CSSS 569 · Visualizing Data

GALLERY 6:
HEATMAPS FOR VISUALIZING CONTINUOUS DYADIC DATA

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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

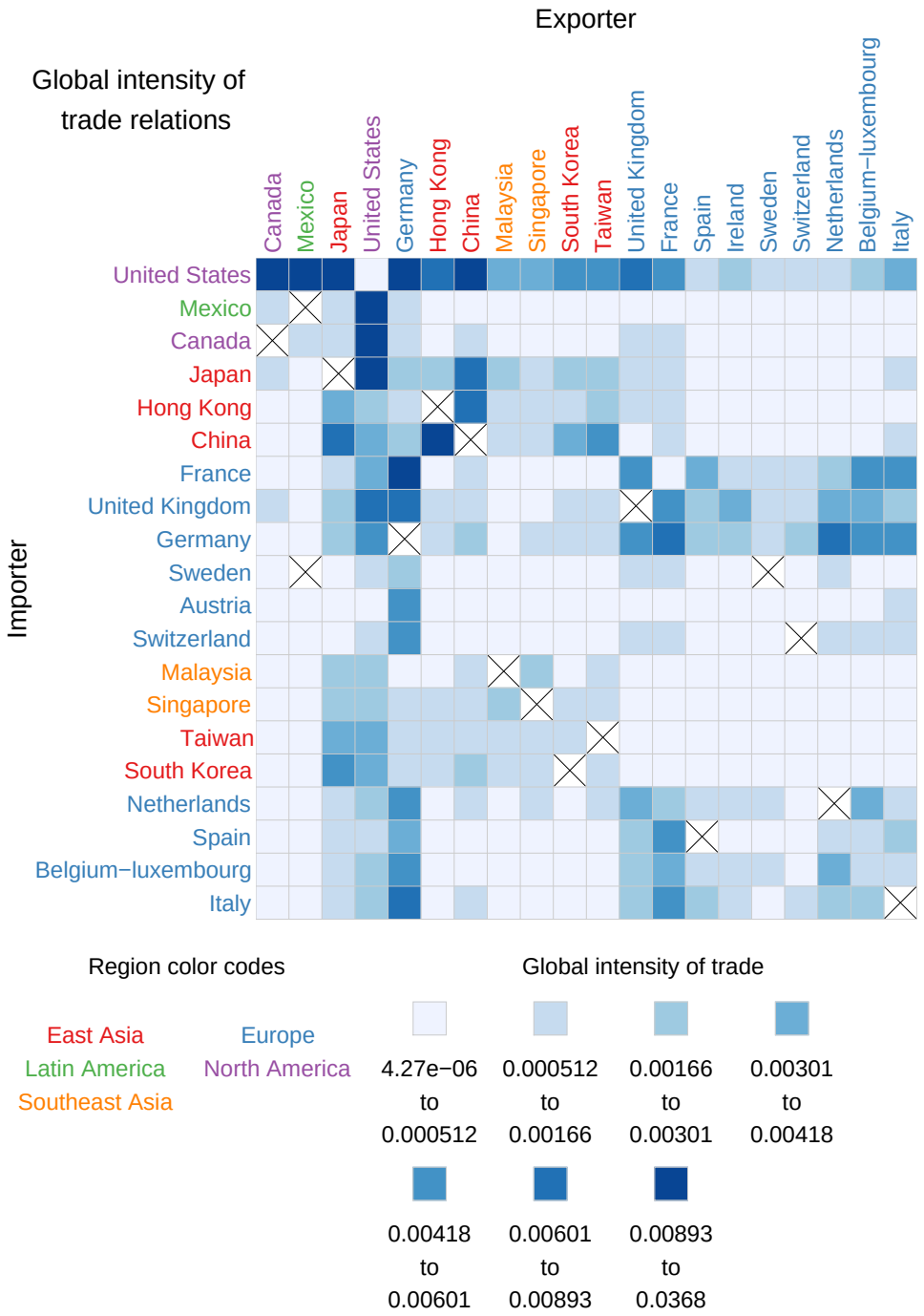
And hard to show direction of trade

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


Exporter
Global intensity of trade relations
Canada
Mexico
Japan
United States
Germany
Hong Kong
China
Malaysia
Singapore
South Korea
Taiwan
United Kingdom
France
Spain
Ireland
Sweden
Switzerland
Netherlands
Belgium−luxembourg
Italy
Importer
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
Region color codes
East Asia
Europe
Latin America
North America
Southeast Asia
Global intensity of trade
4.27e−06 to 0.000512
0.000512 to 0.00166
0.00166 to 0.00301
0.00301 to 0.00418
0.00418 to 0.00601
0.00601 to 0.00893
0.00893 to 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?

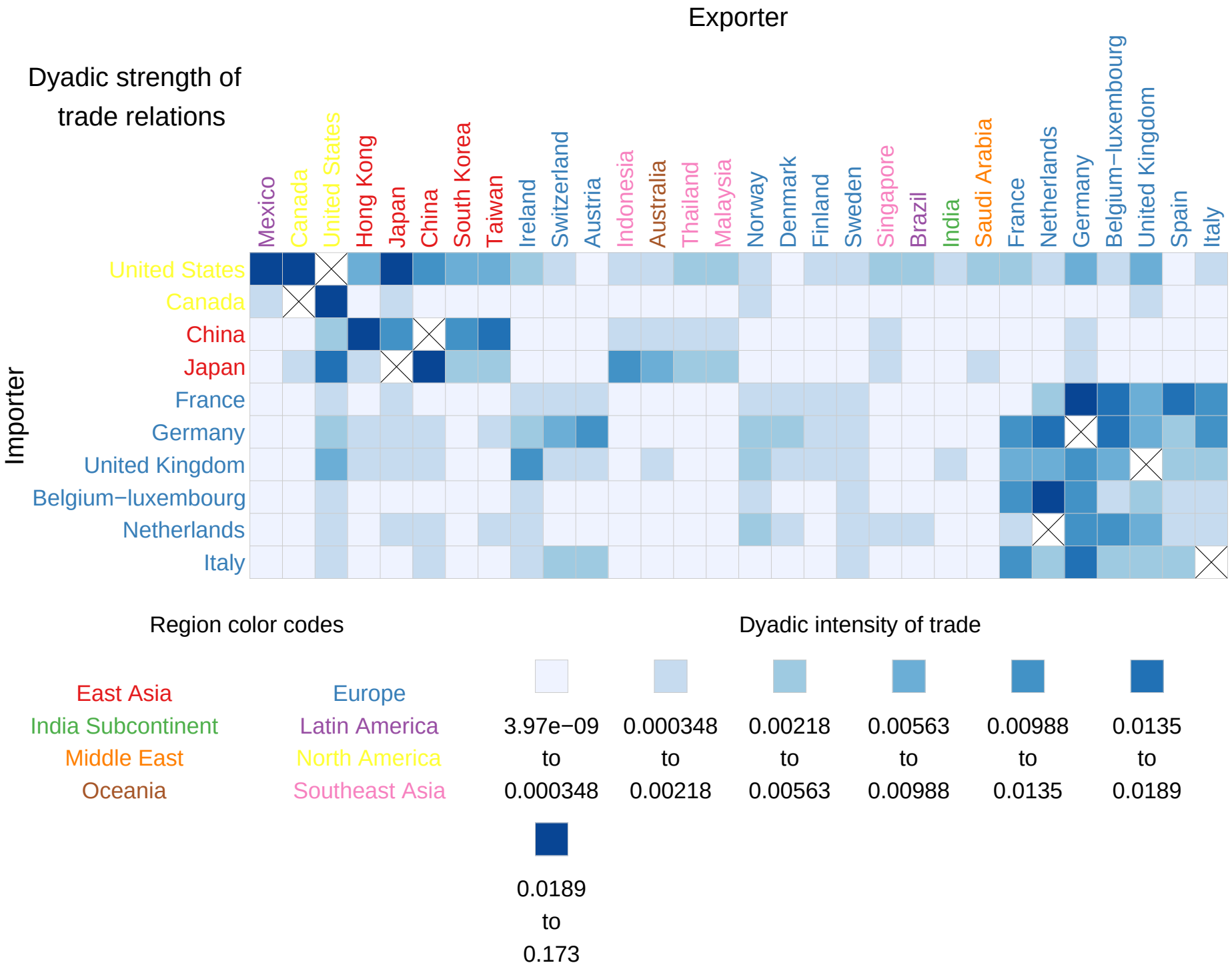
How do we turn those data into color (selecting bins)?

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


Dyadic strength of trade relations
Exporter
Importer
Mexico
Canada
United States
Hong Kong
Japan
China
South Korea
Taiwan
Ireland
Switzerland
Austria
Indonesia
Australia
Thailand
Malaysia
Norway
Denmark
Finland
Sweden
Singapore
Brazil
India
Saudi Arabia
France
Netherlands
Germany
Belgium−luxembourg
United Kingdom
Spain
Italy
United States
Canada
China
Japan
France
Germany
United Kingdom
Belgium−luxembourg
Netherlands
Italy
Region color codes
East Asia
India Subcontinent
Middle East
Oceania
Europe
Latin America
North America
Southeast Asia
Dyadic intensity of trade
3.97e−09 to 0.000348
0.000348 to 0.00218
0.00218 to 0.00563
0.00563 to 0.00988
0.00988 to 0.0135
0.0135 to 0.0189
0.0189 to 0.173

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

   $\rightarrow$ 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

$$\text{Global Intensity of Trade}_{i \to j} = \text{Imports}_{i \to j} / \text{Imports}_{\bullet \to \bullet}$$

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"

$$\begin{aligned}\text{Dyadic Intensity of Trade}_{i \to j} &= \left(\text{Imports}_{i \to j} / \text{Imports}_{\bullet \to j}\right) \\ &\quad \times \left(\text{Imports}_{i \to j} / \text{Imports}_{i \to \bullet}\right)\end{aligned}$$

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

An example

World Trade "= $1000 million"	Amount of Trade	Global Intensity of Trade	Sender's Total Exports	Receiver's Total Imports	Dyadic Intensity of Trade
Mexico → US	$100 m	0.1			
Sweden → Finland	$1 m	0.001			
China → Italy	$1 m	0.001			

An example

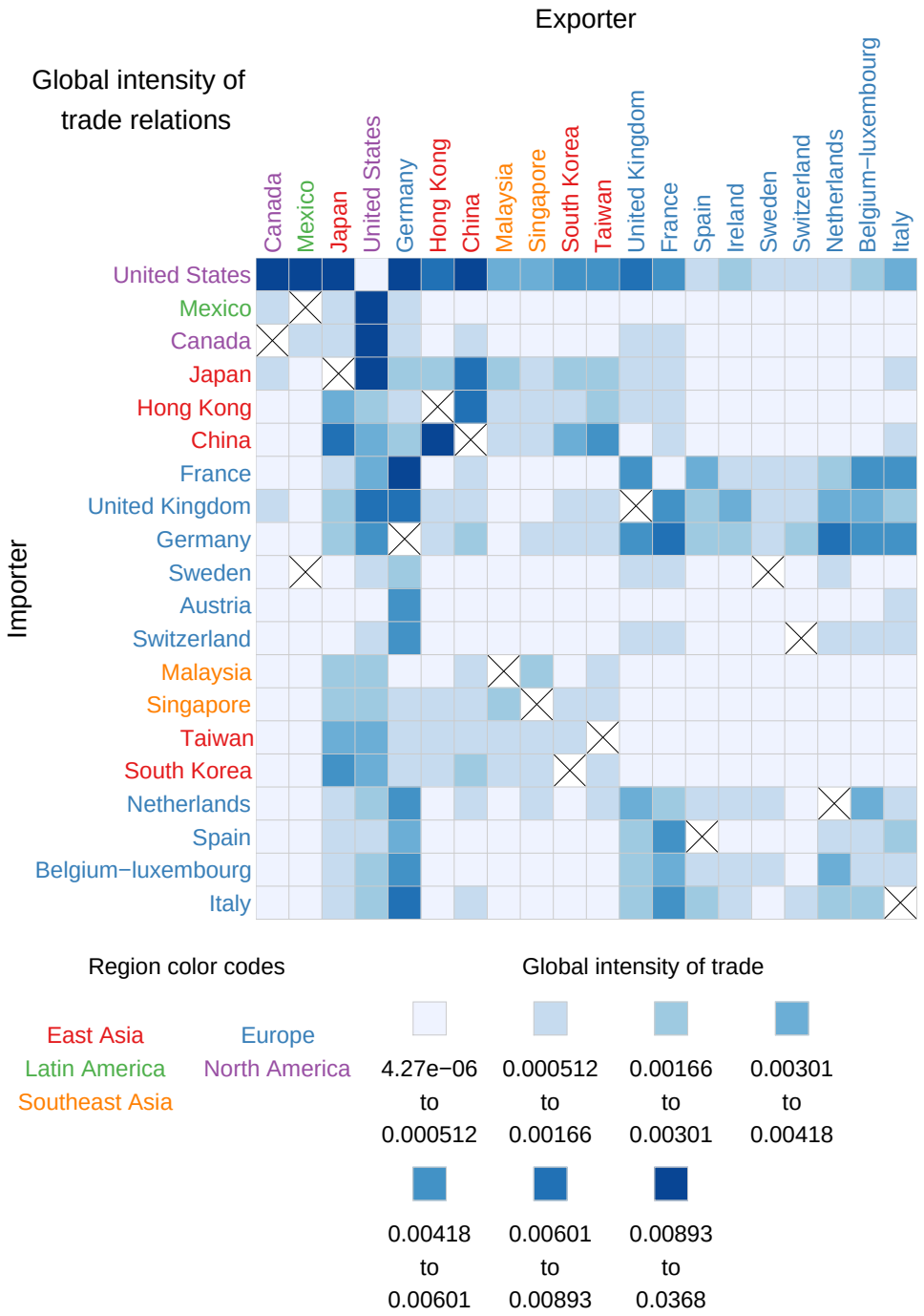
World Trade "= $1000 million"	Amount of Trade	Global Intensity of Trade	Sender's Total Exports	Receiver's Total Imports	Dyadic Intensity of Trade
Mexico → US	$100 m	0.1	$110 m	$200 m	0.455
Sweden → Finland	$1 m	0.001			
China → Italy	$1 m	0.001			

An example

World Trade "= $1000 million"	Amount of Trade	Global Intensity of Trade	Sender's Total Exports	Receiver's Total Imports	Dyadic Intensity of Trade
Mexico → US	$100 m	0.1	$110 m	$200 m	0.455
Sweden → Finland	$1 m	0.001	$2 m	$1.5 m	0.333
China → Italy	$1 m	0.001			

An example

World Trade "= $1000 million"	Amount of Trade	Global Intensity of Trade	Sender's Total Exports	Receiver's Total Imports	Dyadic Intensity of Trade
Mexico → US	$100 m	0.1	$110 m	$200 m	0.455
Sweden → Finland	$1 m	0.001	$2 m	$1.5 m	0.333
China → Italy	$1 m	0.001	$100 m	$10 m	0.001


Exporter
Global intensity of trade relations
Canada
Mexico
Japan
United States
Germany
Hong Kong
China
Malaysia
Singapore
South Korea
Taiwan
United Kingdom
France
Spain
Ireland
Sweden
Switzerland
Netherlands
Belgium−luxembourg
Italy
Importer
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
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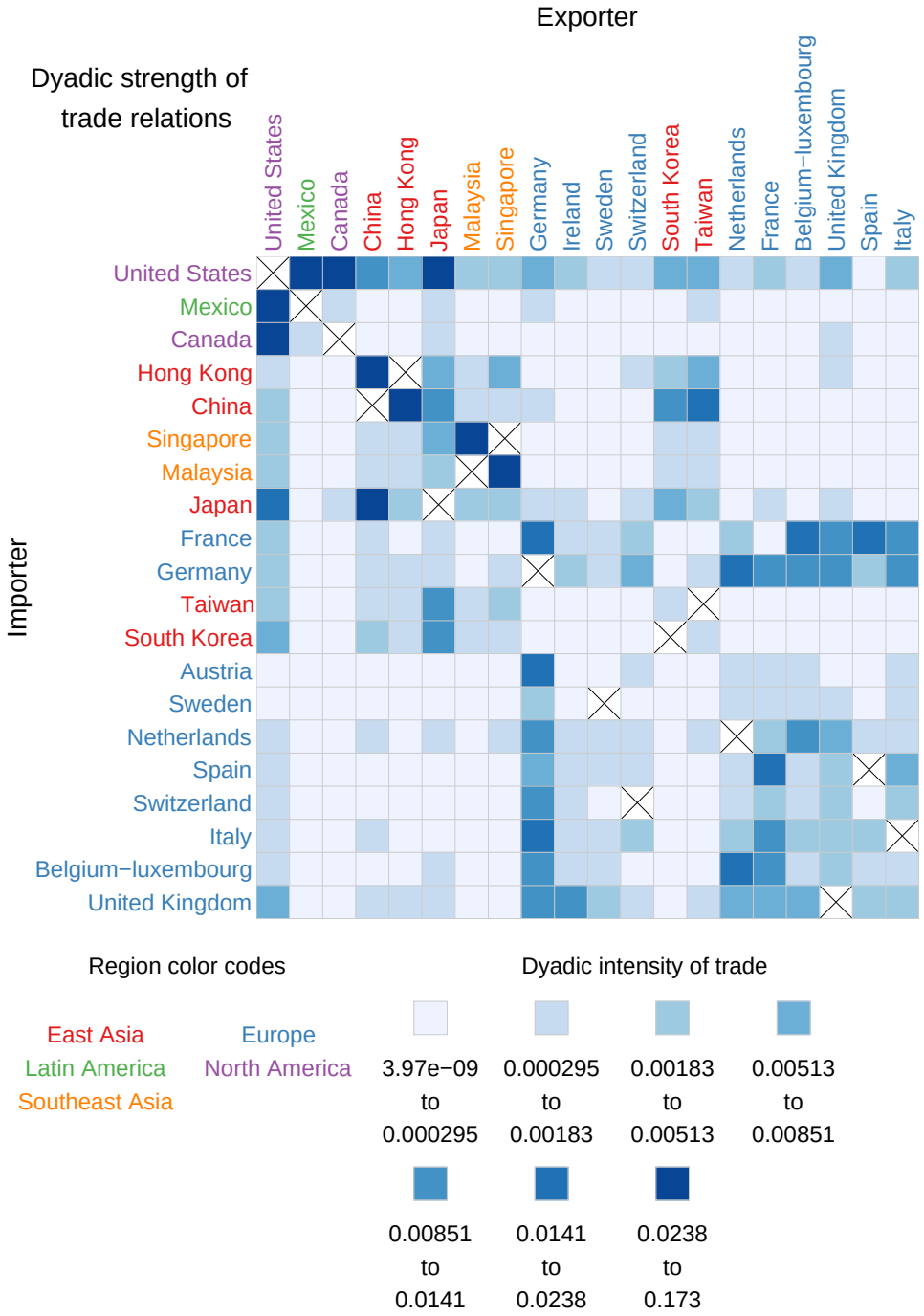
Europe
Latin America
North America
Southeast Asia
Global intensity of trade
4.27e−06 to 0.000512
0.000512 to 0.00166
0.00166 to 0.00301
0.00301 to 0.00418
0.00418 to 0.00601
0.00601 to 0.00893
0.00893 to 0.0368


Exporter
Dyadic strength of trade relations
United States
Mexico
Canada
China
Hong Kong
Japan
Malaysia
Singapore
Germany
Ireland
Sweden
Switzerland
South Korea
Taiwan
Netherlands
France
Belgium−luxembourg
United Kingdom
Spain
Italy
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
Region color codes
East Asia
Europe
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

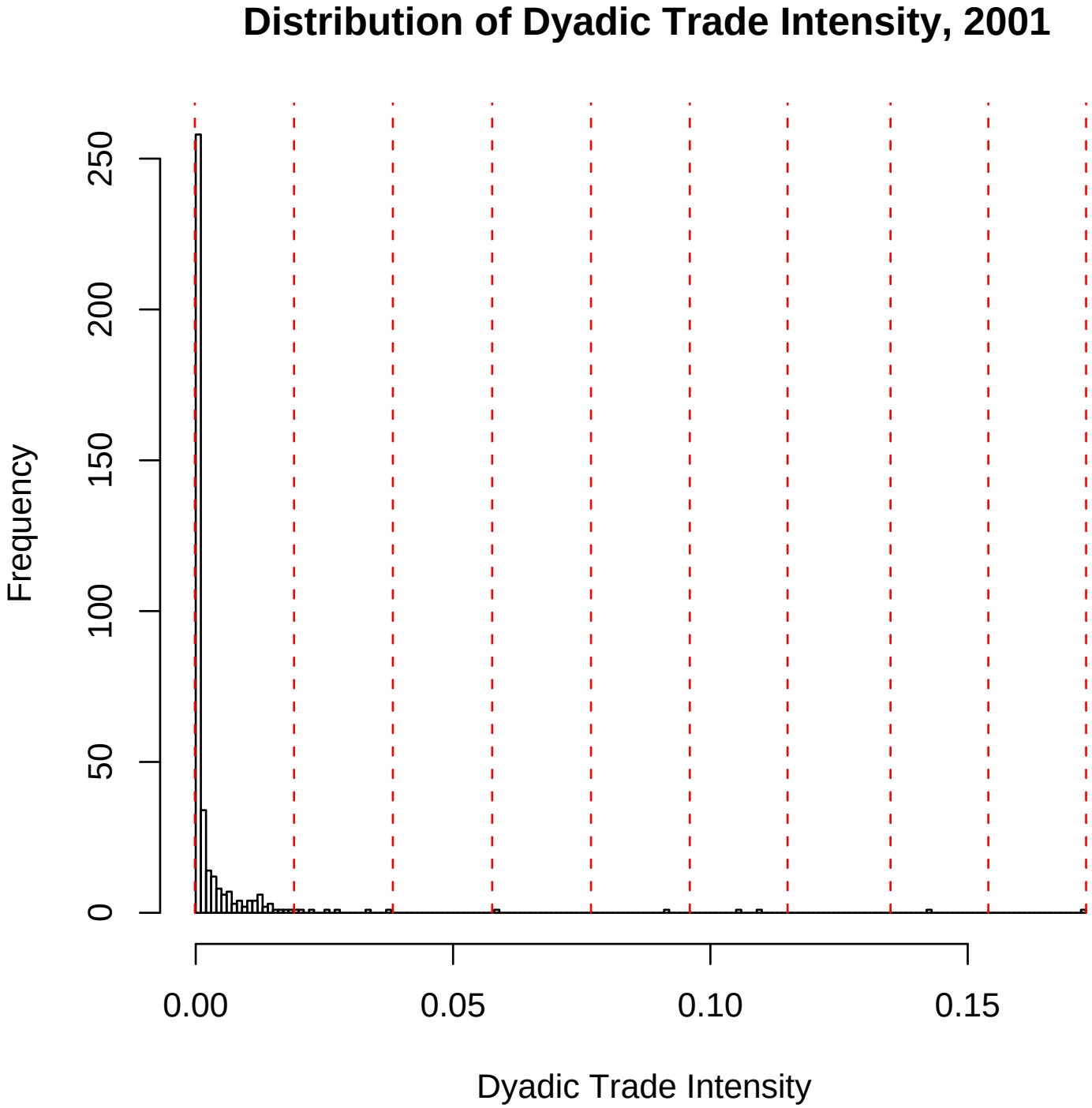
How do we turn those data into colors?

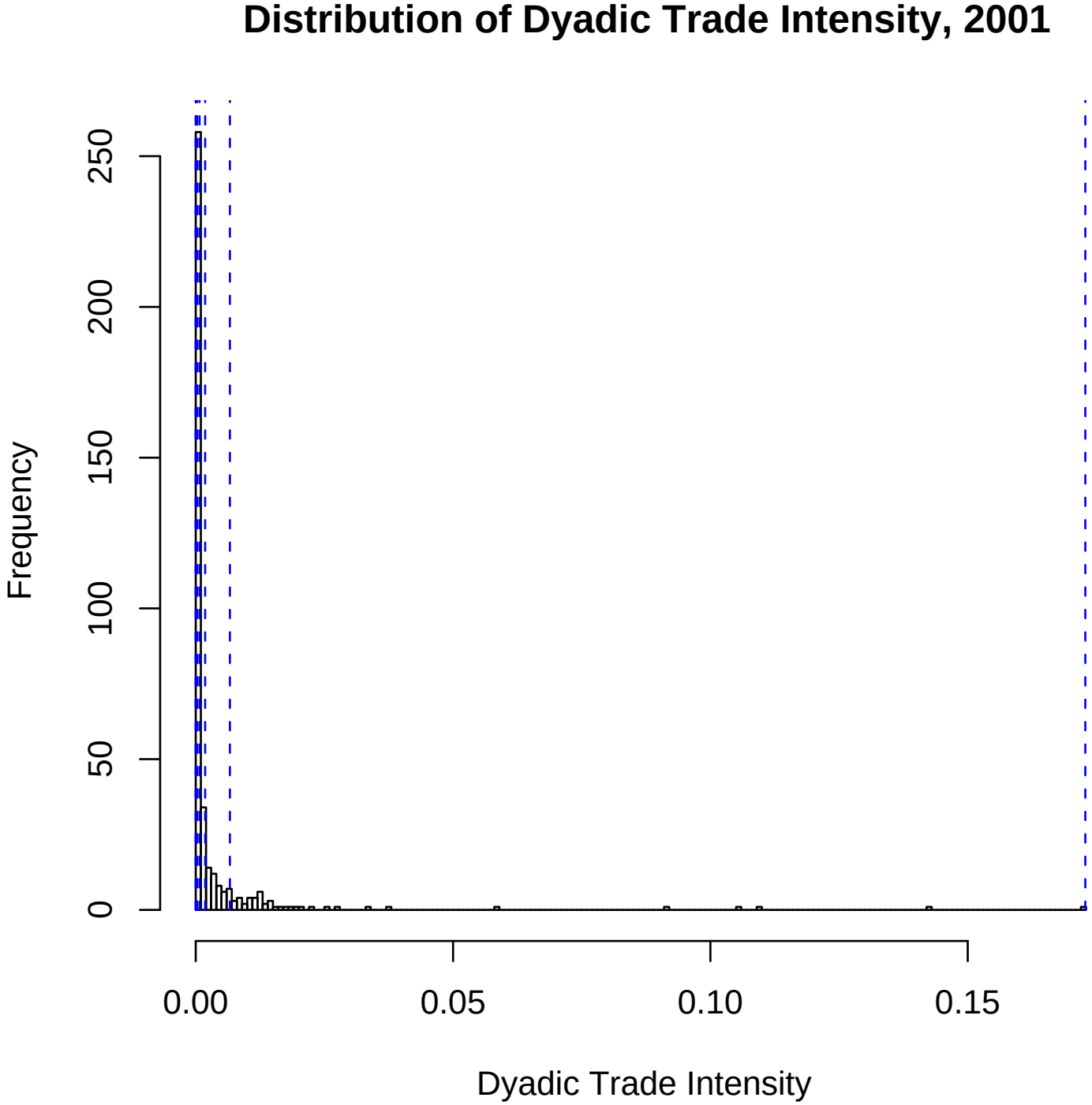
We have our transformed trade data by dyad.

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
Frequency
0
50
100
150
200
250
0.00
0.05
0.10
0.15
Dyadic Trade Intensity


Distribution of Dyadic Trade Intensity, 2001
Frequency
0
50
100
150
200
250
0.00
0.05
0.10
0.15
Dyadic Trade Intensity

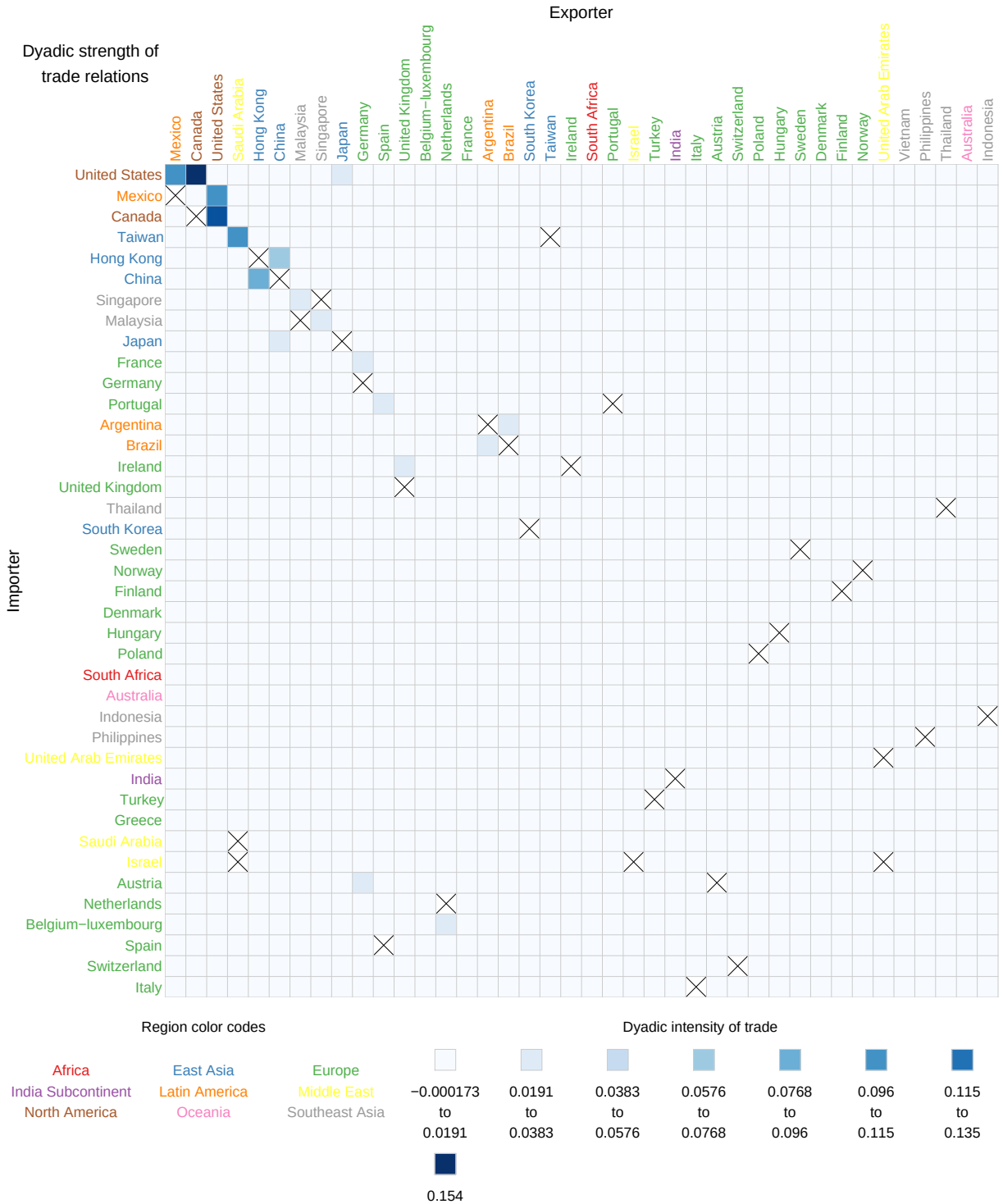
How do we turn those data into colors?

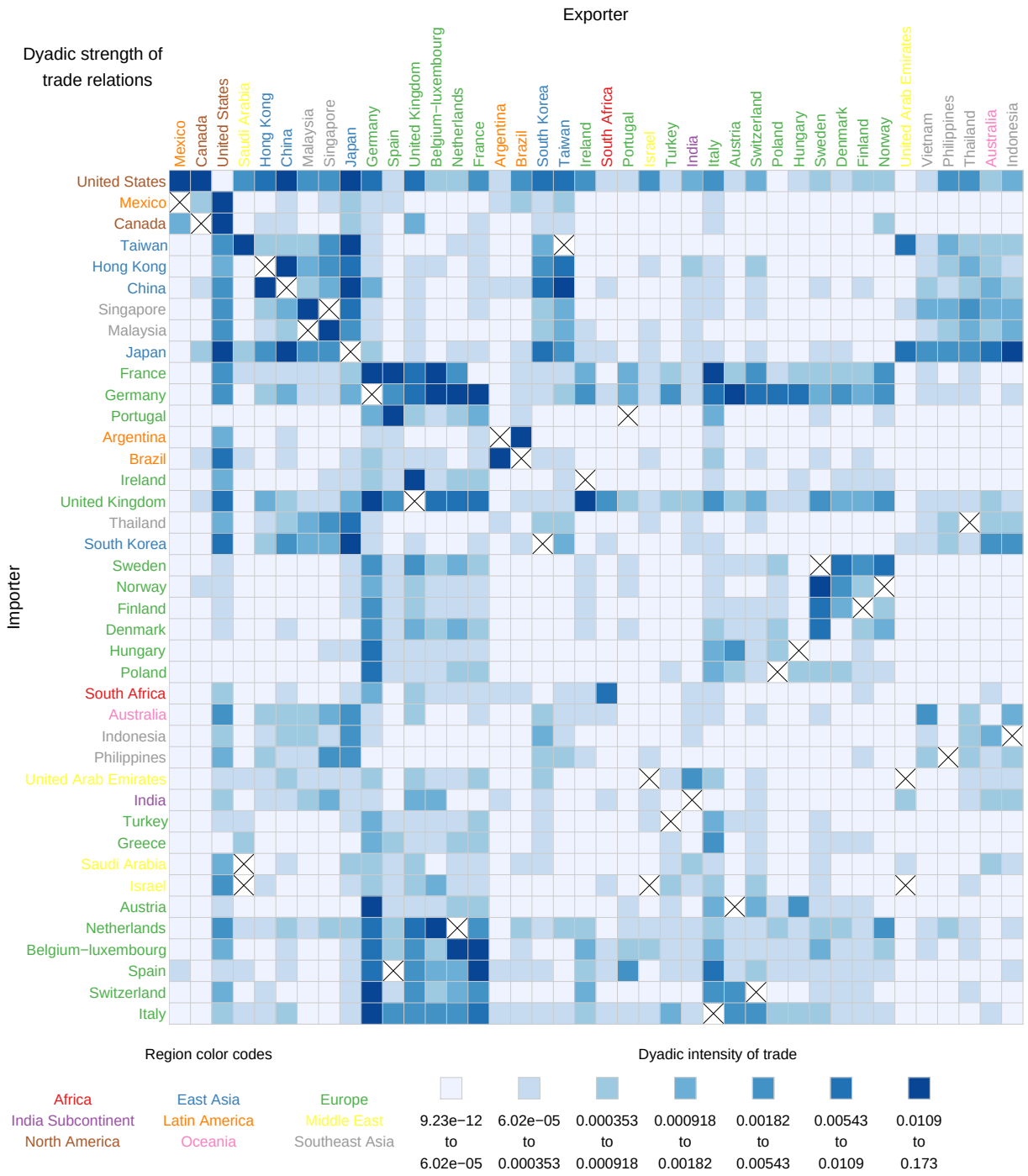
Choosing equally spaced bins will thus submerge most of the variation, and highlight the small handful of strong relationships

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. . .


Exporter
Dyadic strength of trade relations
Mexico
Canada
United States
Saudi Arabia
Hong Kong
China
Malaysia
Singapore
Japan
Germany
Spain
United Kingdom
Belgium−luxembourg
Netherlands
France
Argentina
Brazil
South Korea
Taiwan
Ireland
South Africa
Portugal
Israel
Turkey
India
Italy
Austria
Switzerland
Poland
Hungary
Sweden
Denmark
Finland
Norway
United Arab Emirates
Vietnam
Philippines
Thailand
Australia
Indonesia
Importer
United States
Mexico
Canada
Taiwan
Hong Kong
China
Singapore
Malaysia
Japan
France
Germany
Portugal
Argentina
Brazil
Ireland
United Kingdom
Thailand
South Korea
Sweden
Norway
Finland
Denmark
Hungary
Poland
South Africa
Australia
Indonesia
Philippines
United Arab Emirates
India
Turkey
Greece
Saudi Arabia
Israel
Austria
Netherlands
Belgium−luxembourg
Spain
Switzerland
Italy
Region color codes
Africa
East Asia
Europe
India Subcontinent
Latin America
Middle East
North America
Oceania
Southeast Asia
Dyadic intensity of trade
−0.000173 to 0.0191
0.0191 to 0.0383
0.0383 to 0.0576
0.0576 to 0.0768
0.0768 to 0.096
0.096 to 0.115
0.115 to 0.135
0.154


Exporter
Dyadic strength of trade relations
Importer
Mexico
Canada
United States
Saudi Arabia
Hong Kong
China
Malaysia
Singapore
Japan
Germany
Spain
United Kingdom
Belgium−luxembourg
Netherlands
France
Argentina
Brazil
South Korea
Taiwan
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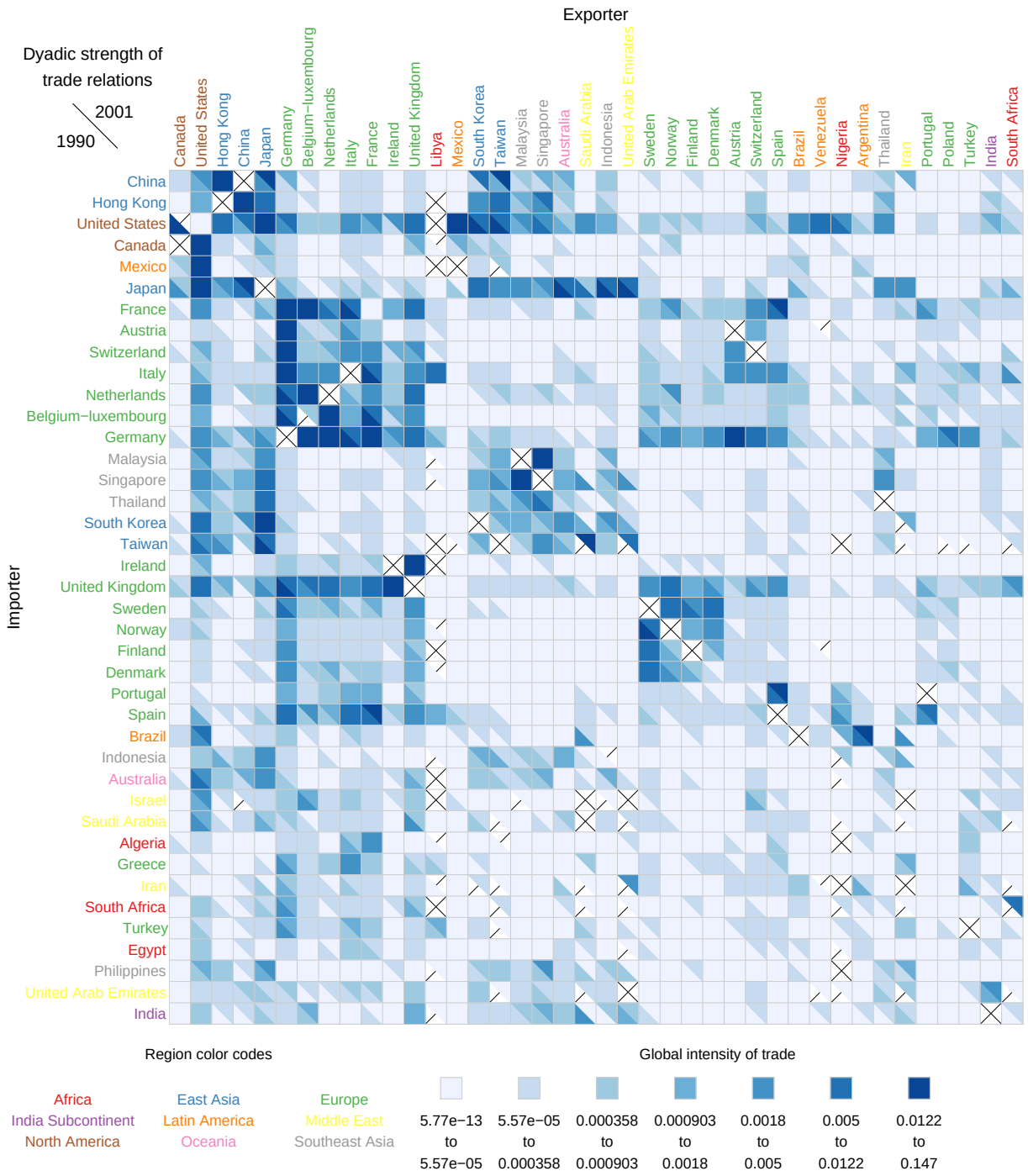
South Africa
Portugal
Israel
Turkey
India
Italy
Austria
Switzerland
Poland
Hungary
Sweden
Denmark
Finland
Norway
United Arab Emirates
Vietnam
Philippines
Thailand
Australia
Indonesia
Region color codes
Africa
East Asia
Europe
India Subcontinent
Latin America
Middle East
North America
Oceania
Southeast Asia
Dyadic intensity of trade
9.23e−12 to 6.02e−05
6.02e−05 to 0.000353
0.000353 to 0.000918
0.000918 to 0.00182
0.00182 to 0.00543
0.00543 to 0.0109
0.0109 to 0.173

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


Exporter
Dyadic strength of trade relations
2001
1990
Canada
United States
Hong Kong
China
Japan
Germany
Belgium−luxembourg
Netherlands
Italy
France
Ireland
United Kingdom
Libya
Mexico
South Korea
Taiwan
Malaysia
Singapore
Australia
Saudi Arabia
Indonesia
United Arab Emirates
Sweden
Norway
Finland
Denmark
Austria
Switzerland
Spain
Brazil
Venezuela
Nigeria
Argentina
Thailand
Iran
Portugal
Poland
Turkey
India
South Africa
Importer
China
Hong Kong
United States
Canada
Mexico
Japan
France
Austria
Switzerland
Italy
Netherlands
Belgium−luxembourg
Germany
Malaysia
Singapore
Thailand
South Korea
Taiwan
Ireland
United Kingdom
Sweden
Norway
Finland
Denmark
Portugal
Spain
Brazil
Indonesia
Australia
Israel
Saudi Arabia
Algeria
Greece
Iran
South Africa
Turkey
Egypt
Philippines
United Arab Emirates
India
Region color codes
Africa
East Asia
Europe
India Subcontinent
Latin America
Middle East
North America
Oceania
Southeast Asia
Global intensity of trade
5.77e−13 to 5.57e−05
5.57e−05 to 0.000358
0.000358 to 0.000903
0.000903 to 0.0018
0.0018 to 0.005
0.005 to 0.0122
0.0122 to 0.147