0.10 0.15

0 50 100 150 200 250
How do we turn those data into colors?

Choosing equally spaced bins will thus submerge most of the variation, and highlight the small handful of strong relationships

Alternatively, we could choose bins based on quantiles, e.g.,

- **Bin 1**: 50th percentile and below
- **Bin 2**: 75th percentile down to 50th
- **Bin 3**: 85th percentile down to 75th
- **Bin 4**: 90th percentile down to 85th
- **Bin 5**: 95th percentile down to 90th
- **Bin 6**: 97.5th percentile down to 95th
- **Bin 7**: 100th percentile down to 97.5th

which is what we’ve been using for all our previous plots...
More advanced features for heatmaps

Color coded nodes:
I’ve used region here, but could be any variable, categorical or continuous

Change the axes:
To explore the evolution of a single exporter’s trading partners, replace the exporter dimension with time, or with different categories of trade

Parquet plots:
Split the square to show change over time, or differences across traded goods
Future extensions

Interface directly with SQL database

Create a web version (currently an R package)