# Indonesia's Economy Through the eyes of Economic Complexity

**César A. Hidalgo**
Full Professor, Toulouse School of Economics,
Director, Center for Collective Learning,
CIAS Corvinus University of Budapest &
IAST Toulouse School of Economics

**centerforcollectivelearning.org**

# Thomas Thwaites

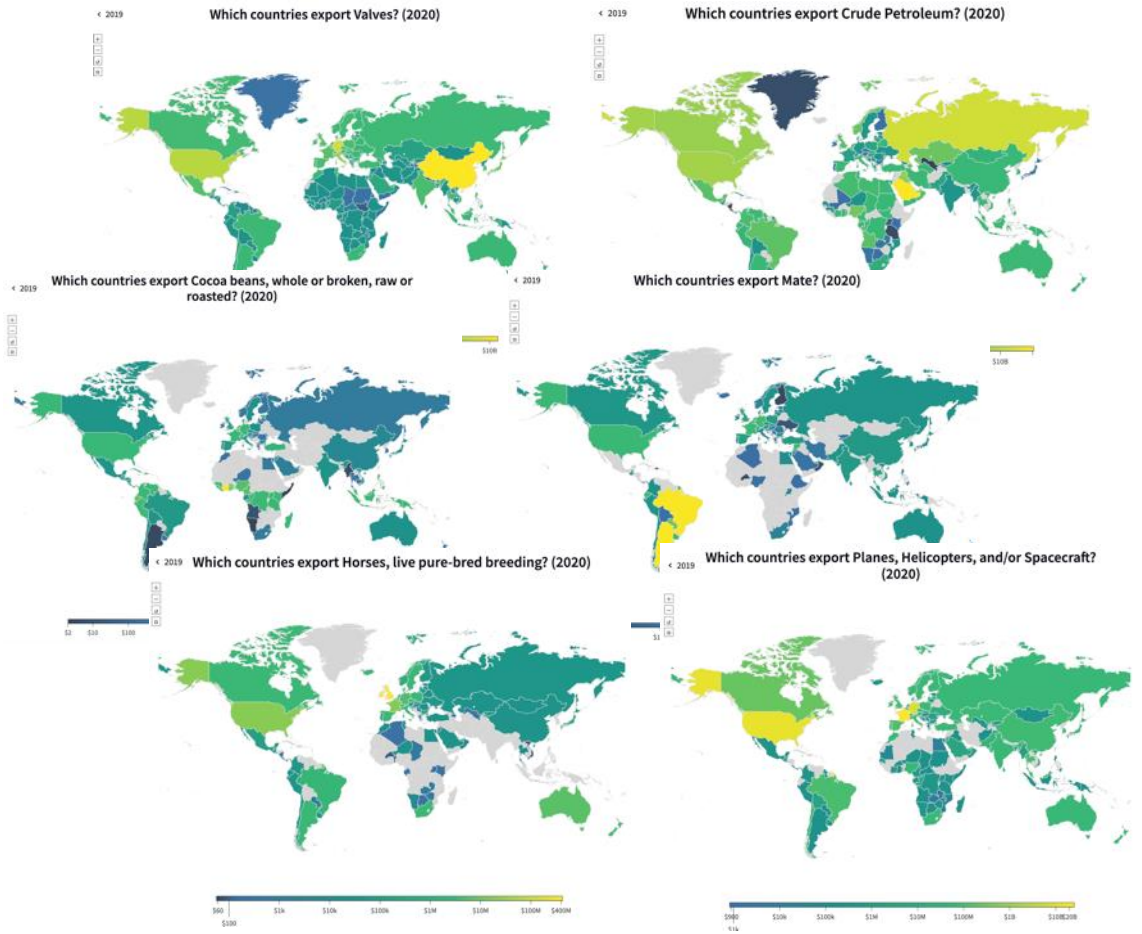
The world works not because a few people know a lot, but because many people know a little.

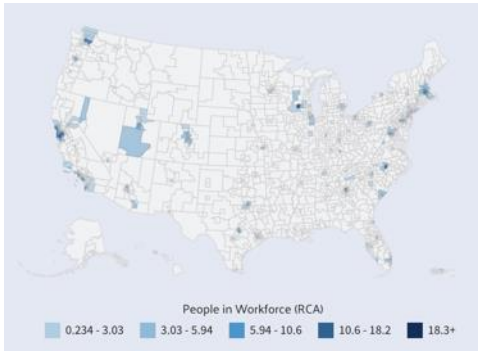
**Economic complexity** is about understanding how that knowledge comes together.

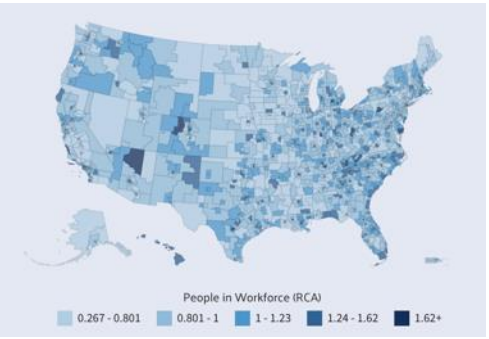
# Economic complexity

machine learning
+
economic data
=
development outcomes

Starting in 2006-2007

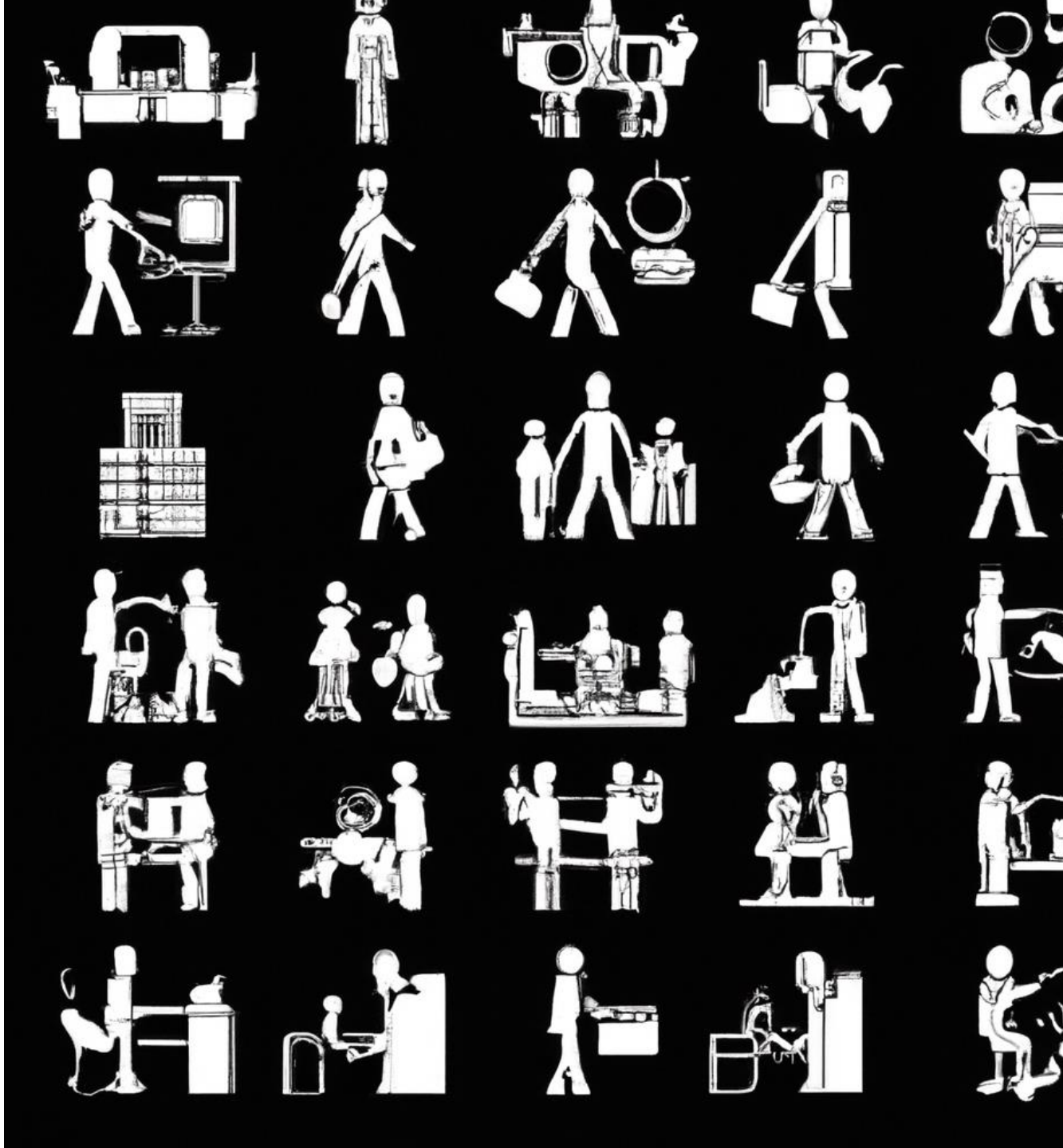


# Why Machine Learning?

Because factors of production, and in particular **knowledge**, are **non-interchangeable** or **non-fungible.**

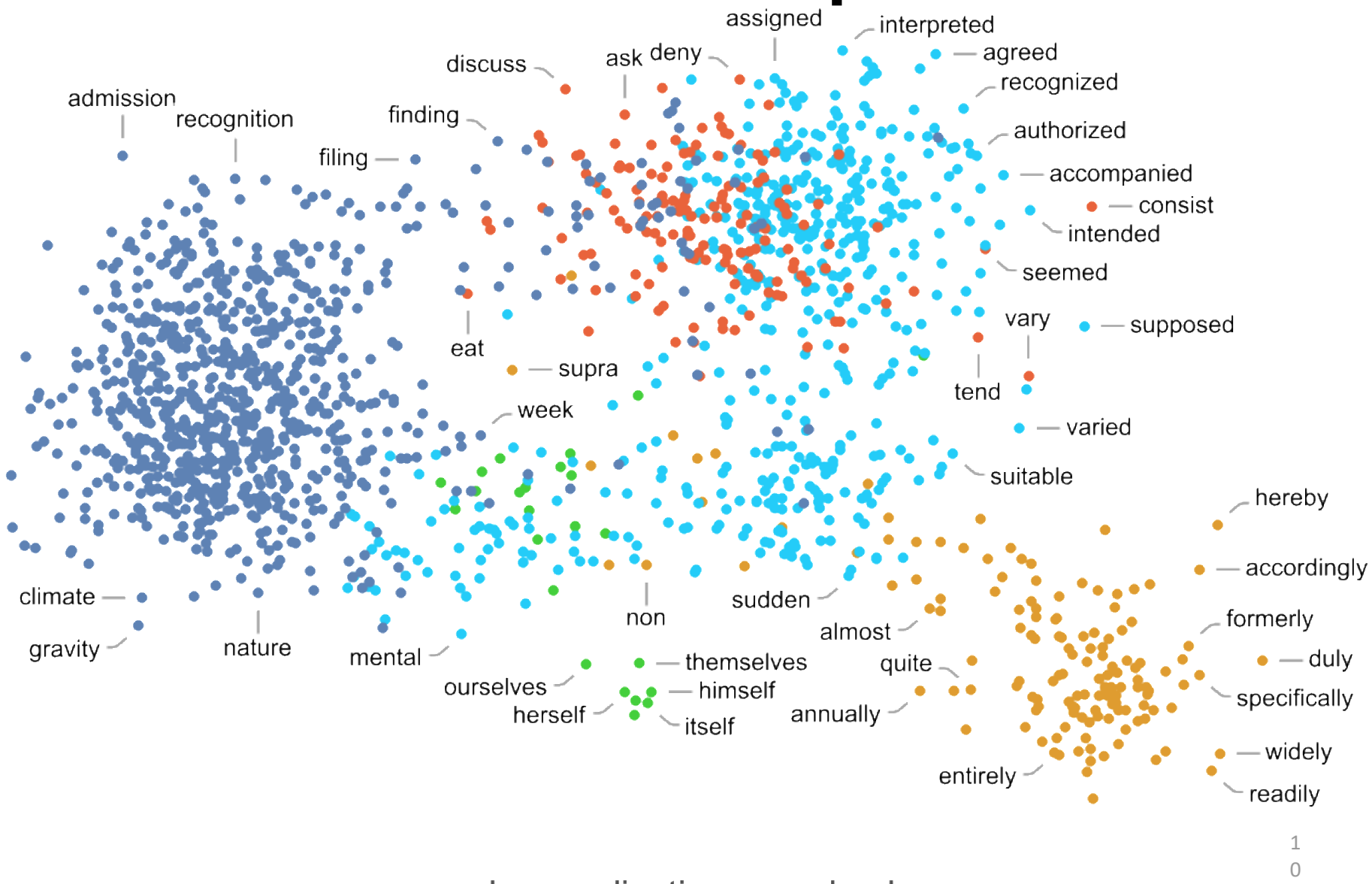


# Parts-of-speech representation of words do not honor their non-fungibility

## Verb, Nouns, Adjectives, and Adverbs List

| Verbs | Nouns | Adjectives | Adverbs |
|---|---|---|---|
| accuse | accusation | accusing | accusingly |
| argue | argument | arguable | arguably |
| characterize | character | characteristic | characteristically |
| condition | condition | conditional | conditionally |
| darken | dark, darkness | dark, darkened | darkly |
| destroy | destruction | destructive | destructively |
| drink | drink, drunkenness | drunk, drunken | drunkenly |

# Word Embeddings Provide Semantic Representations That Transcend Parts of Speech Limitations



# “Parts of Speech” Representation of Products or Activities

Manufacture

Capital Intensive

Agriculture

Capital Intensive

Agriculture

Labor Intensive

Manufacture

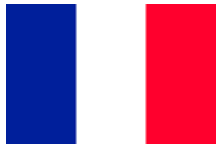
Labor Intensive

# AI or LLMs

Just like we can count the number of words in each sentence or paragraph, and their co-occurrences, to create representations of their semantic meaning, we can count the number of economic activities that are present across cities, regions, and countries to create representations of the knowledge embedded in them.

# Economic Complexity

Spark Ignition Engines, Tobacco, Engine Parts, Aircraft Parts, Vaccines, Plywood, Tractors, Coffee, Frozen Bovine Meat, etc…



Spark Ignition Engines, Engine Parts, Aircraft Parts, Aircraft, Wheat, Wine, Perfumes, Vaccines, etc…

Crude Petroleum, Refined Petroleum, Petroleum Gases, Wheat, Aircraft Parts, etc.

# But…
# Who cares about Economic Complexity?

# Economic Complexity is the First Mission of Malaysia's New Industrial Master Plan

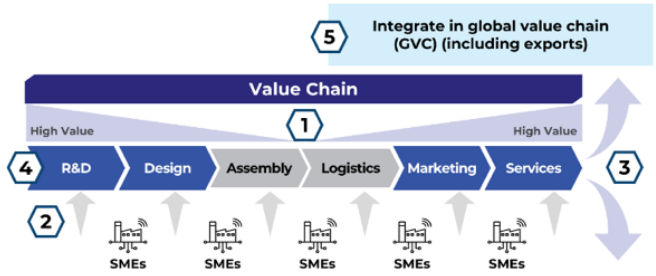
HOME NEW INDUSTRIAL MASTER PLAN MISSION ABOUT US EVENTS DOCUMENTS MEDIA FAQ

Home > Mission > Mission 1: Advance economic complexity

## Mission 1: Advance economic complexity

Mission 1 focuses on encouraging the industry to innovate and produce more sophisticated products to increase economic complexity

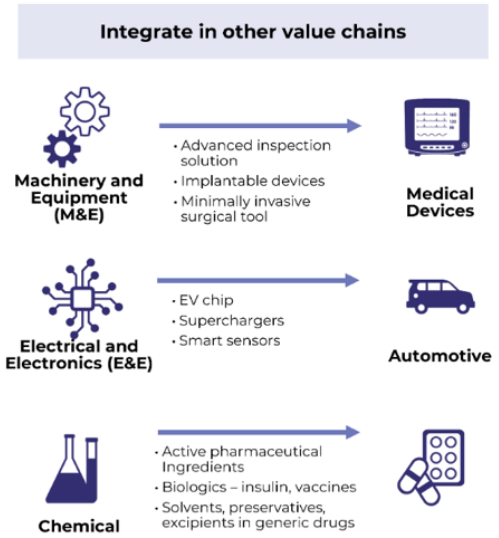
1. Expand to higher value-added activities
2. Develop ecosystem to support high value-added activities
3. Establish 'vertical integration' for GVC
4. Foster RDCI ecosystem
5. Increase manufacturing exports




Malaysia's strategic focus is on transitioning to higher value-added activities, moving beyond traditional manufacturing models towards an innovation-driven manufacturing hub.

This transformation involves fostering an ecosystem that encourages the growth of industries engaged in high-value economic activities, integrating value chains across sectors and promoting vertical integration among ASEAN countries.

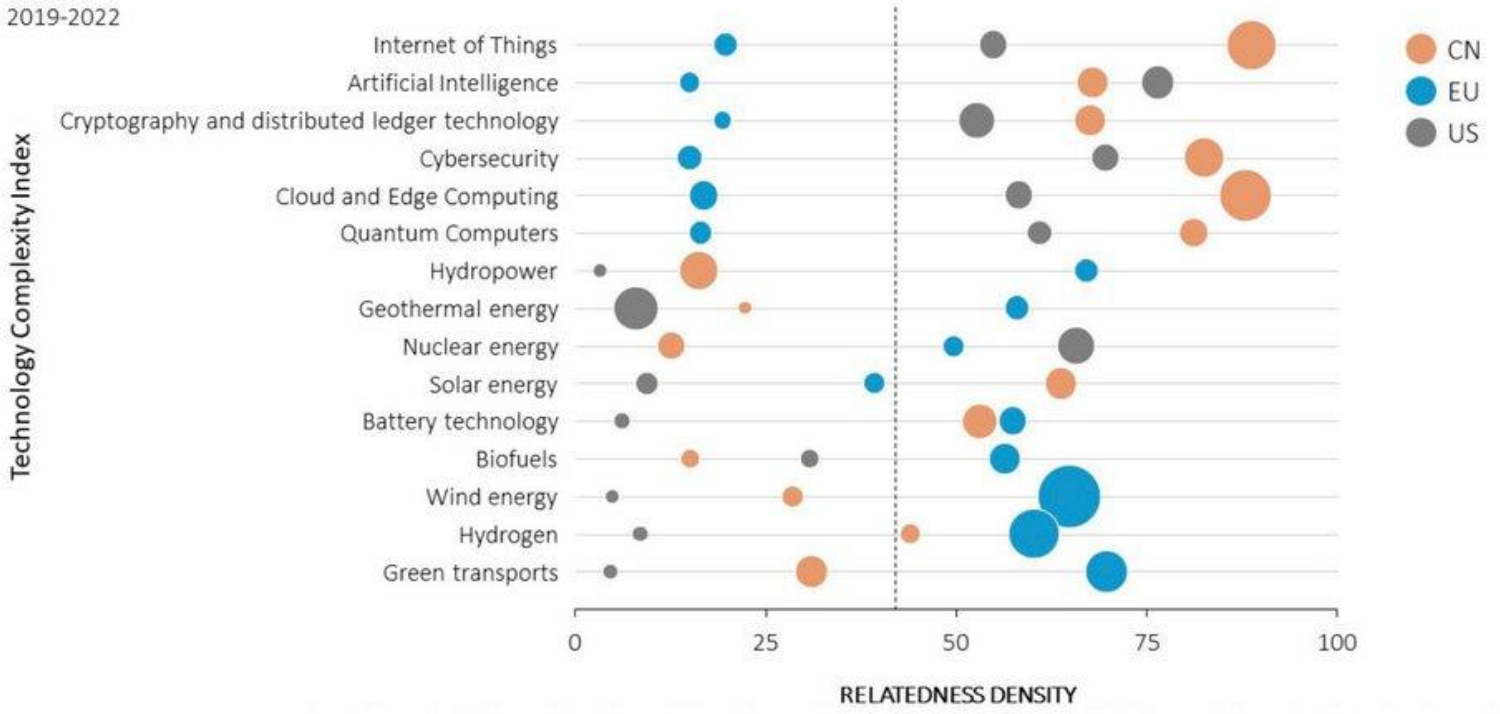
The Research, Development, Commercialisation, and Innovation (RDCI) cycle plays a pivotal role in enhancing economic complexity and cultivating high-skilled talent, facilitating the introduction of innovative products and services that drive job creation and economic expansion. Central to this approach is the goal of increasing manufacturing exports to bolster Malaysia's economic growth and global competitiveness




# Economic Complexity was used in the recent Draghi Report to the EU

FIGURE 2

**The EU's position in complex (digital and green) technologies**




*Notes: The results are based on an analysis of patent data to understand the complexity and potential for specialisation in different technology areas. On the y-axis, technologies are ranked according to how advanced or complex they are, with scores ranging between 0 (less complex) and 100 (more complex). The x-axis (showing the relatedness density) represents how easily a country can build comparative advantage in a particular technology, depending on how closely related it is to other technologies the country is already strong in. The size of the bubbles shows how much each country has already specialised in a technology, using a measure of "revealed comparative advantage"(RCA), which reflects their competitive strenght in that field.*

*Source: European Commission, DG RTD.*

The future of European Competitiveness. "Draghi Report" 2024

# Economic Complexity has motivated the creation of dozens of economic data observatories



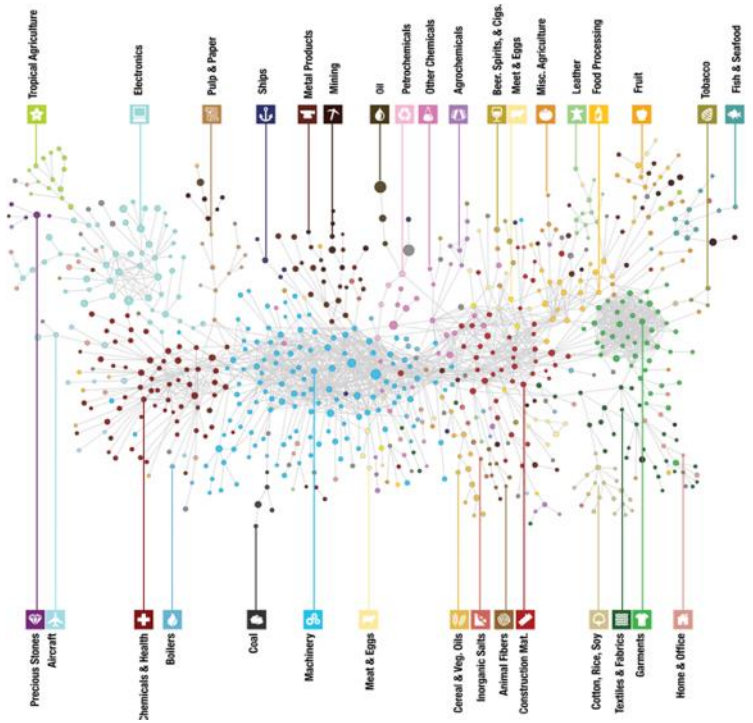






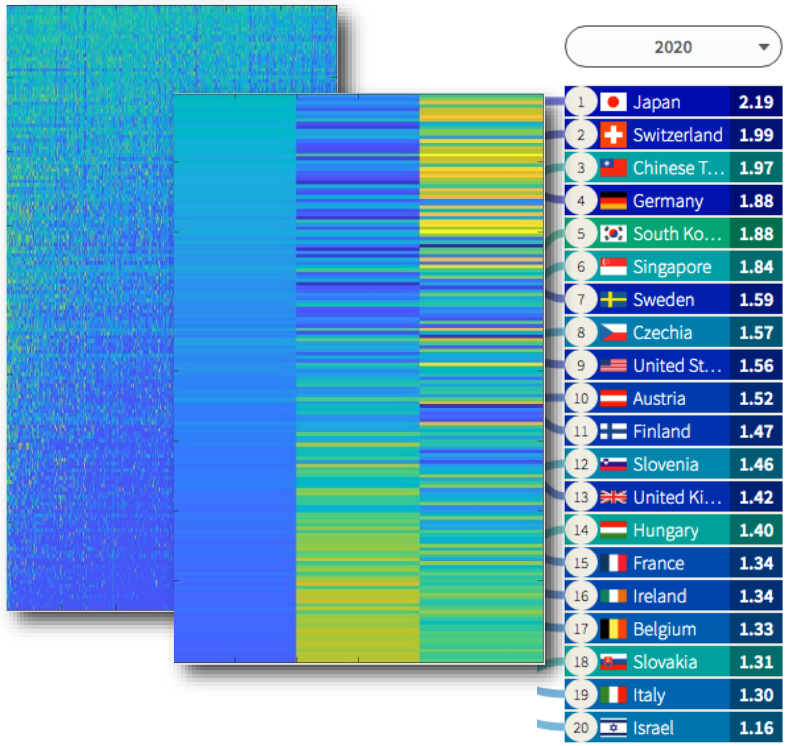

# Two Key Concepts

## Relatedness




**Hidalgo et al. Science (2007)**

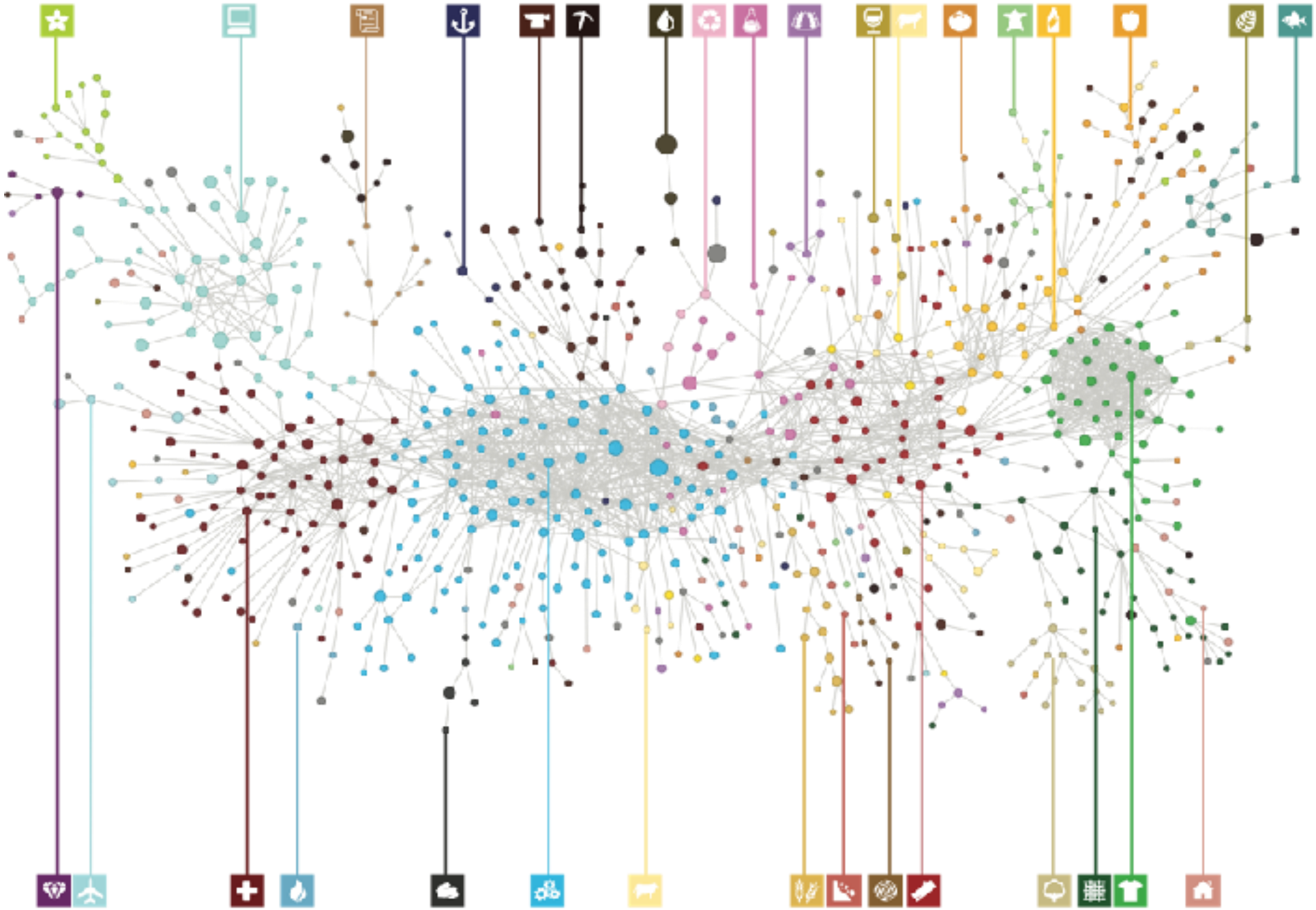
## Complexity Indexes




**Hidalgo & Hausmann. PNAS (2009)**

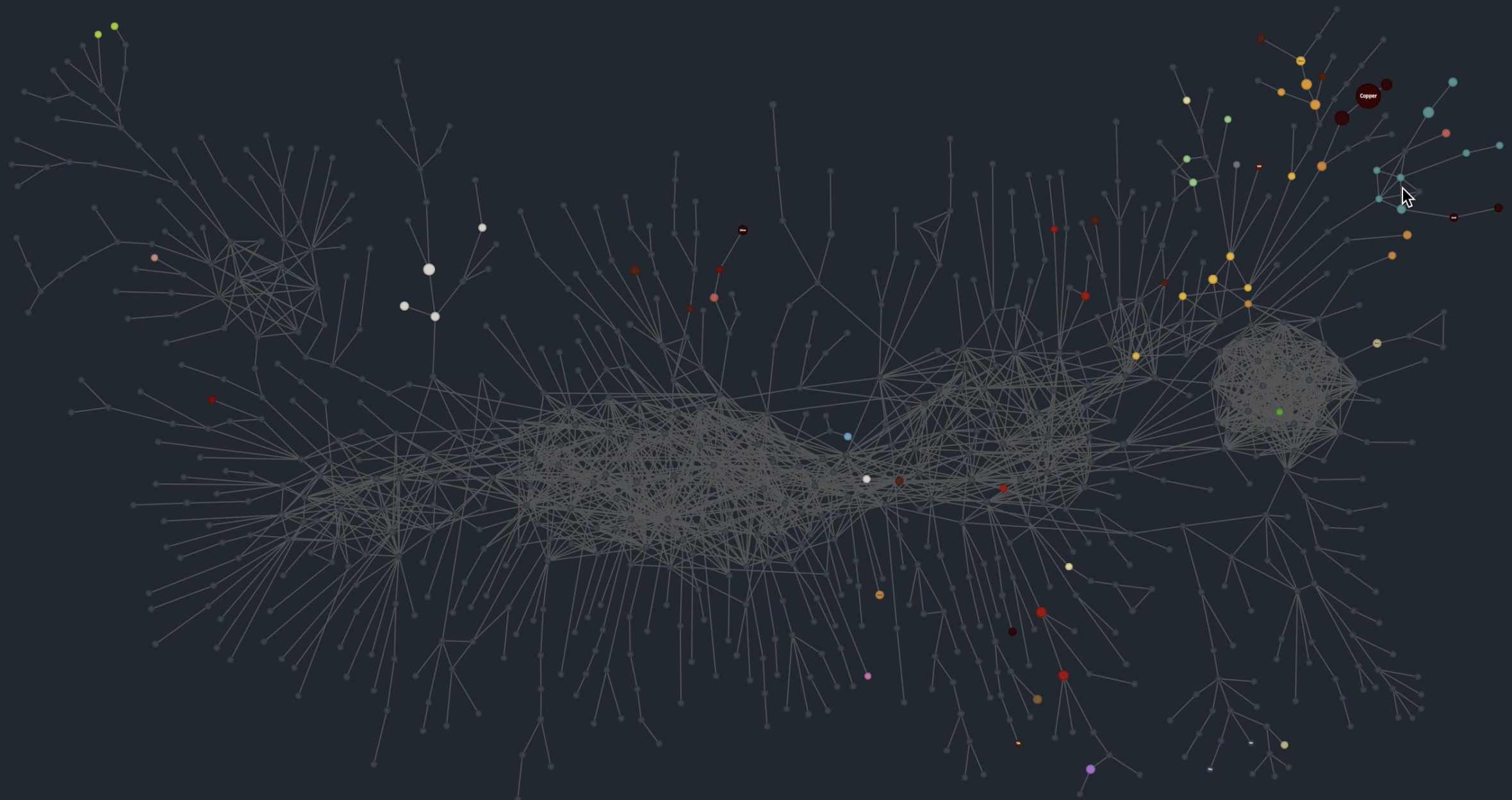

Vespa

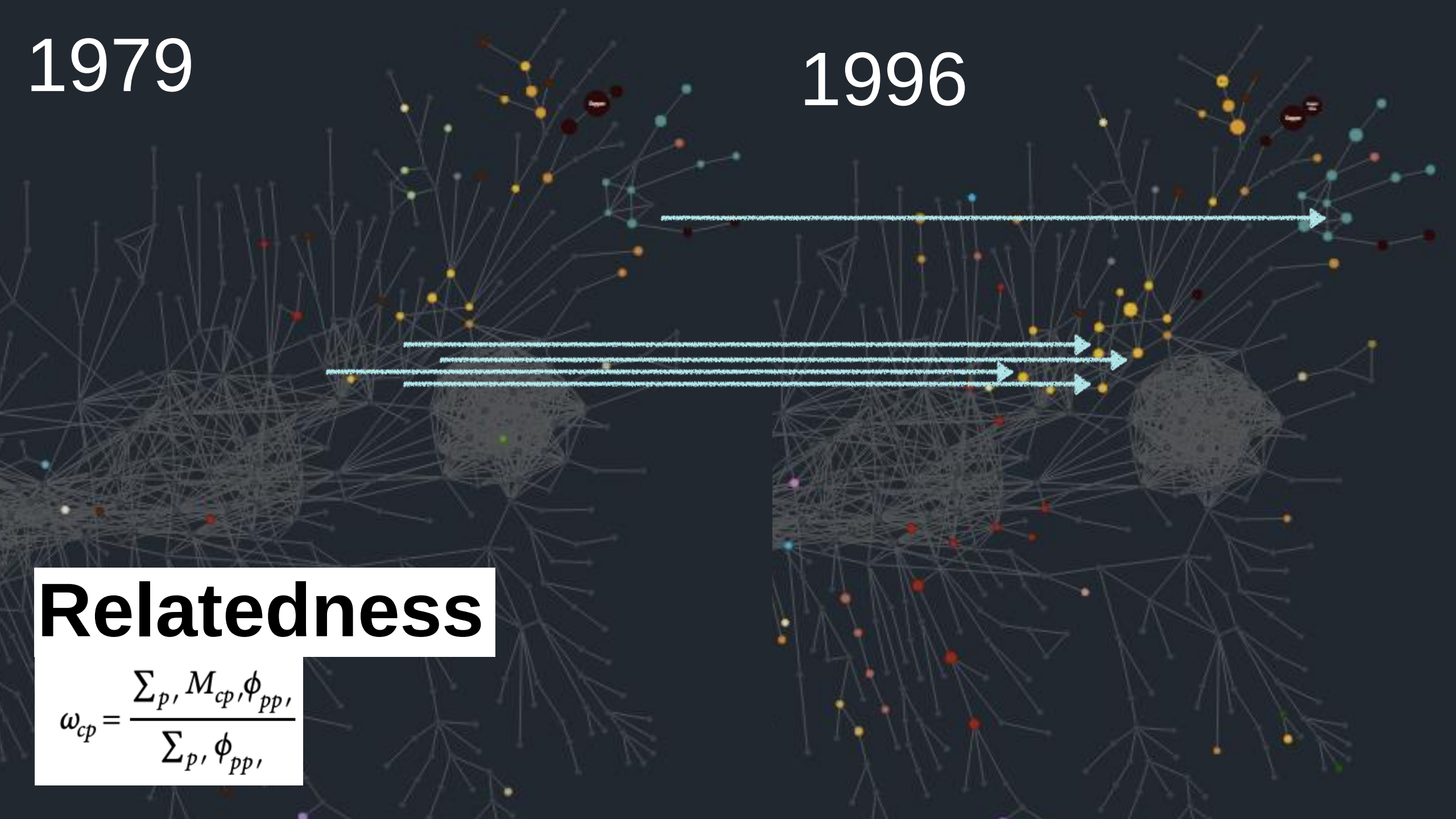
Corradino
D’Ascanio



# What are the export opportunities of Chile? (1979)

TOTAL: $3.67B




1979
1996
Relatedness
$\omega_{cp} = \frac{\sum_{p'} M_{cp'} \phi_{pp'}}{\sum_{p'} \phi_{pp'}}$

# THE PRINCIPLE OF RELATEDNESS

Products

Industries

Products

(Hidalgo et al 2007)

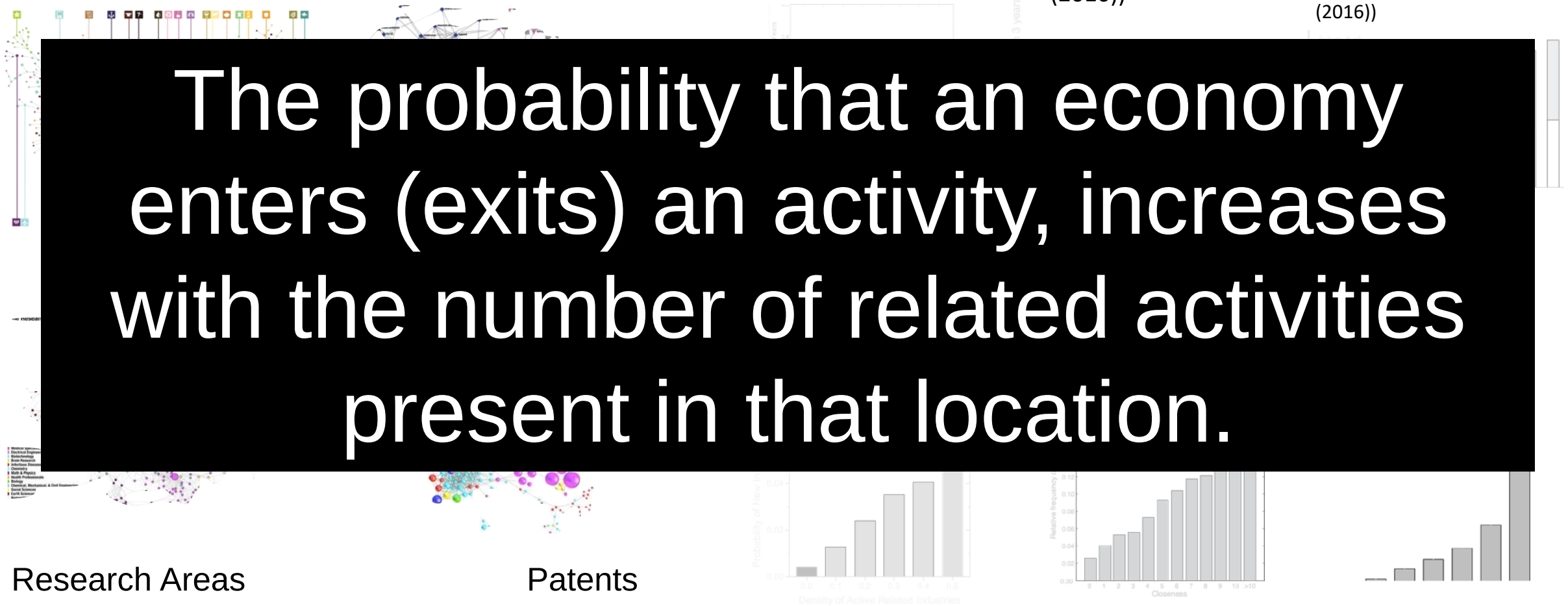
Research Areas

(Guevara et al. (2016))

Patents

(Kogler et al. (2013), Boschma et al. (2015), Alstott et al. (2016))

The probability that an economy enters (exits) an activity, increases with the number of related activities present in that location.



Research Areas

Patents

César A. Hidalgo, Pierre-Alexandre Balland, Ron Boschma, Mercedes Delgado, Maryann Feldman, Koen Frenken, Edward Glaeser, Dieter F. Kogler, Andrea Morrison, Frank Neffke, David Rigby, Scott Stern, Siqi Zheng, Canfei He, & Shengjun Zhu. “The Principle of Relatedness” CCS 2018. Springer Proceedings in Complexity. Springer (2018)


Let’s Look at Indonesia

## Yearly Trade

FLOW

Exports | Imports

COLOR

Trade Value | Growth | Growth (%)

DEPTH

HS2 | HS4 | HS6

YEAR

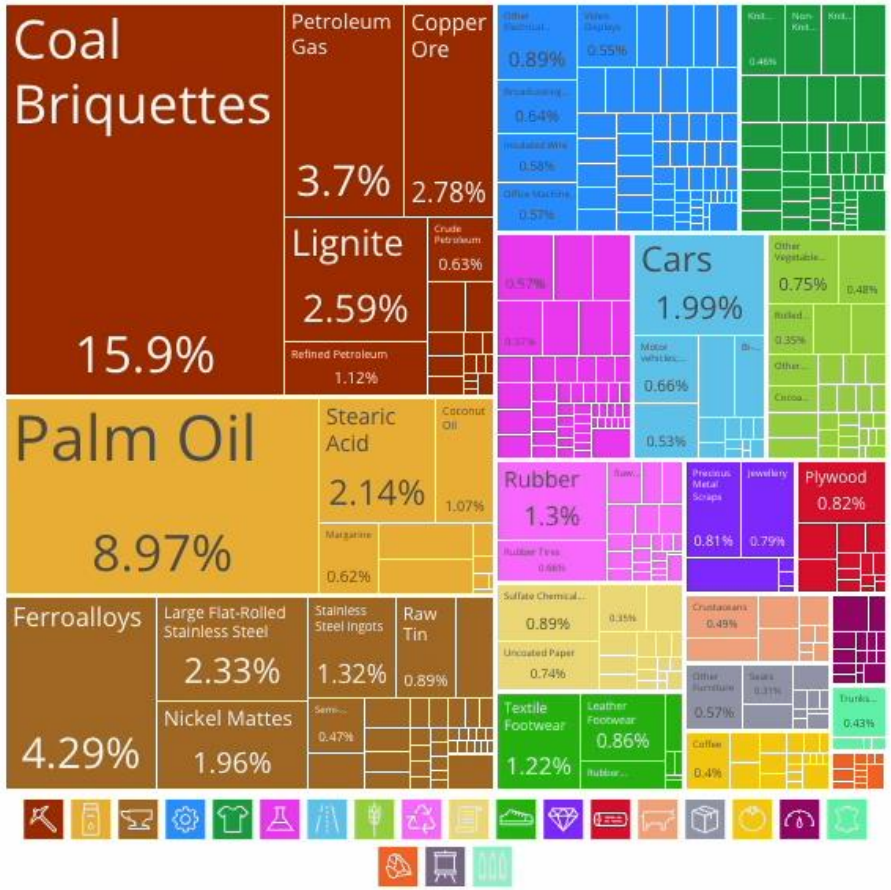
2022

Top Export (2022)
Coal Briquettes

Top Destination (2022)
China

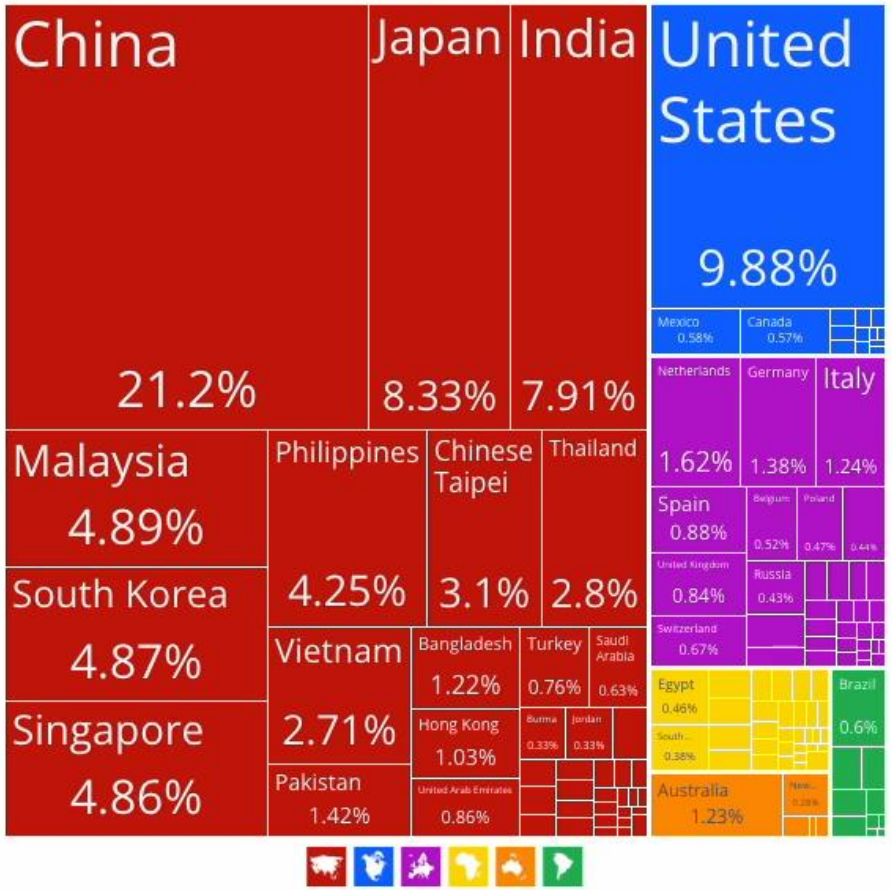
### Exports (2022)
[Click to Select a Product]

Total: $320B




### Destinations (2022)
[Click to Select a Country]

Total: $320B




http://oec.world

IDN

LATEST TRENDS | HISTORICAL DATA | POTENTIAL EXPORTS | SERVICE TRADE | ECONOMIC COMPLEXITY

## Product Space

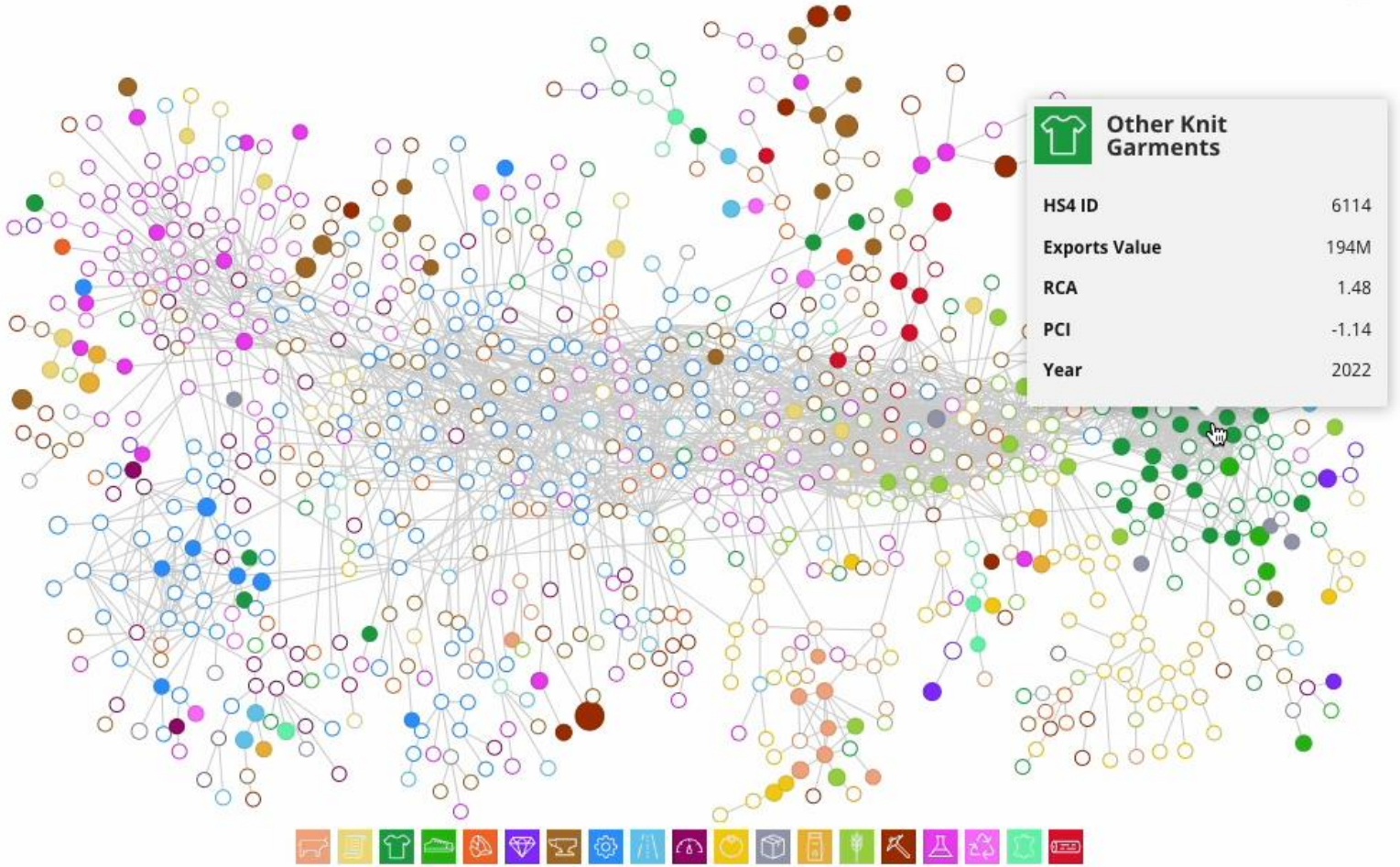
YEAR

2022

SPECIALIZATION

RCA > 1

The product space is a network connecting products that are likely to be co-exported. The product space can be used to predict future exports, since countries are more likely to start




http://oec.world

IDN

LATEST TRENDS | HISTORICAL DATA | POTENTIAL EXPORTS | SERVICE TRADE | ECONOMIC COMPLEXITY

# POTENTIAL EXPORTS

## Potential Exports

TYPE

Product | Country

SECTION

ALL PRODUCTS

FLOW

Exports | Imports

DEPTH

Section | HS2 | HS4

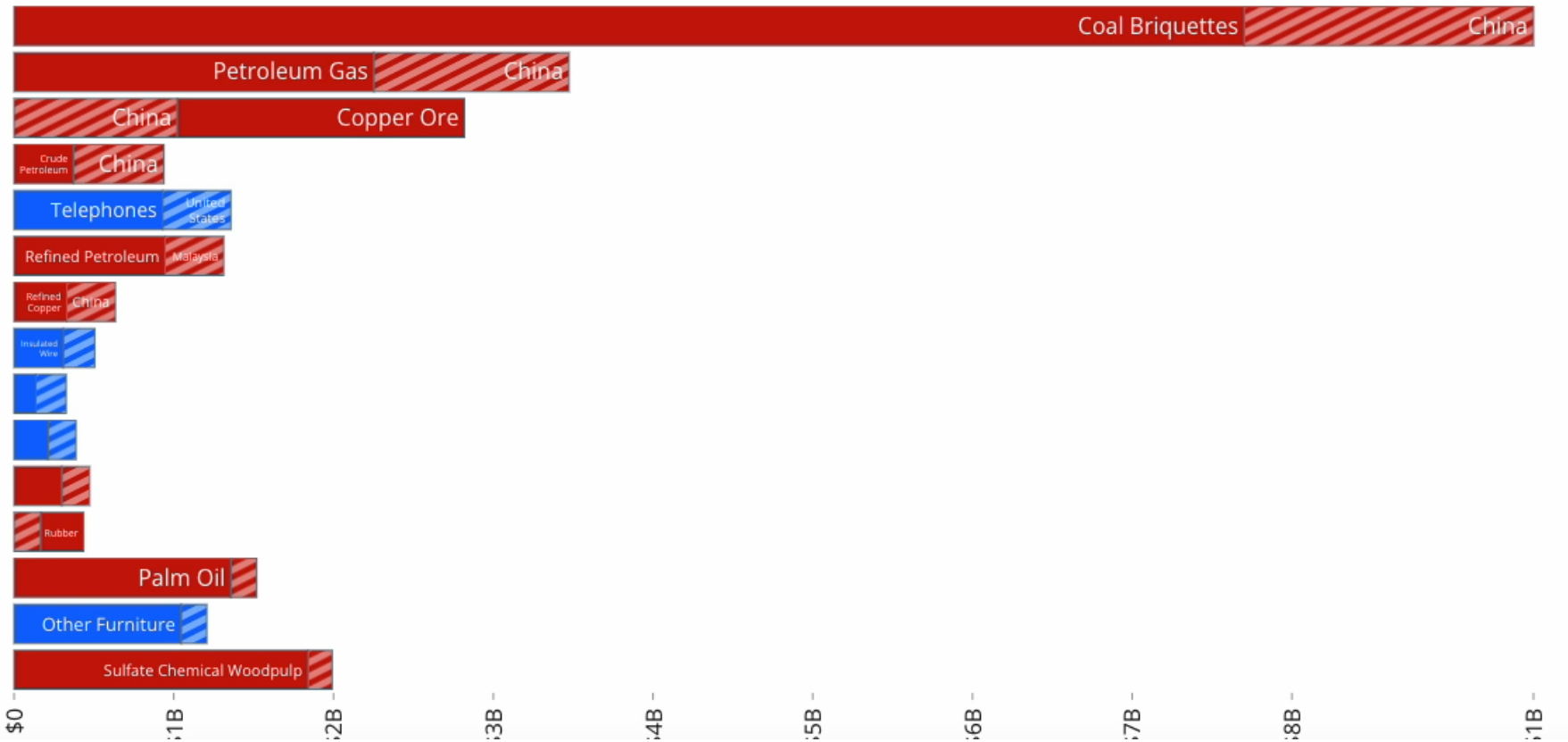
VIEW

Top 10 | Top 15 | Top 20

SORT BY

Highest Potential | Most Saturated

### Exports with highest growth potential (Indonesia)

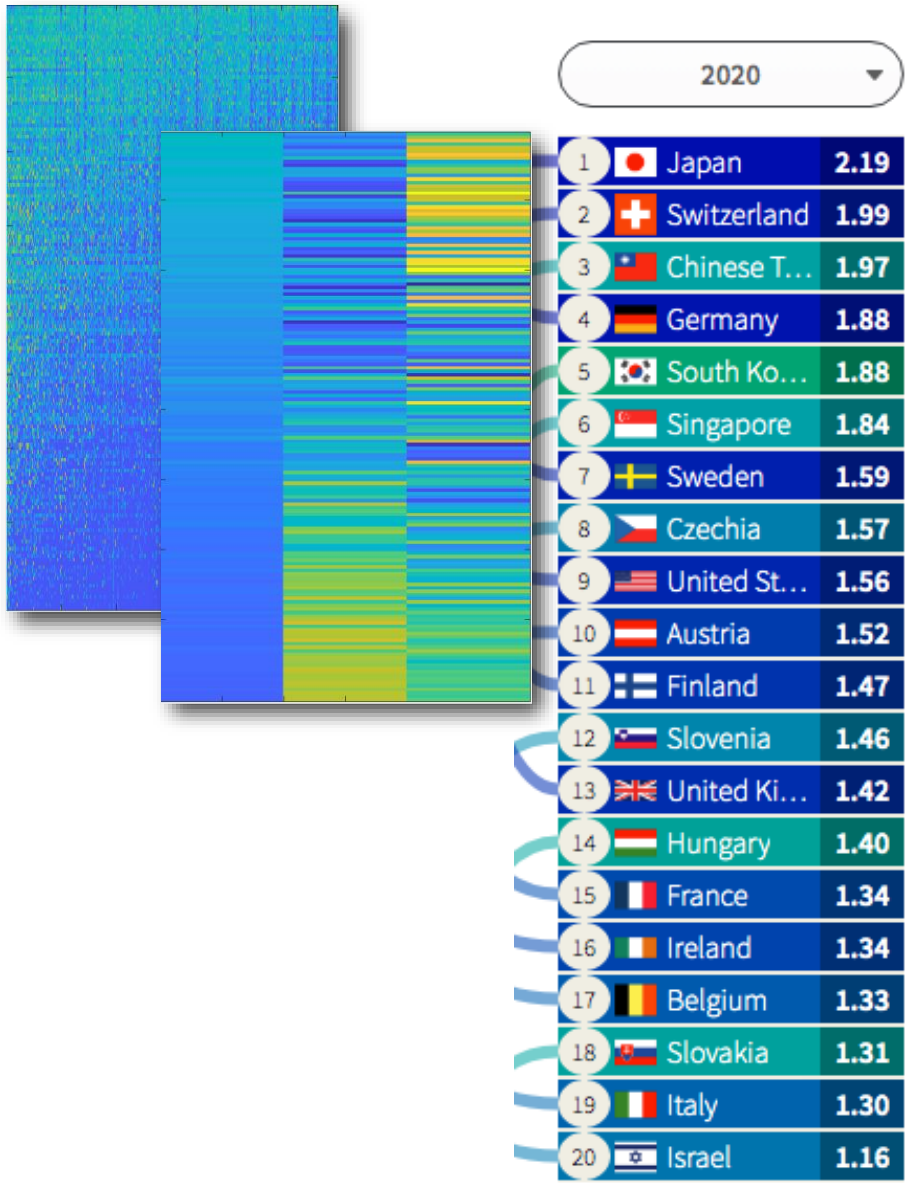



Jun et al. JEE 2019

http://oec.world

# Economic Complexity

Measures of the value of an activity (e.g. a product, industry, etc.) and of the portfolio of activities present in an economy.




Hidalgo CA, Nature Review Physics (2021), PNAS (2009)

# Economic Complexity

**The complexity (*Kc*) of an economy is the complexity (*Kp*) of its activities.**

**The complexity (*Kp*) of an activity is the complexity (*Kc*) of the economies where that activity is produced.**

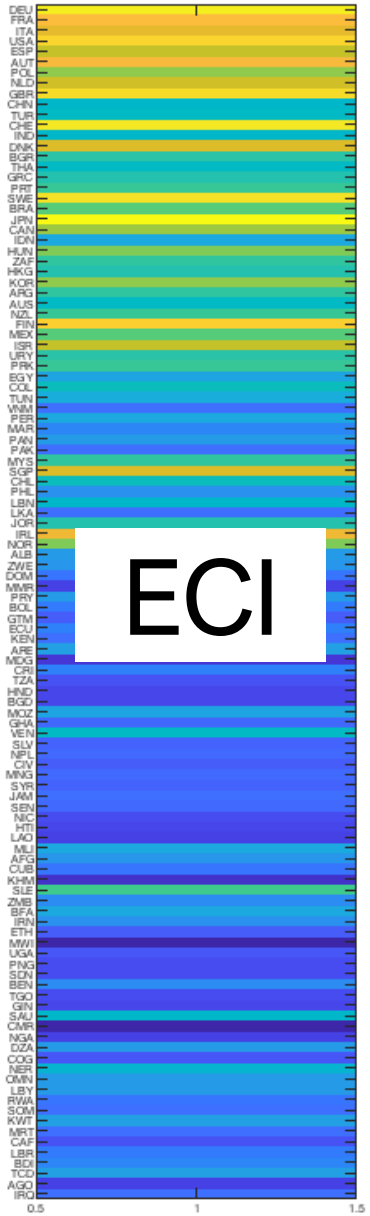
$$K_c = f(M_{cp}, K_p),$$

$$K_p = g(M_{cp}, K_c),$$

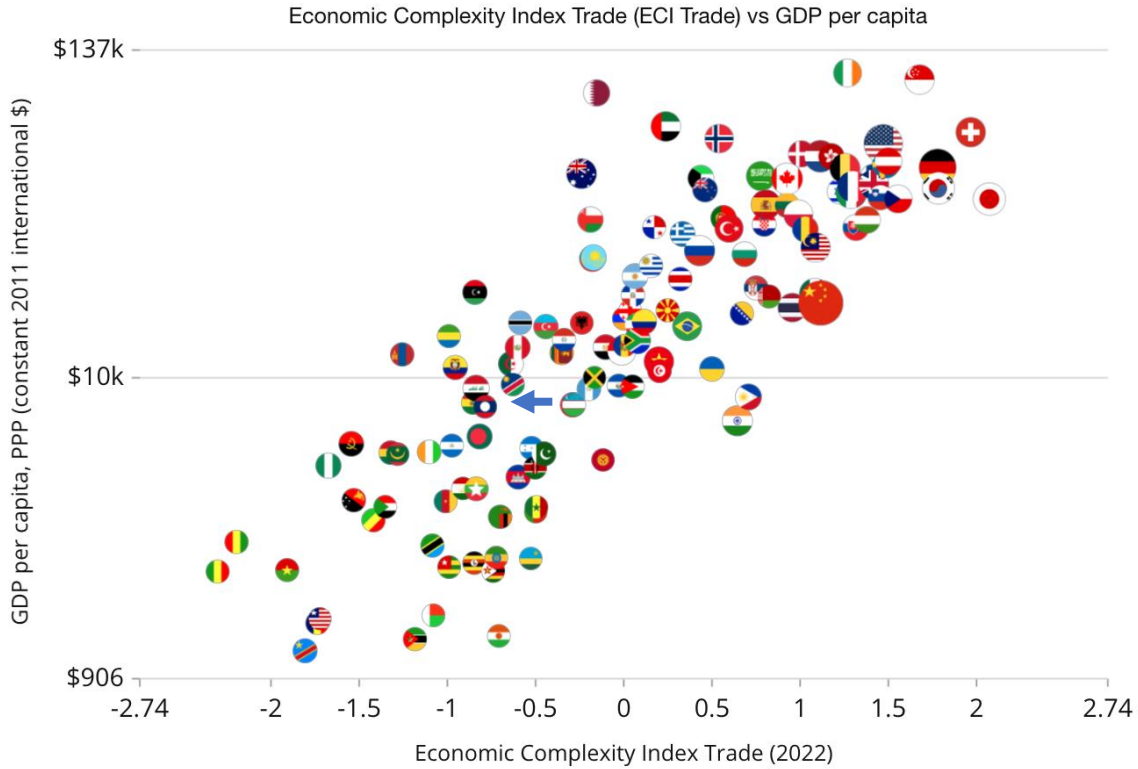
$$K_c = f\left(M_{cp}, g(M_{cp}, K_c)\right),$$

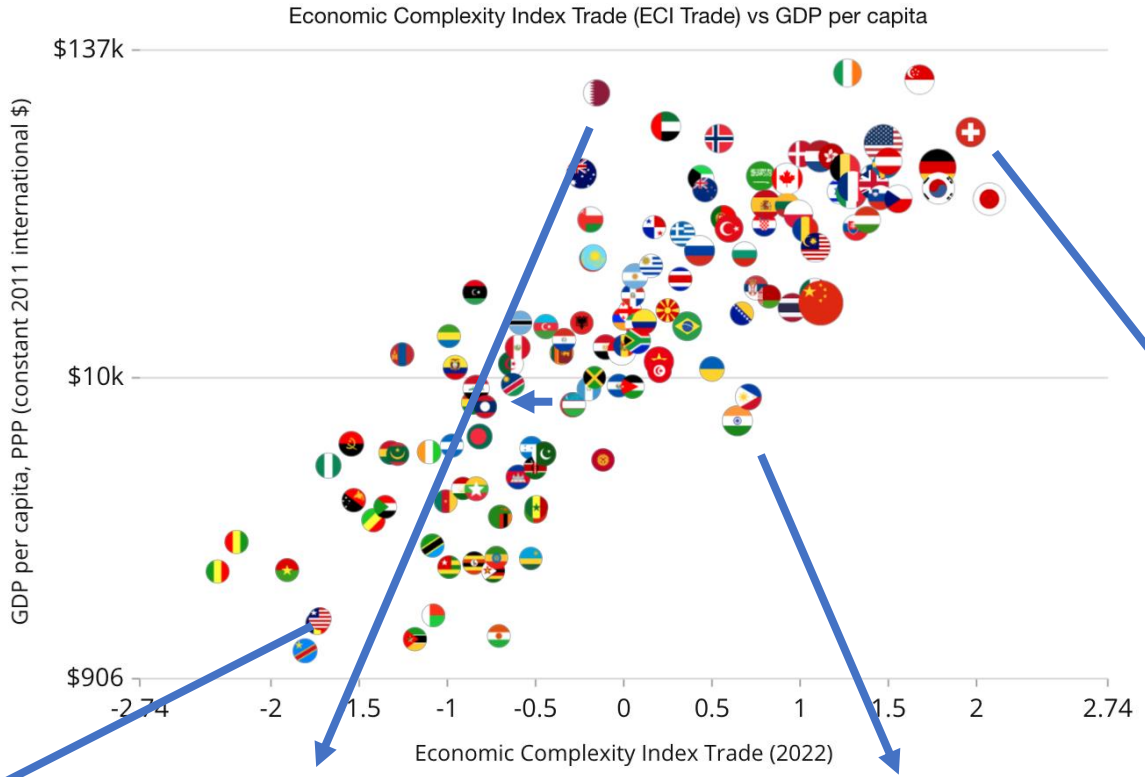
$$\tilde{M}_{cc'} K_{c'} = \lambda K_c$$

**Complexity can be estimated as a solution to the following eigenproblem.**

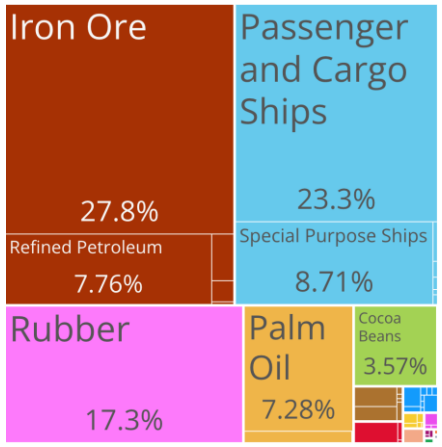



Hidalgo CA, Nature Review Physics (2021), PNAS (2009)

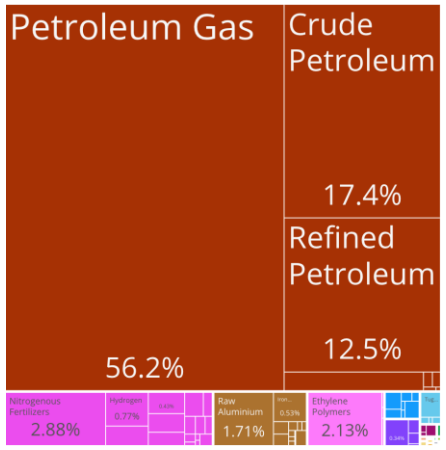

Economic Complexity Index Trade (ECI Trade) vs GDP per capita
$137k
$10k
$906
GDP per capita, PPP (constant 2011 international $)
-2.74
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.74
Economic Complexity Index Trade (2022)



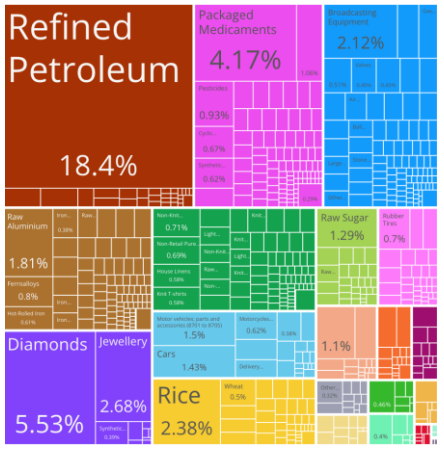

## Liberia (Poor & not complex)



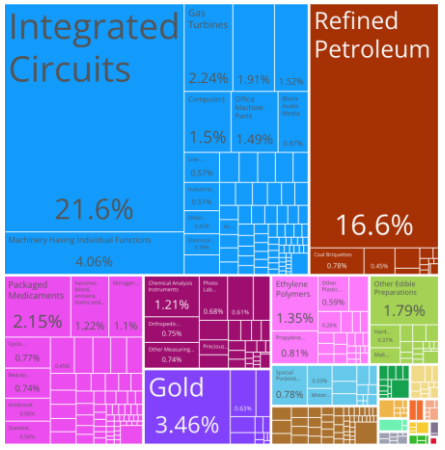

## Qatar (Rich & Not too Complex)




## India (Poor & quite complex)




## Singapore (Rich & Complex)



# Economic Complexity Explains…

## Economic Growth

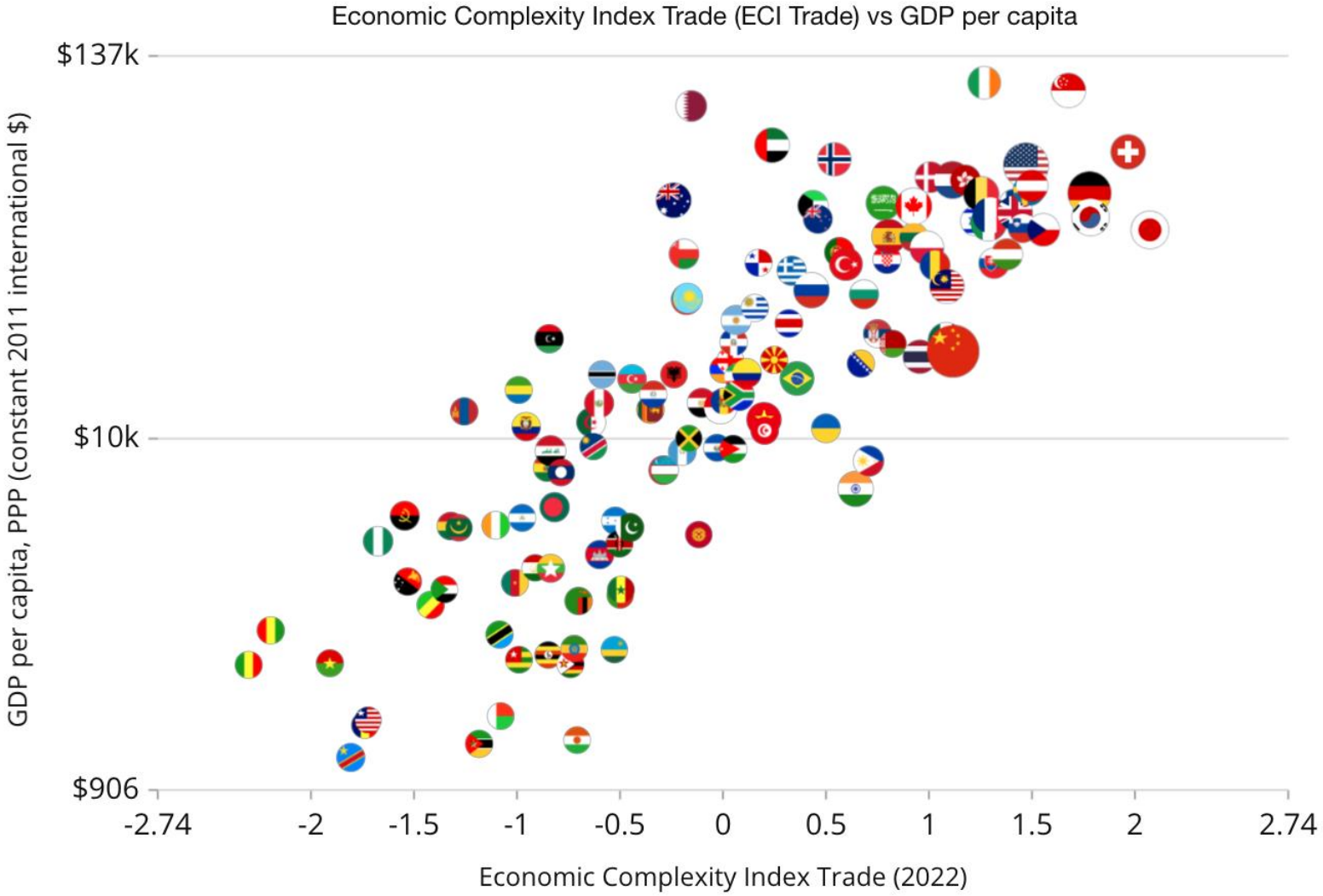
Hidalgo and Hausmann, 2009; Chávez et al., 2017; Domini, 2019; Hausmann et al., 2014; Koch, 2021; Lo Turco and Maggioni, 2020; Ourens, 2012; Stojkoski et al., 2016

## Inequality

Hartmann et al., 2017,Barza et al., 2020; Ben Saâd and Assoumou-Ella, 2019; Chu and Hoang, 2020; Fawaz and Rahnama-Moghadamm, 2019

## Emissions

Can and Gozgor, 2017; Dordmond et al., 2020; Fraccascia et al., 2018; Hamwey et al., 2013; Lapatinas et al., 2019; Mealy and Teytelboym, 2020; Neagu, 2019; Romero and Gramkow, 2021




# Among other outcomes

Explorations in Economic History
Volume 83, January 2022, 101421

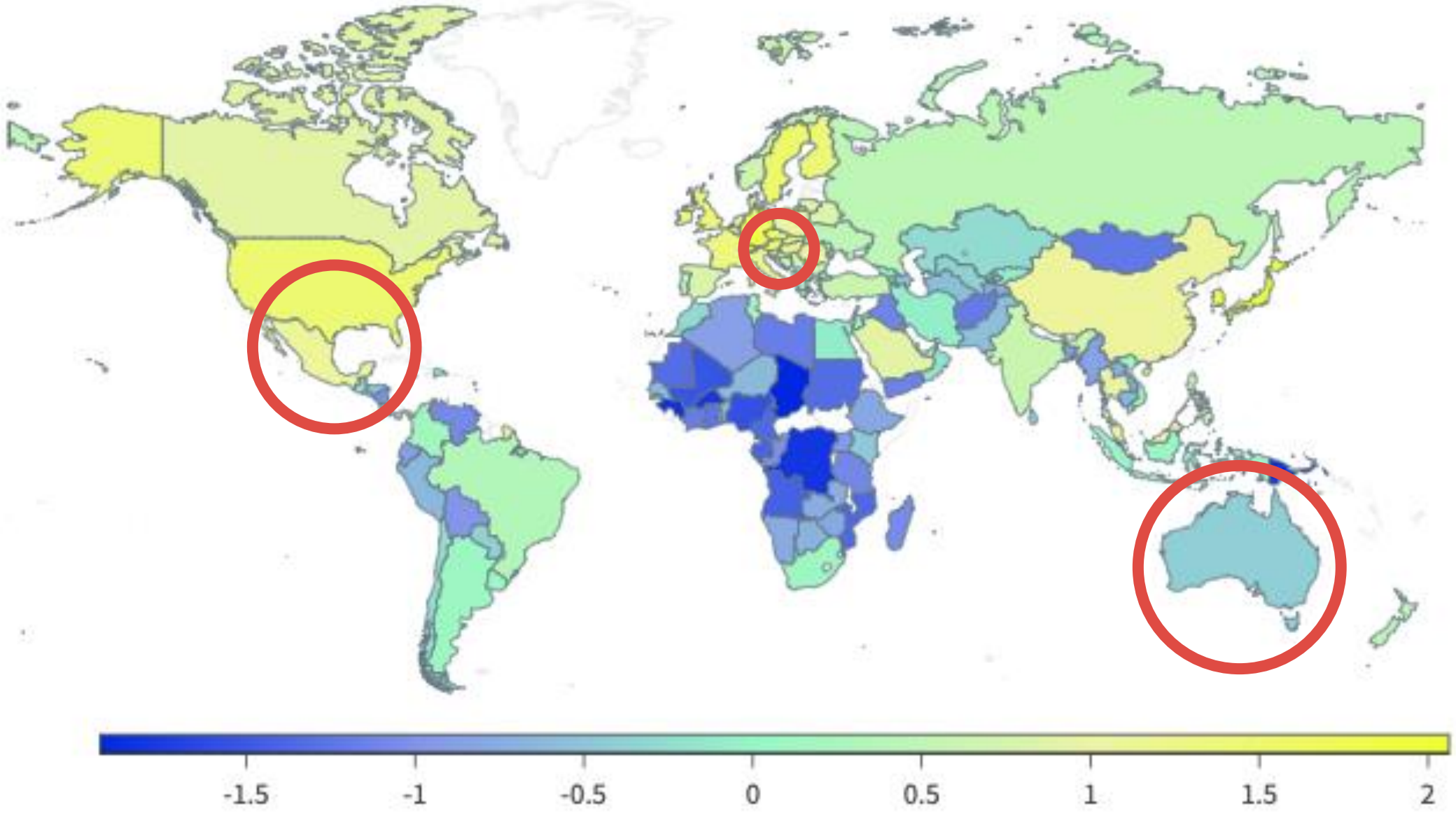
# Patterns of specialization and economic complexity through the lens of universal exhibitions, 1855-1900

Giacomo Domini

| | (3) | (4) |
|---|---|---|
| | **Next-century growth** | **Next-century growth** |
| **ECI** | 0.509*** | 0.400*** |
| | (0.154) | (0.128) |
| **GDP per capita** | -0.597*** | -0.542** |
| | (0.161) | (0.219) |
| **Constant** | -0.128 | -0.092** |
| | (0.121) | (0.043) |
| **Country fixed effects** | No | Yes |
| **N of observations** | 96 | 96 |
| **N of countries** | 33 | 33 |
| **N of time periods** | 5 | 5 |
| **Adjusted $R^2$** | 0.221 | 0.770 |

Domini, Giacomo. *Explorations in Economic History* 83 (2022): 101421.

# Limitations of ECI trade




Stojkoski, Viktor, Philipp Koch, and César A. Hidalgo. "Multidimensional economic complexity and inclusive green growth." *Communications Earth & Environment* 4.1 (2023): 130.

# Solution: Combine Different Data Sources

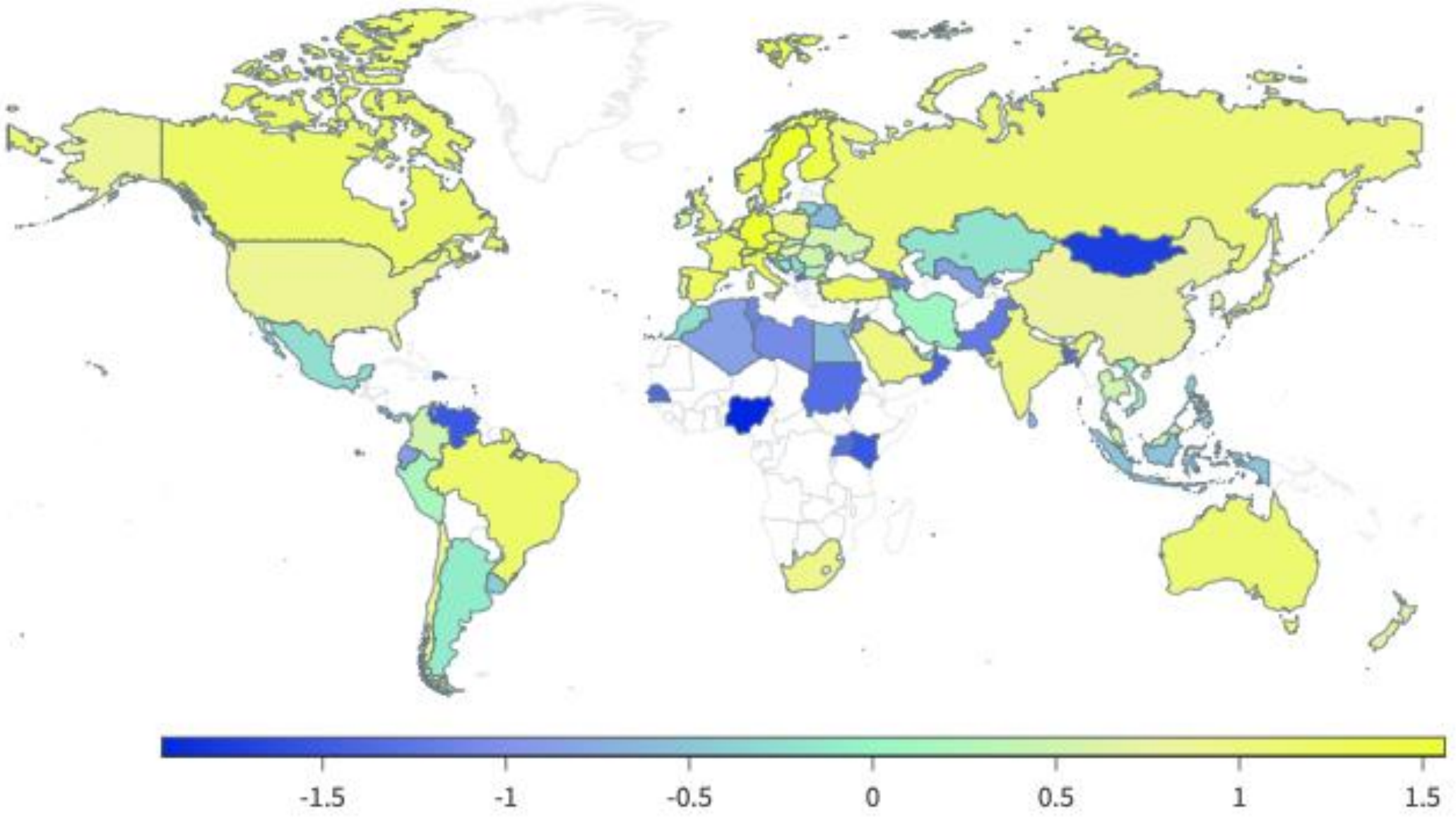
International Trade

Patents

Research Papers

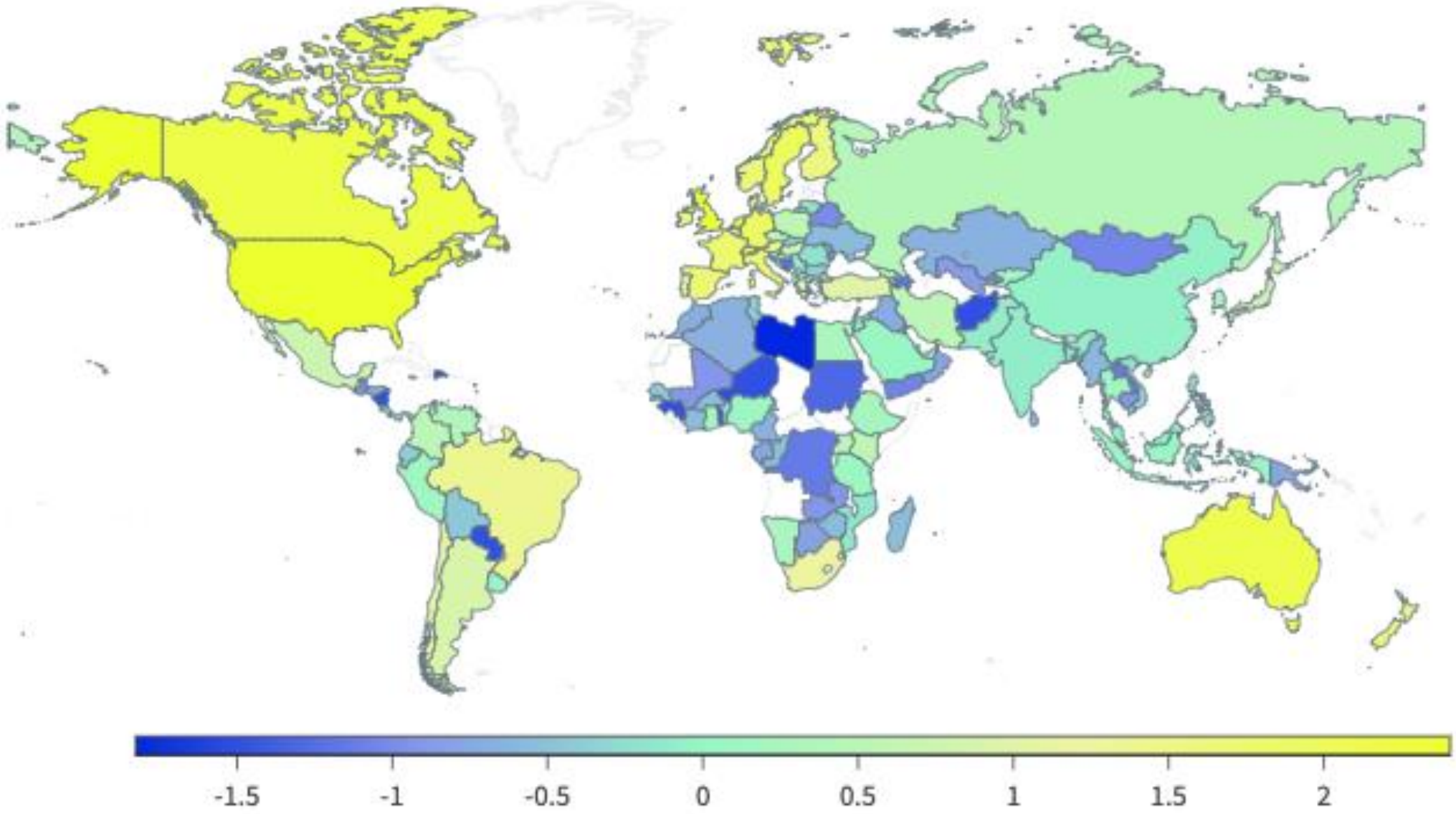
Stojkoski, Viktor, Philipp Koch, and César A. Hidalgo. "Multidimensional economic complexity and inclusive green growth." *Communications Earth & Environment* 4.1 (2023): 130.

# ECI Tech



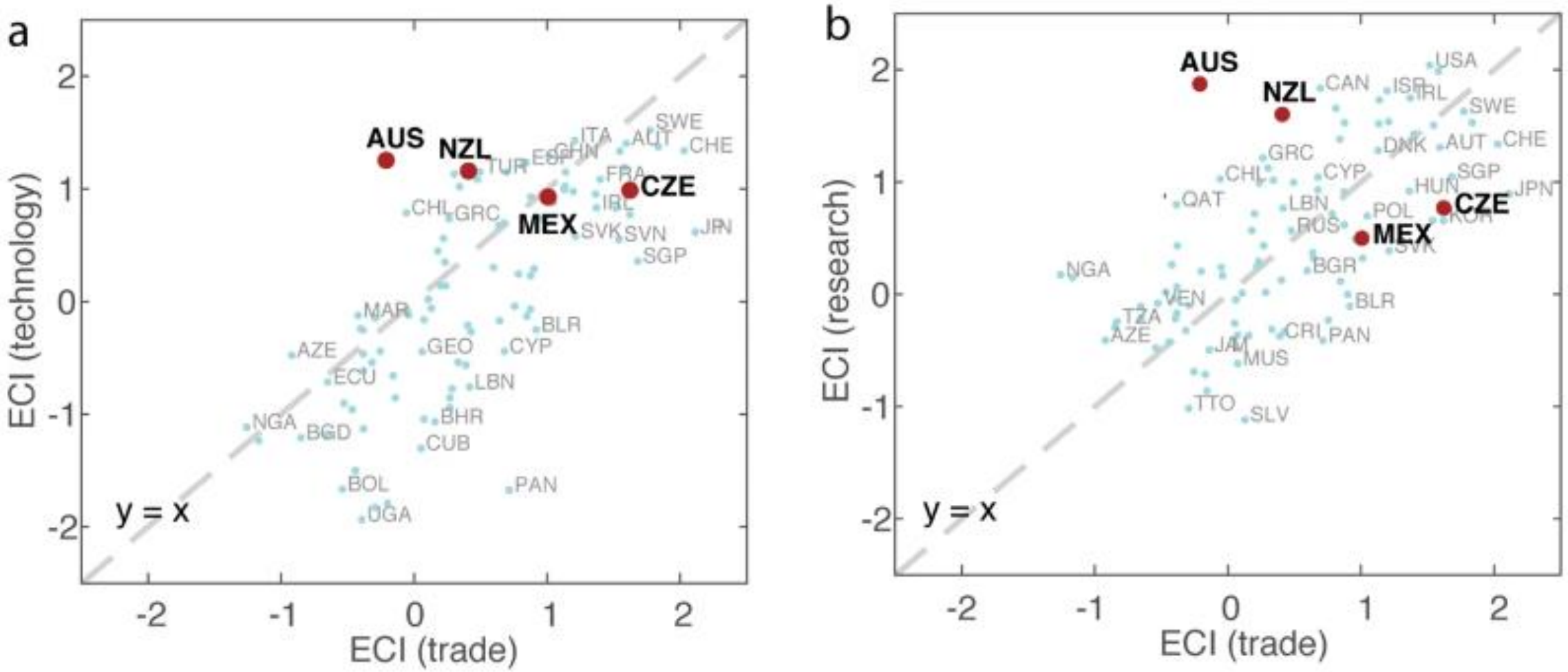

Stojkoski, Viktor, Philipp Koch, and César A. Hidalgo. "Multidimensional economic complexity and inclusive green growth." *Communications Earth & Environment* 4.1 (2023): 130.

# ECI Research




Stojkoski, Viktor, Philipp Koch, and César A. Hidalgo. "Multidimensional economic complexity and inclusive green growth." *Communications Earth & Environment* 4.1 (2023): 130.

# ECI Trade, Tech, & Research are complementary




Stojkoski, Viktor, Philipp Koch, and César A. Hidalgo. "Multidimensional economic complexity and inclusive green growth." *Communications Earth & Environment* 4.1 (2023): 130.


Let’s Look at Indonesia

ECONOMIC COMPLEXITY (TRADE)

**-0.012**

Rank 67 Of 133

ECONOMIC COMPLEXITY (TECHNOLOGY)

**-0.51**

Rank 63 Of 96

ECONOMIC COMPLEXITY (RESEARCH)

**-0.047**

Rank 56 Of 135

## ECI Trade

| | | |
|---|---|---|
| 1 | JAPAN | 2.07 |
| 2 | SWITZERLAND | 1.97 |
| 3 | CHINESE... | 1.94 |
| 4 | SOUTH KOREA | 1.78 |
| 5 | GERMANY | 1.78 |
| 50 | GREECE | 0.33 |
| 51 | COSTA RICA | 0.32 |
| 52 | NORTH... | 0.25 |
| 53 | UNITED ARA... | 0.24 |
| 54 | TUNISIA | 0.20 |
| 55 | VIETNAM | 0.20 |
| 56 | PANAMA | 0.17 |
| 57 | URUGUAY | 0.15 |
| 58 | COLOMBIA | 0.11 |
| 59 | SOUTH AFRICA | 0.08 |
| 60 | IRAN | 0.07 |
| 61 | ARGENTINA | 0.06 |
| 62 | DOMINICAN... | 0.05 |
| 63 | JORDAN | 0.05 |
| 64 | GEORGIA | 0.04 |
| 65 | MOLDOVA | 0.00 |
| 66 | ARMENIA | 0.00 |
| 67 | INDONESIA | -0.01 |
| 68 | EL SALVADOR | -0.03 |

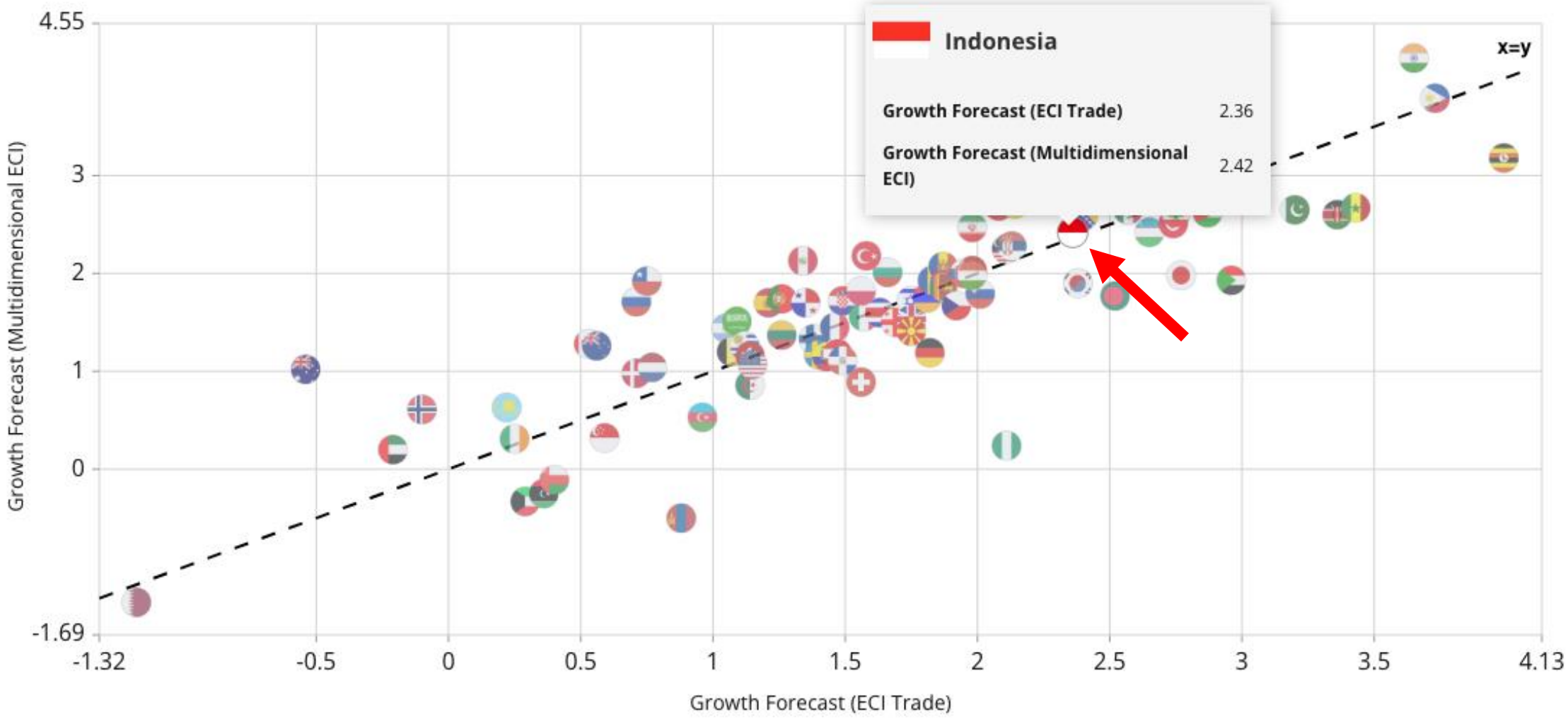
## ECI Tech

| | | |
|---|---|---|
| 1 | SWEDEN | 1.56 |
| 2 | GERMANY | 1.55 |
| 3 | AUSTRIA | 1.50 |
| 4 | FINLAND | 1.38 |
| 5 | ITALY | 1.34 |
| 50 | UNITED ARA... | -0.03 |
| 51 | BOSNIA AN... | -0.07 |
| 52 | ARGENTINA | -0.10 |
| 53 | KAZAKHSTAN | -0.20 |
| 54 | SERBIA | -0.23 |
| 55 | MOROCCO | -0.24 |
| 56 | MEXICO | -0.25 |
| 57 | LITHUANIA | -0.31 |
| 58 | MOLDOVA | -0.34 |
| 59 | PHILIPPINES | -0.36 |
| 60 | URUGUAY | -0.44 |
| 61 | INDONESIA | -0.51 |
| 62 | EGYPT | -0.60 |
| 63 | BELARUS | -0.62 |
| 64 | SRI LANKA | -0.62 |
| 65 | COSTA RICA | -0.72 |
| 66 | ARMENIA | -0.73 |
| 67 | ALGERIA | -0.85 |
| 68 | UZBEKISTAN | -0.86 |

## ECI Research

| | | |
|---|---|---|
| 1 | UNITED... | 2.49 |
| 2 | UNITED... | 2.41 |
| 3 | CANADA | 2.26 |
| 4 | AUSTRALIA | 2.18 |
| 5 | NETHERLANDS | 2.14 |
| 50 | PERU | -0.01 |
| 51 | SOUTH... | -0.04 |
| 52 | INDONESIA | -0.05 |
| 53 | RUSSIA | -0.05 |
| 54 | ETHIOPIA | -0.06 |
| 55 | URUGUAY | -0.07 |
| 56 | QATAR | -0.10 |
| 57 | DEMOCRATI... | -0.13 |
| 58 | SERBIA | -0.14 |
| 59 | THAILAND | -0.15 |
| 60 | UNITED ARA... | -0.20 |
| 61 | PHILIPPINES | -0.20 |
| 62 | EGYPT | -0.23 |
| 63 | NAMIBIA | -0.25 |
| 64 | JORDAN | -0.26 |
| 65 | CHINESE... | -0.26 |
| 66 | GUINEA | -0.33 |
| 67 | ZAMBIA | -0.33 |
| 68 | ALBANIA | -0.34 |

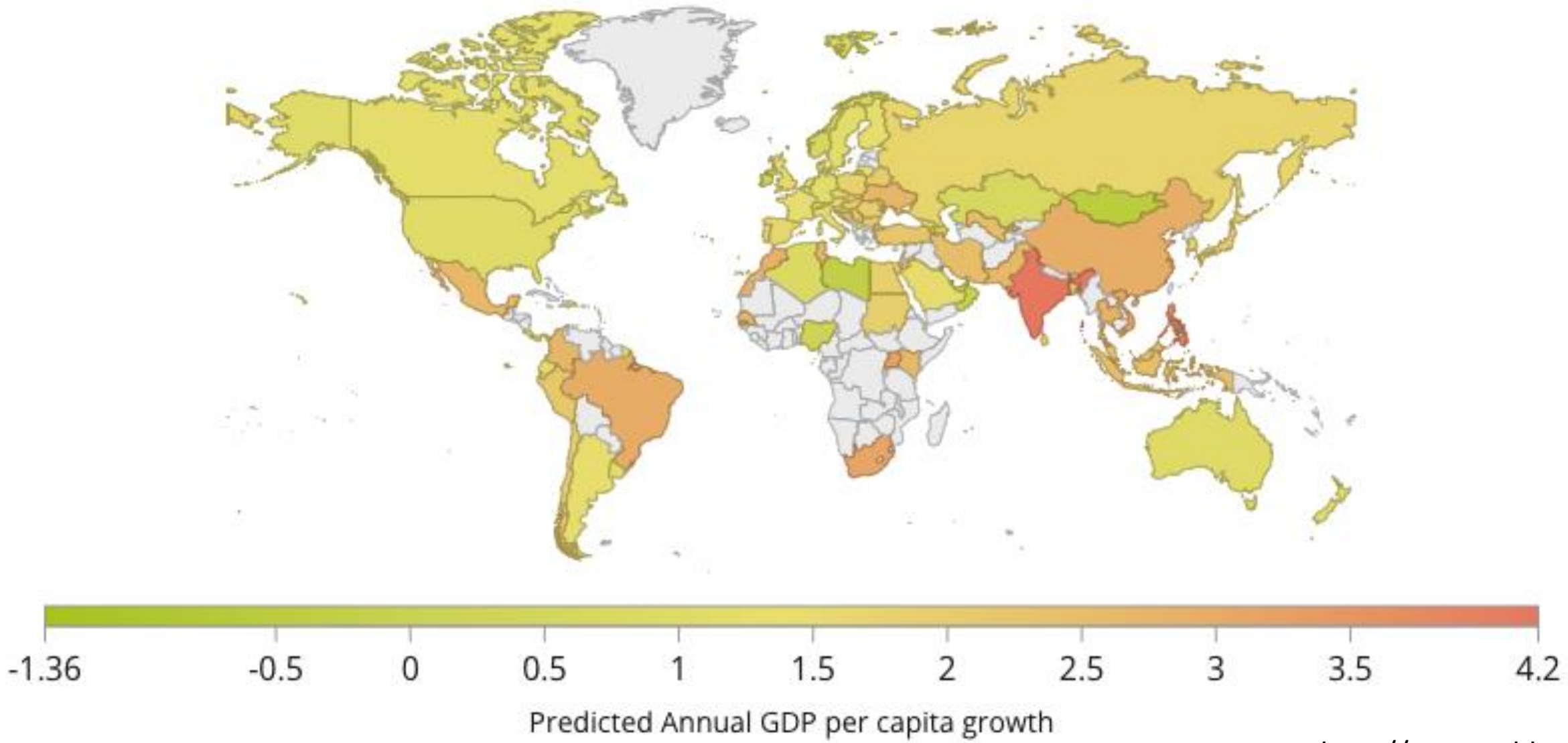
# Multidimensional Economic Complexity predicts Indonesia will be one of the potentially fastest growing economies in the world




*Growth can be larger since these estimates suffer from regression to the mean.

http://oec.world

# Indonesia is in a region with high economic growth potential




*Growth can be larger since these estimates suffer from regression to the mean.

http://oec.world

# Moving into digital trade

International Trade

Patents

Research Papers


Stojkoski, Viktor, Philipp Koch, and César A. Hidalgo. "Multidimensional economic complexity and inclusive green growth." *Communications Earth & Environment* 4.1 (2023): 130.

# Creating a dataset on digital products

2,502 Internet companies with revenues of USD 1B+



Decompose revenue of each company into 29 sectors

13,013 firns and app developers



Digital consumption Patterns for 2 sectors: mobile apps & games

**Gradient-boosted regression tree.**

**(leave 20% out-of-sample cross-validation. MSE 0.048)**

(Extends data to 129 additional countries and to 29 sectors)

**Optimal Transport Reallocation**

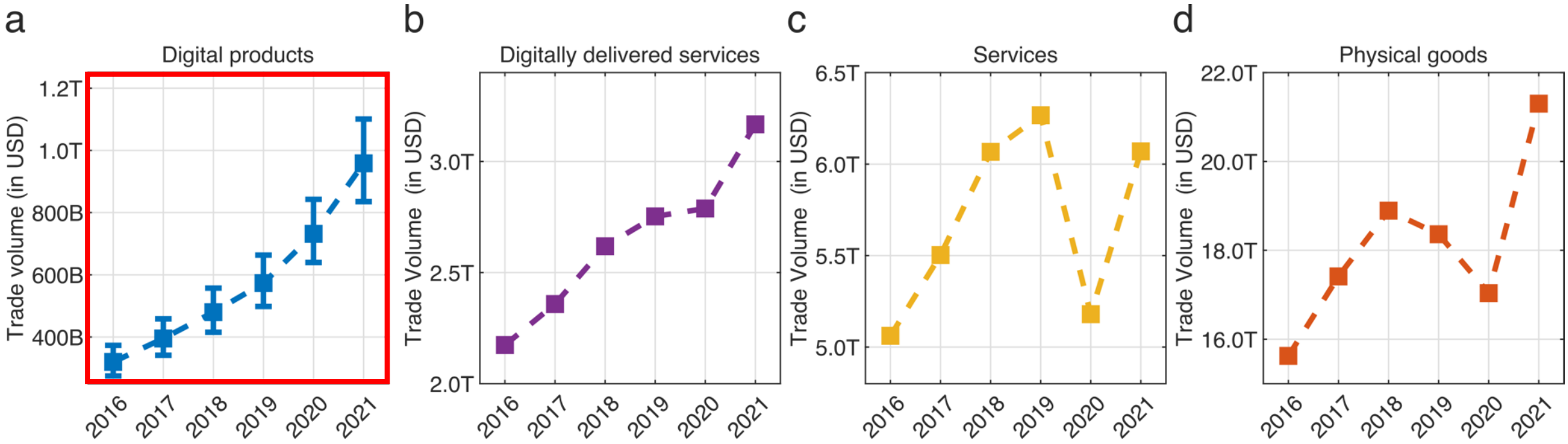
(Assigns trade to closest subsidiary constrained by total revenue amounts)

**Resulting Dataset**

Bilateral digital product trade estimates for 189 countries, 31 sectors, and 15,255 firms

Stojkoski et al. Nature Communications (2024)

# Digital Trade is Growing Fast




25% CAGR

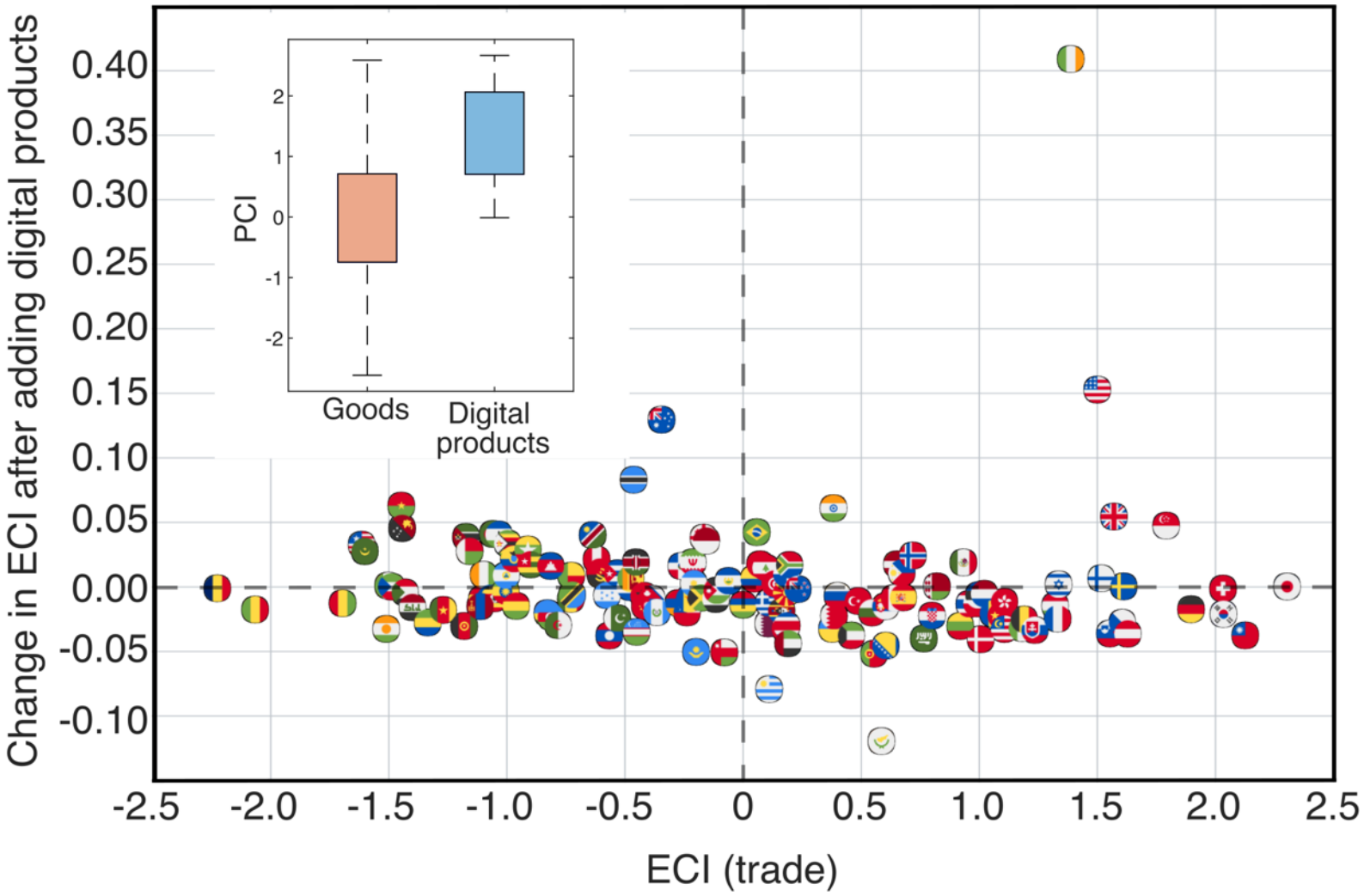
8% CAGR

4% CAGR

6% CAGR

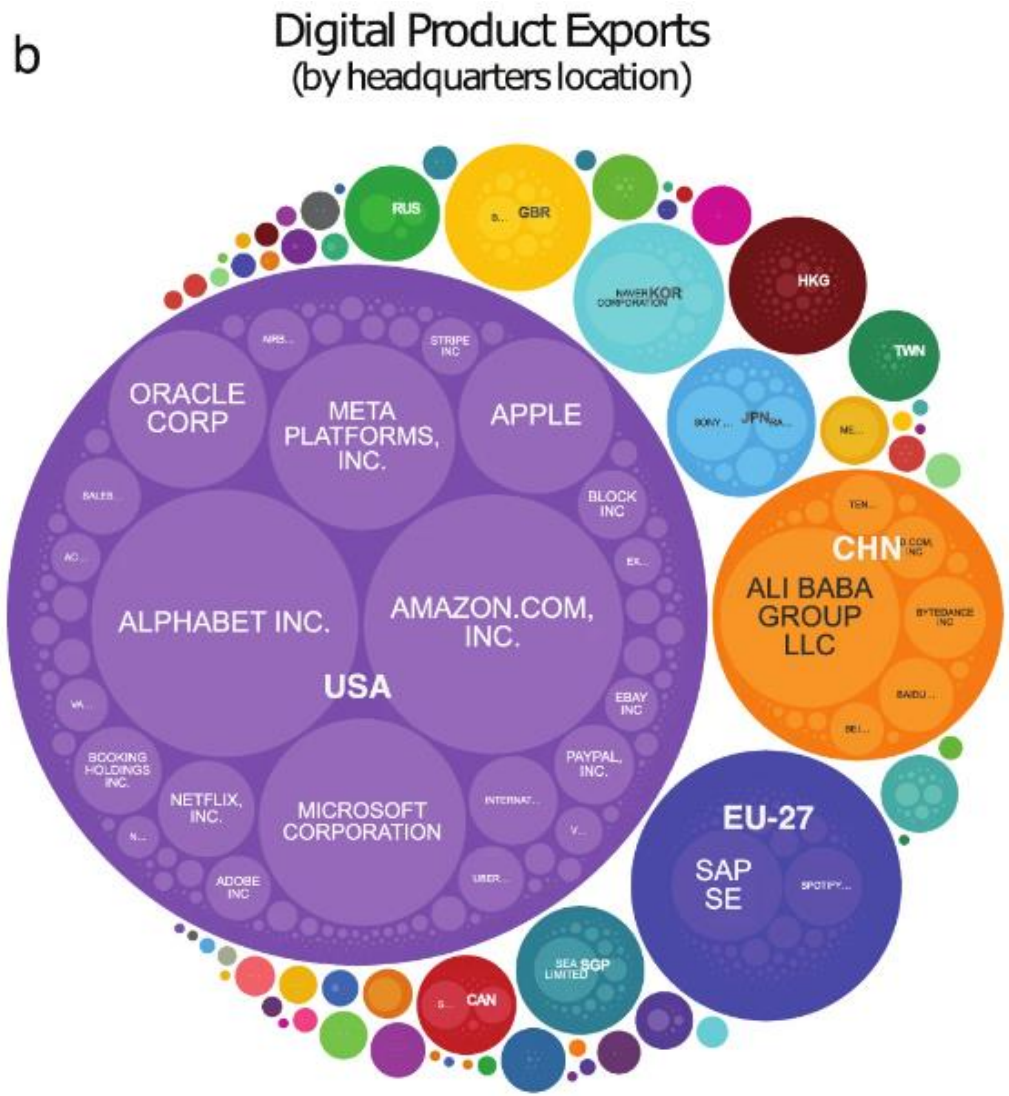
Stojkoski, Viktor, et al. "Estimating digital product trade through corporate revenue data." *Nature Communications* 15.1 (2024): 5262.

# Digital Trade is High Complexity




Stojkoski, Viktor, et al. "Estimating digital product trade through corporate revenue data." *Nature Communications* 15.1 (2024): 5262.

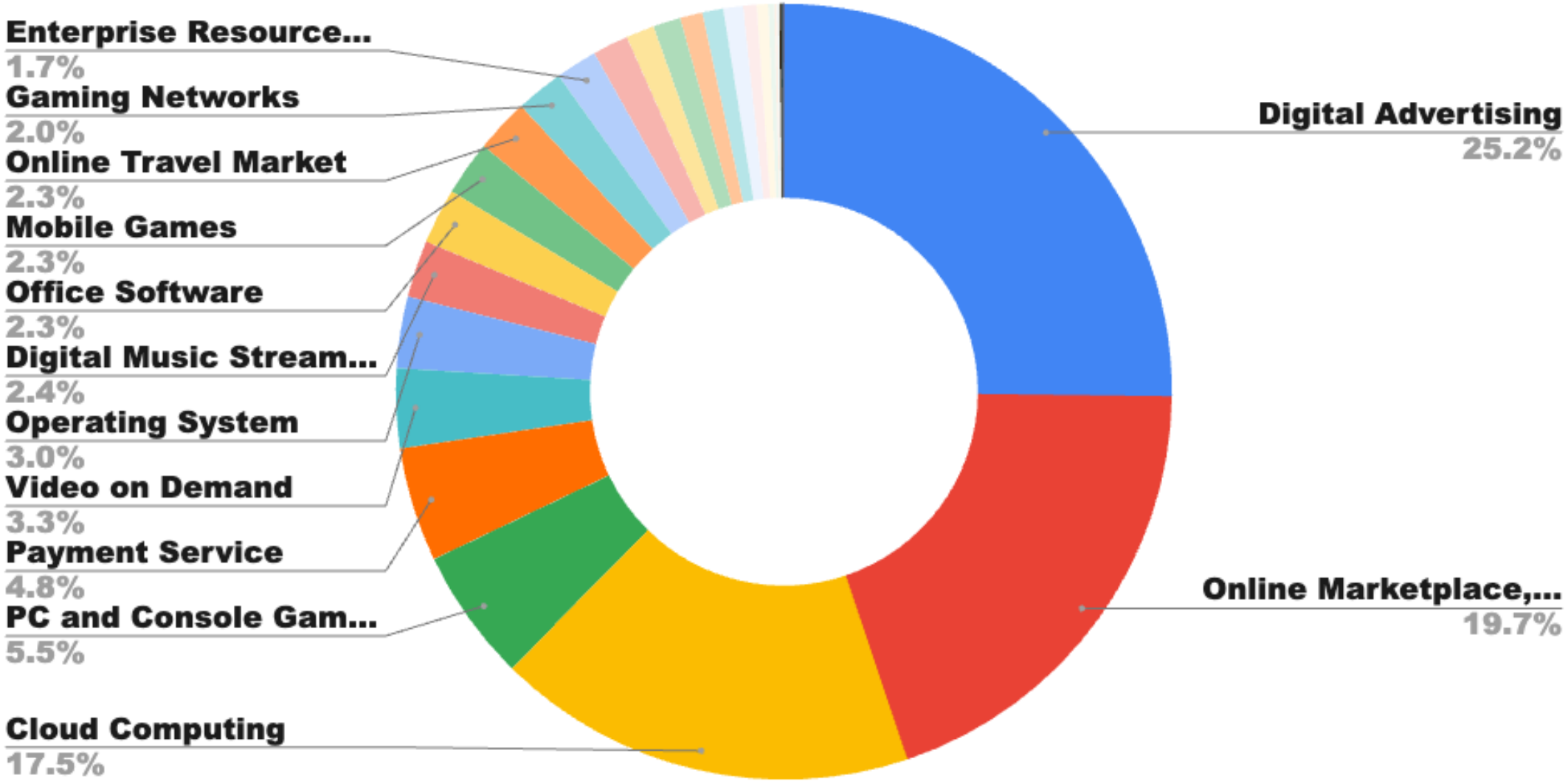
# Digital Product Trade Has Few Origins




Stojkoski, Viktor, et al. "Estimating digital product trade through corporate revenue data." *Nature Communications* 15.1 (2024): 5262.


Let’s Look at Indonesia

# Digital Import Estimates by Indonesia (2021)  11.6B USD




Stojkoski, Viktor, et al. "Estimating digital product trade through corporate revenue data." *Nature Communications* 15.1 (2024): 5262.

# Putting these ideas into practice

# Data MÉXICO

EXPLORA, VISUALIZA, COMPARA, Y DESCARGA DATOS MEXICANOS

ECONOMÍA
SECRETARÍA DE ECONOMÍA

¡Más de 12.000 perfiles para descubrir!

Ej. Ciudad de México, Monterrey

BUSCAR

## ¿Qué es DataMéxico?

DataMéxico permite la integración, visualización y análisis de datos públicos para fomentar la innovación, inclusión y diversificación de la economía mexicana.

### PERFILES

Explore México mediante datos económicos, sociales y ocupacionales a través de visualizaciones interactivas personalizables.

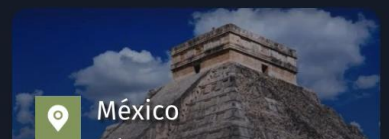
### COMPLEJIDAD ECONÓMICA

Conozca el nivel de desarrollo industrial y económico en México a múltiples niveles geográficos.

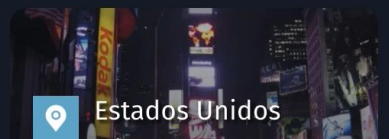
### VIZ BUILDER

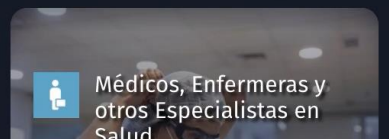
Genere sus propias visualizaciones con base en la selección de datos de su interés.

CIUDADES & LUGARES | INDUSTRIAS | PAÍSES ¡NUEVO! | OCUPACIONES | PRODUCTOS | INSTITUCIONES





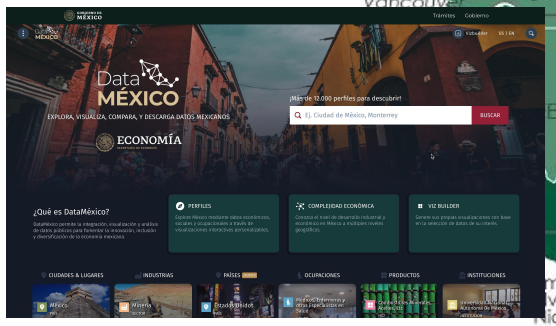


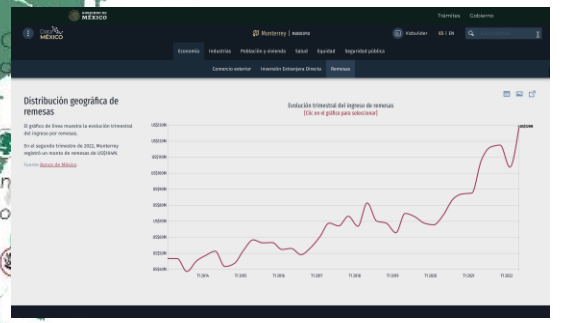



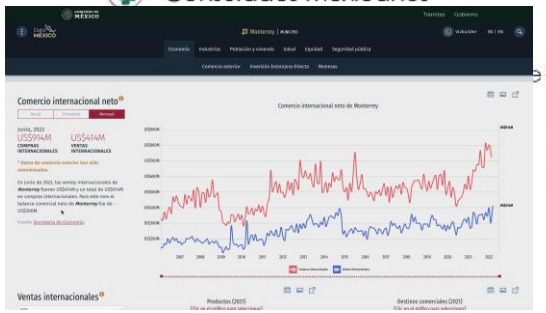


# La diplomacia de México

## Representacion mexicana en el mundo



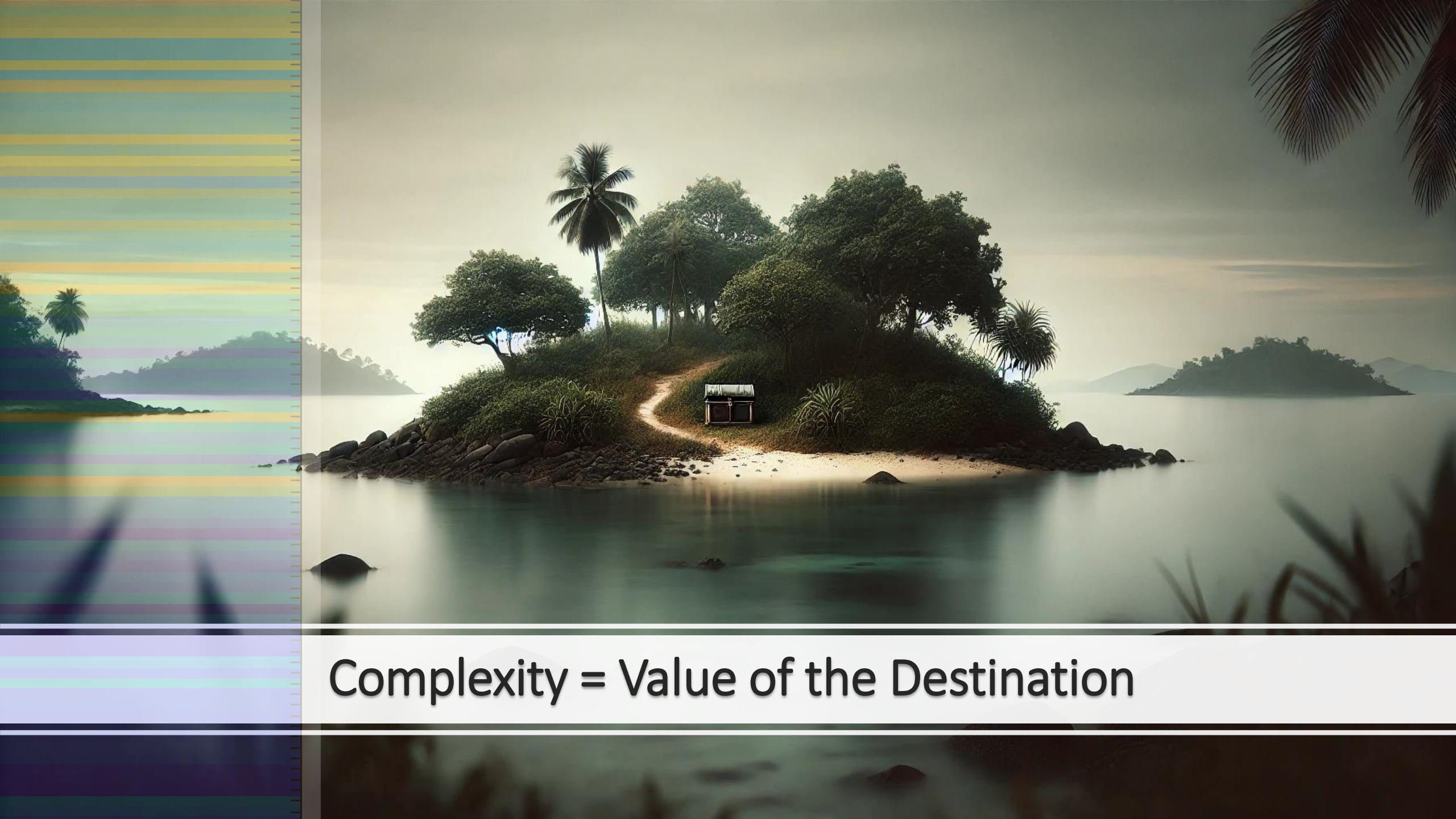


Embajadas mexicanas

Consulados mexicanos

**Cartografía:**
Abel Gil Lobo (2020)
**Fuente:**
Global Diplomacy Index, Lowy Institute (2019)

# Relatedness = Direction of the Wind



# Complexity = Value of the Destination

You don’t want to simply follow the wind.

You want to navigate to the right destination.

## Diversification Frontier

**FILTER**

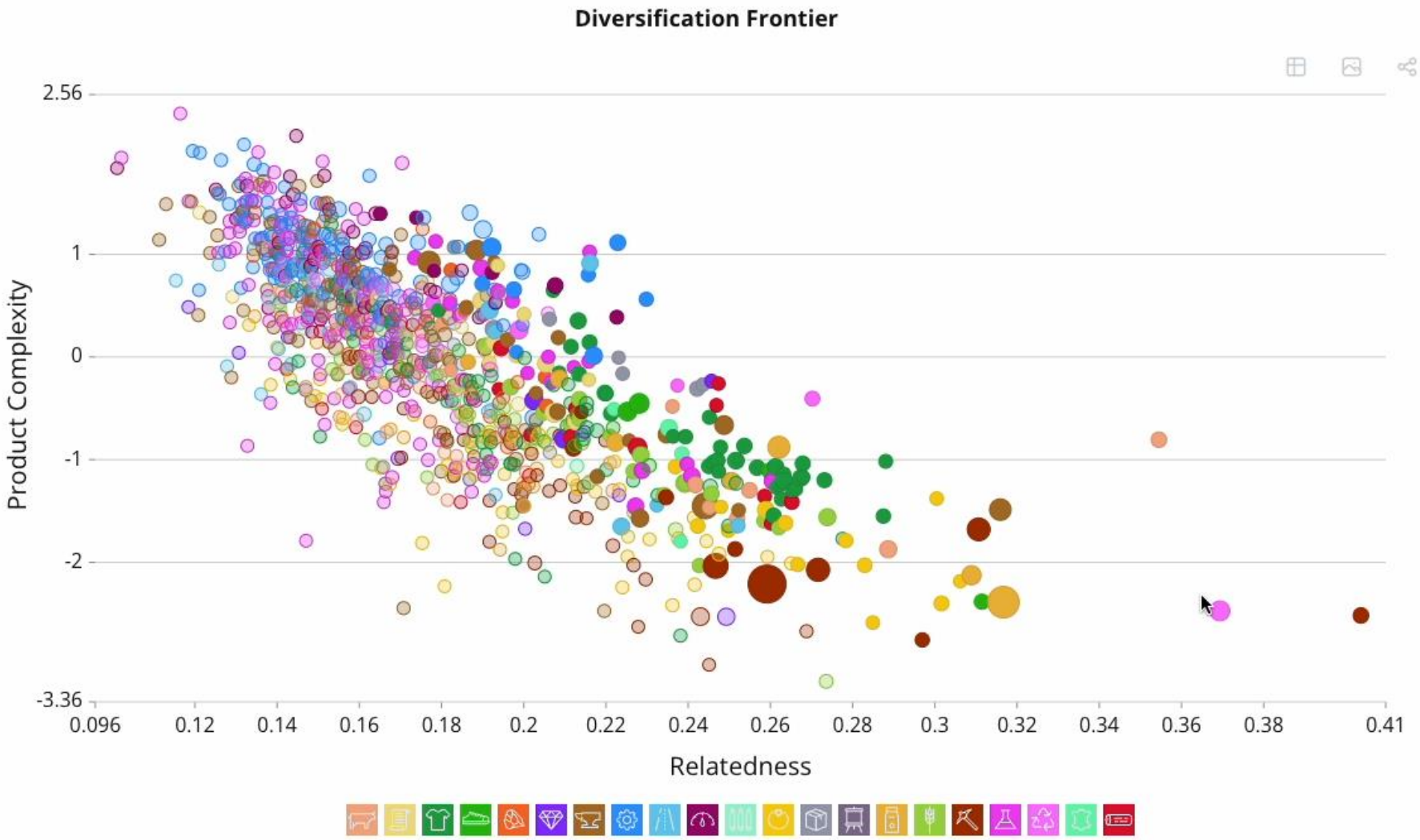
All | RCA ≤ 1 | RCA > 1

**DEPTH**

Section | HS2 | **HS4**

The Complexity-Relatedness diagram compares the risk vs strategic value of a country's potential export oppotunities. Relatedness is predictive of the probability that a country increases its exports in a product. Complexity, is associated with higher levels of income, economic growth, less income inequality, and lower greenhouse emissions.

Data from BACI HS6 REV. 1992 (1995 - 2022).



Optimize Exports Portfolio to target the complexity

Country | ECI

Norway 14/125

Include Gold | Include Oil

Optimize Portfolio

Summary

Table

Analytics

Methods

# Welcome to the Economic Complexity Optimization Tool

Create optimized export portfolio to develop a more complex economy.

Select A Target | Start Tutorial

## 1 Create Scenario

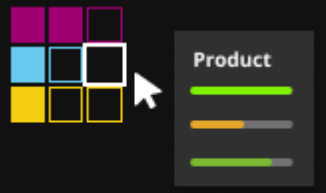
### Optimize By Country

Select a target country to create a similar portfolio of product exports

### Optimize By ECI

Select a target Economic Complexity Index to create an optimal portfolio of the most complex products

## 2 Explore The Results




See what product to develop and the export volume to achieve by sectors.
Browse the recommended products to understand their potential today and in 5 years.

## 3 Analyse Further

### Advanced Table

Complete view of the portfolio, at different level of granularity of products.

### Analytical Tools

Interact with the results, compare, and plan the diversification.

### Learn The Methodology

Learn more about Economic complexity and the Optimization methods.

**Optimize Exports Portfolio to target the complexity**

Country | ECI

Norway 14/125

Include Gold | Include Oil

Optimize Portfolio

# Optimized Portfolio

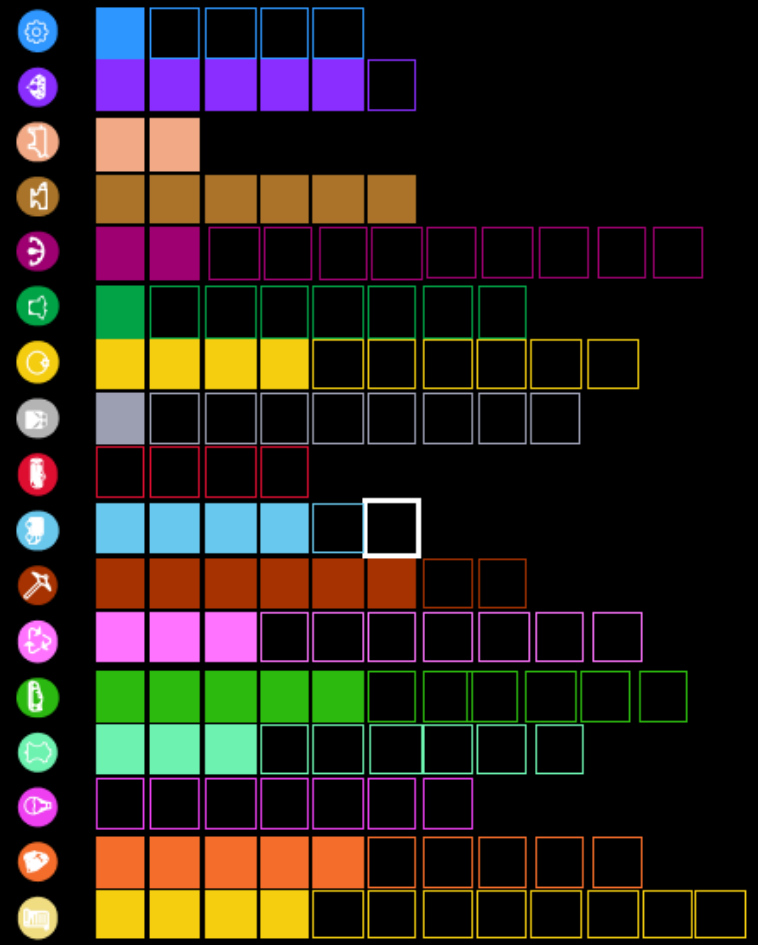
Summary

Table

Analytics

Methods

Select a Product | Recommended | Specialized | Further develop



## Reach Norway Complexity

To achieve Norway's level of economic complexity within 10 years, we recommend reaching the following export portfolio within 5 years. The optimized portfolio includes an increase in exports across **58 products**, with a primary focus on the **Machinery** and **Chemical** sectors. The total expected increase in export volume is **$5,642,625 USD**.

ECI
**0,66**
▲ +45 ranks

Today

2032

**Cars**
Machines

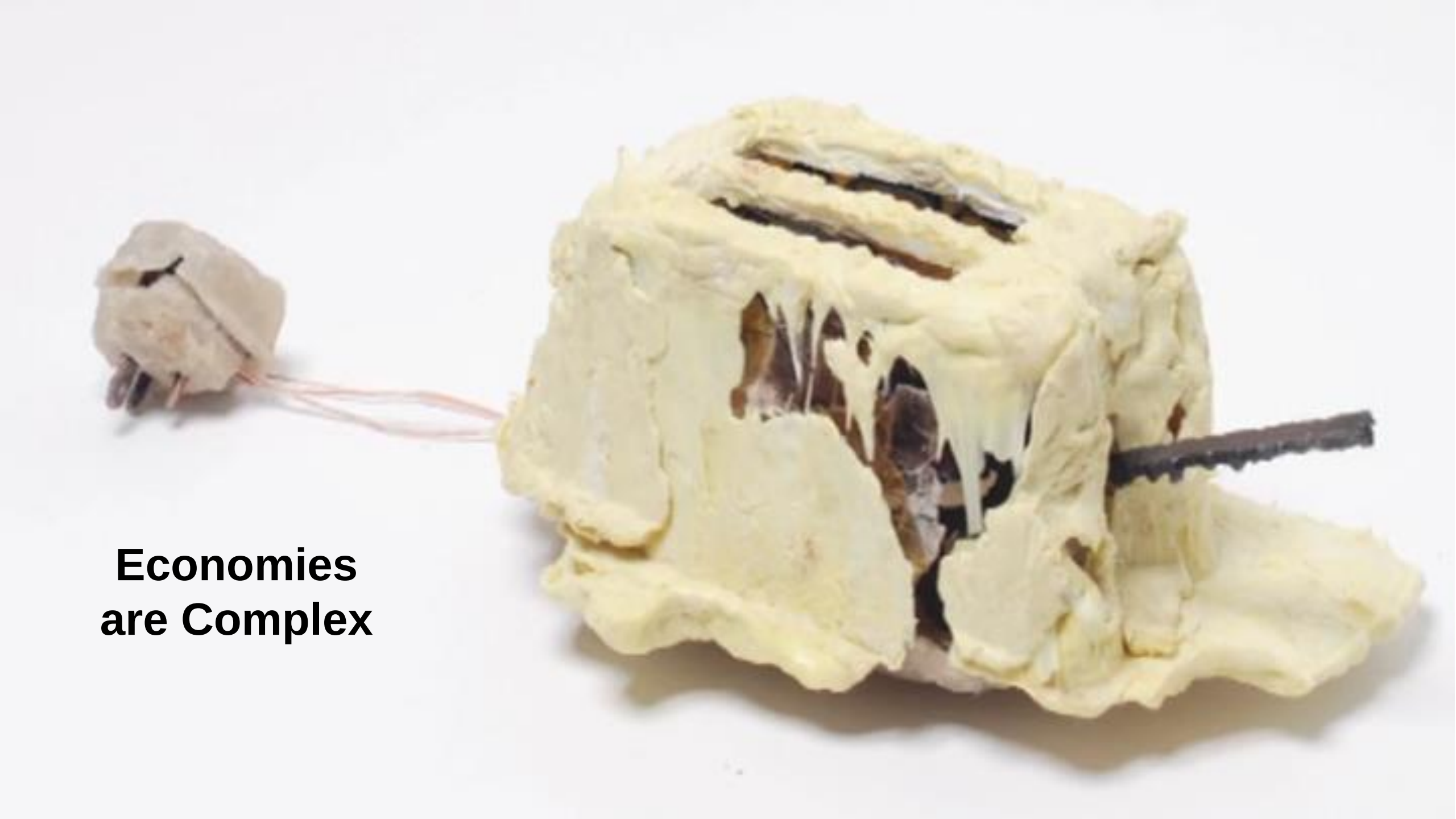
123

| | | |
|---|---|---|
| Global Growth | | ▲ 5% |
| Current Export | | USD 39,586,744 |
| 5 years Export | + USD 3,586,744 | USD 46,586,744 |

| | |
|---|---|
| NEARBY DISTANCE | PRODUCT COMPLEXITY |
| 5 YEARS NEARBY DISTANCE | 5 YEARS PRODUCT COMPLEXITY |
| COMPETITIVE ADVANTAGE | OPPORTUNITY GAIN |
| 5 YEARS COMPETITIVE ADVANTAGE | EMISSION |

See Full Table

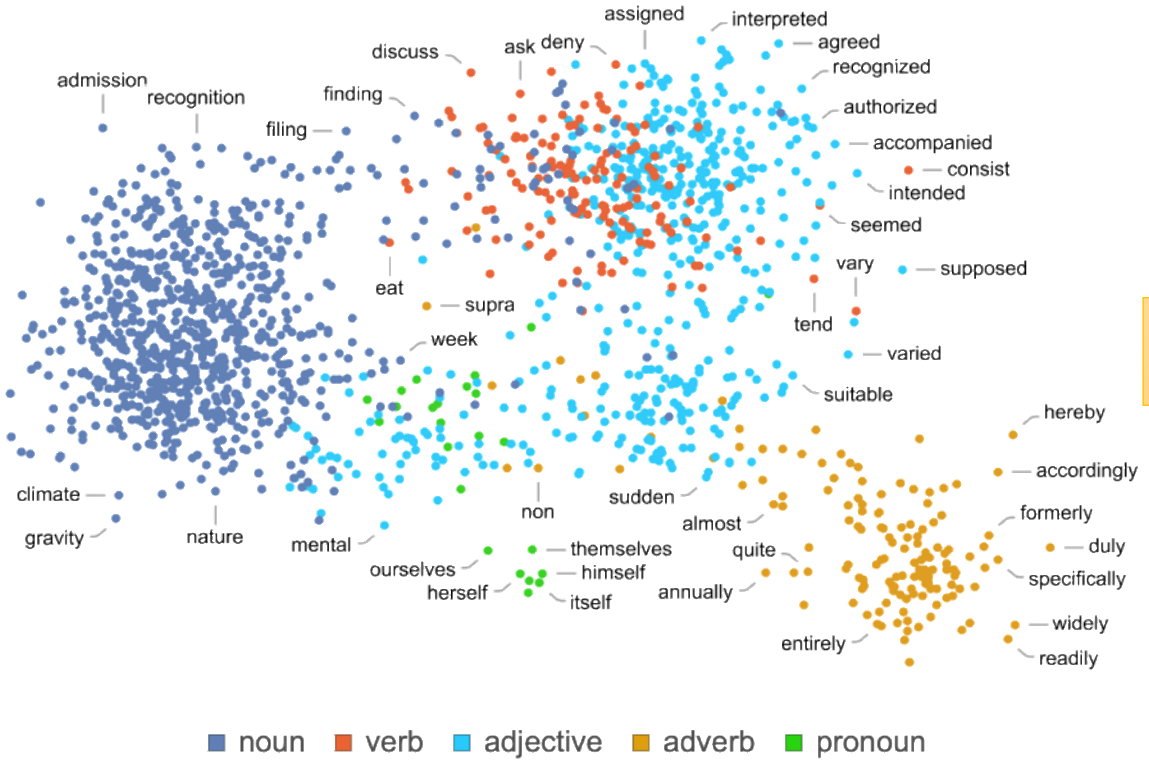
# …to Conclude

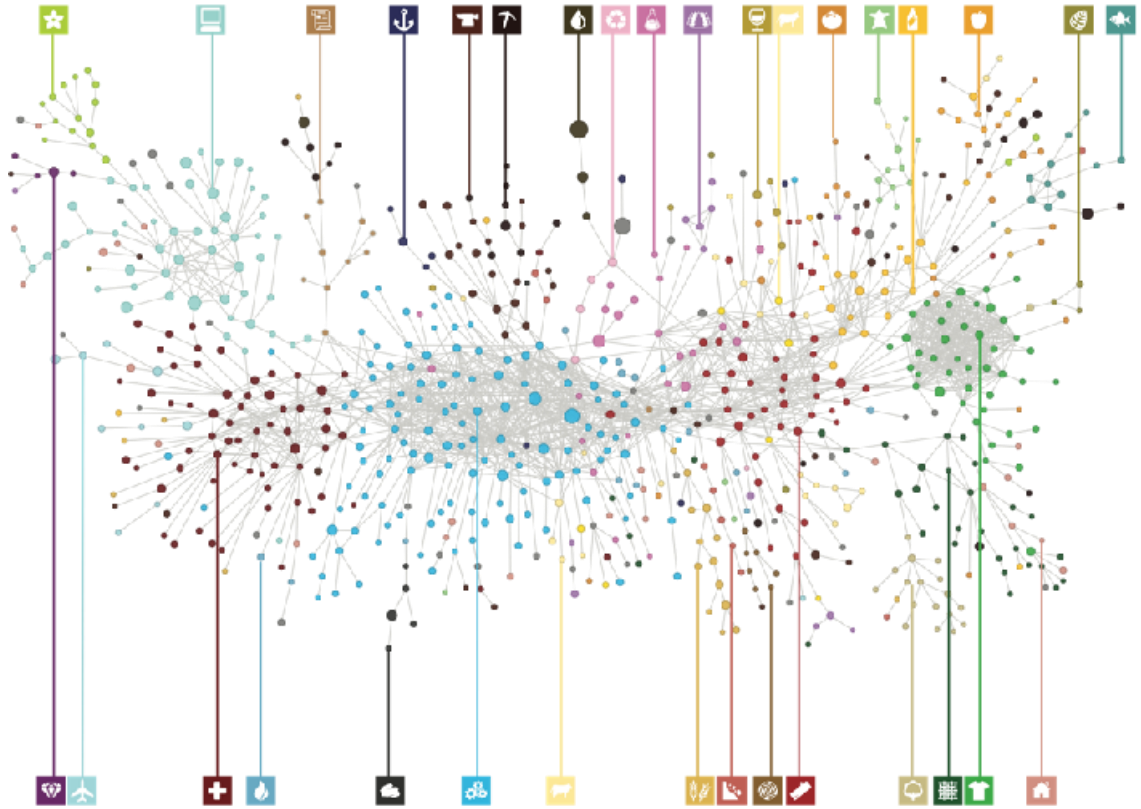


# Economies are Complex

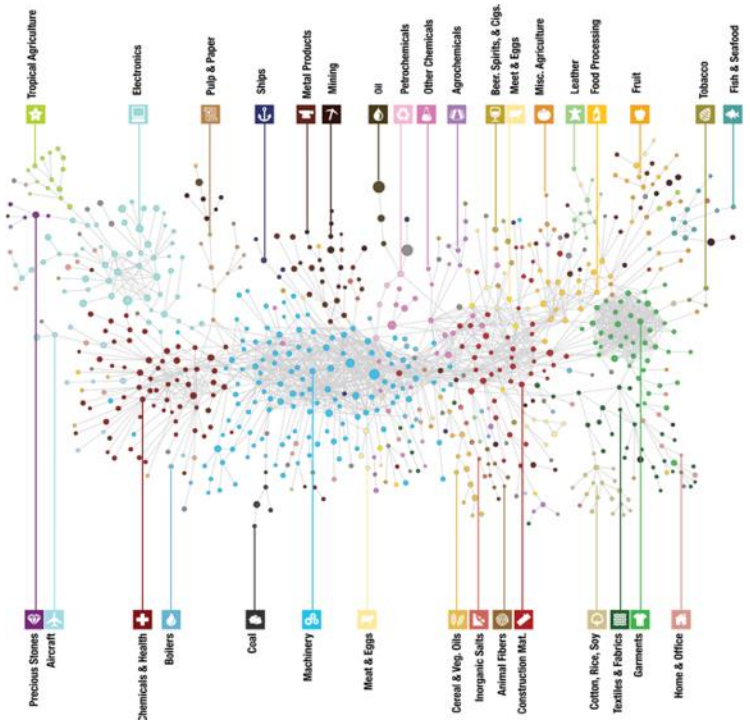

Because
Knowledge is
non-fungible !

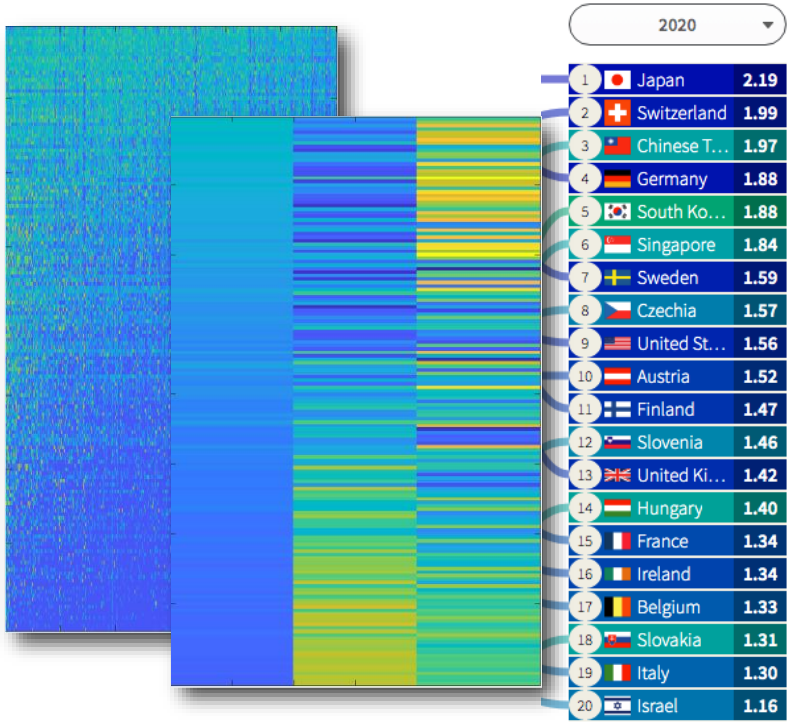
# To understand the economy in detail we need granular representations



Economic complexity is that change!
It provides granular representations of economies that can help us understand where they stand and where they are going.




Research: centerforcollectivelearning.org
Tech: datawheel.us