The Product Space Conditions the Development Of Nations

Paper by Cesar A Hidalgo, Bailey Klinger, Albert-László Barabási, Ricardo Hausmann
Presented by Astra Ford

Agenda

- Paper Topic & Motivation
- Methodology & Results
  - The product space network
  - Analyzing how countries develop over time
  - The paper’s conclusion
- Evaluation of the paper

Paper Topic & Motivation

- Is the rate of economic development of countries influenced by what goods they specialize in?
- There may be many links between products that make certain economic transitions easier, but prior economic models had to make assumptions about those links.
- The paper addresses this by generating a “product space” network of how related goods are, then uses this network to analyze how countries develop.

The Product Space Network

- The paper's assumption: If two goods are related (in that they require similar developmental factors to produce), then they will tend to be produced in tandem.
- **Revealed Comparative Advantage (RCA)** - Does a country export more of a given good relative to its total exports than the world average?
- The paper generates a weighted network of product similarities for 775 different products based on the conditional probability that a country has an RCA in good *i* is given that it has an RCA in good *j*.
    - Formula for the similarity/proximity (ϕ) of two goods:

$$\phi_{i,j} = min(P(\text{RCA}_i \mid \text{RCA}_j), P(\text{RCA}_j \mid \text{RCA}_i))$$

The Product Space Matrix

A

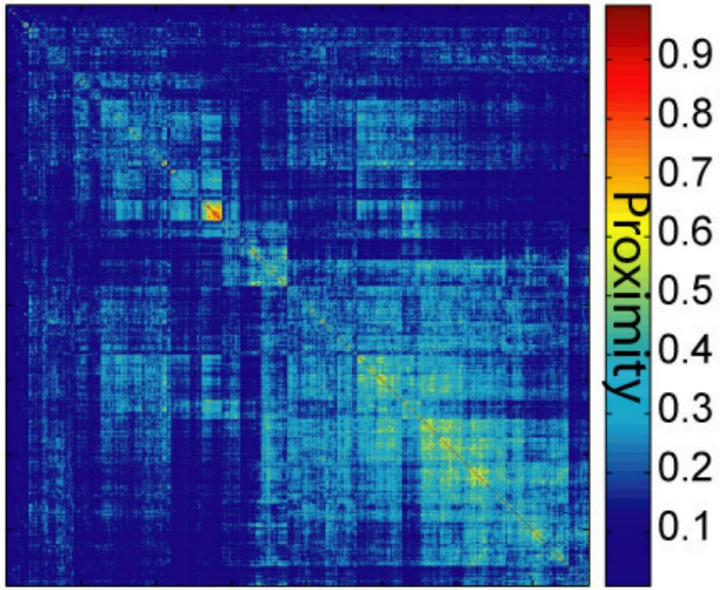


Figure 1A: A hierarchically clustered proximity matrix representing the 775 SITC-4 product classes exported in the 1998-2000 period.

The Product Space Network

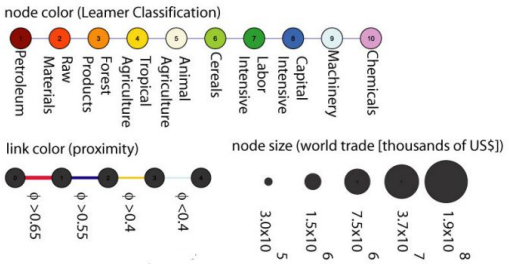
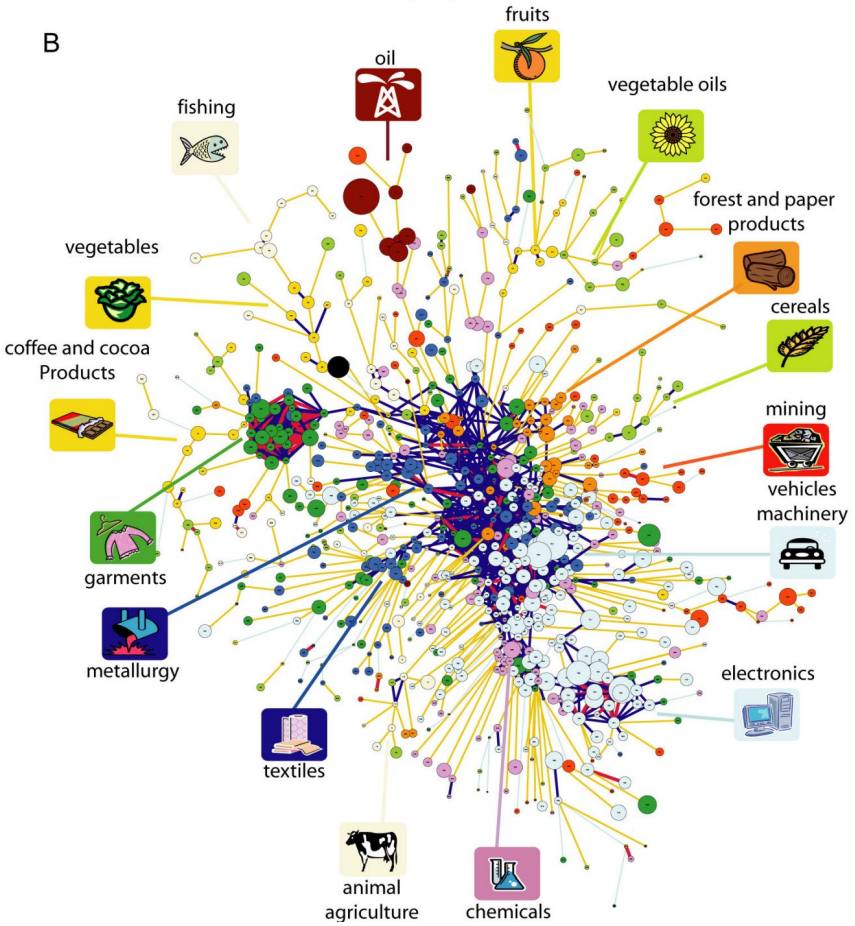


Figure 1B: A network representation of the product space matrix that shows the minimum spanning tree as well as all links with ϕ > 0.55.



The Product Space Network

- Most similarity values (65%) are below 0.2, so a network representation can be used to explore the structure of product relatedness.
- The paper notes significant clusters around electronics, heavy industries such as vehicles and metallurgy, garments, and textiles, plus a fringe composed mainly of primary economic activities (resource production and extraction).

The Product Space Network

- The paper looks at what groups of countries specialize in various clusters
  - Long-industrialized countries: heavy industries
  - East Asia: electronics, textiles, garments
  - Latin America & Caribbean: garments, primary industries
  - Sub-Saharan Africa: primary industries

The Product Space Network

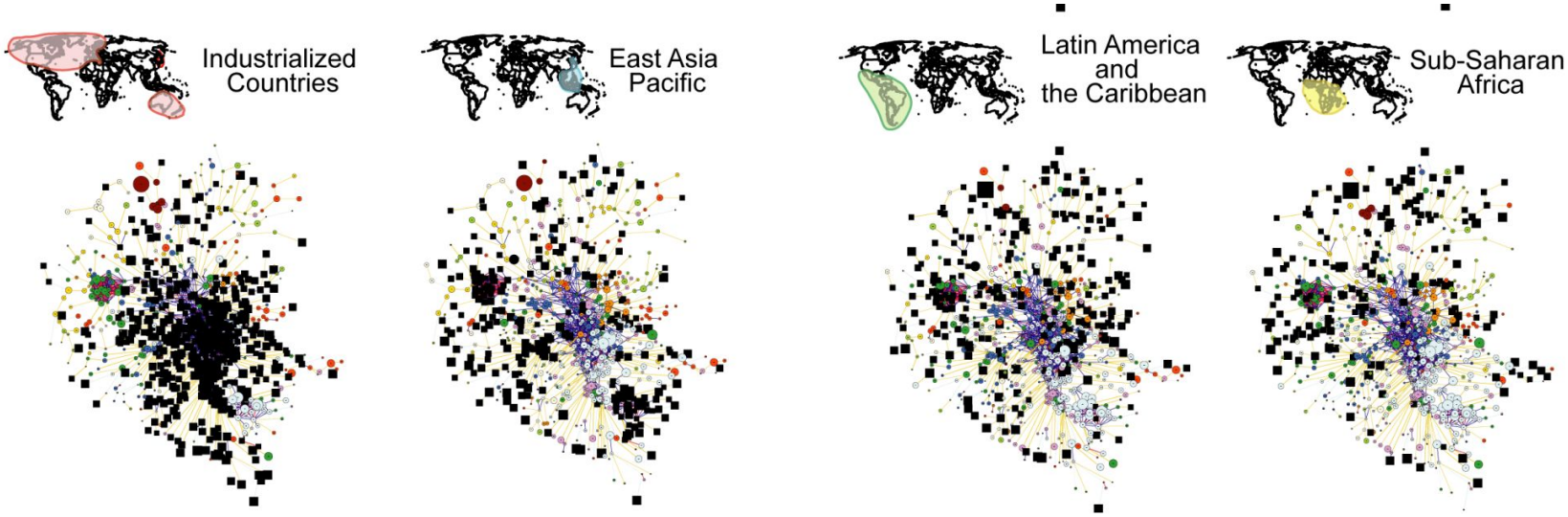


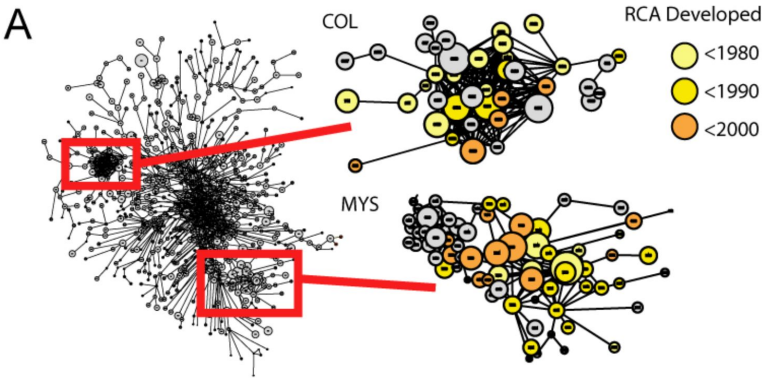
Figure 2: A plot of which goods various regions specialize in. Black squares denote that the region as a whole has an RCA in that industry.

Analyzing How Countries Develop Over Time

- Does the product space network give insights into how countries develop?
- Approach 1: Density of nearby goods
  - Formula for density ω_j^k around good *j* for country *k* (x_i = 1 if RCA > 1 for a country in good *i*):

$$\omega_j^k = (\sum_i x_i \phi_{i,j}) / (\sum_i \phi_{i,j})$$

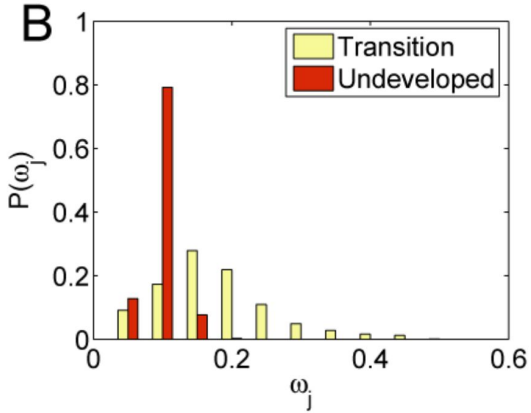
Figure 3A: An example timeline of RCA spreading for Colombia (COL) and Malaysia (MYS).



Analyzing How Countries Develop Over Time

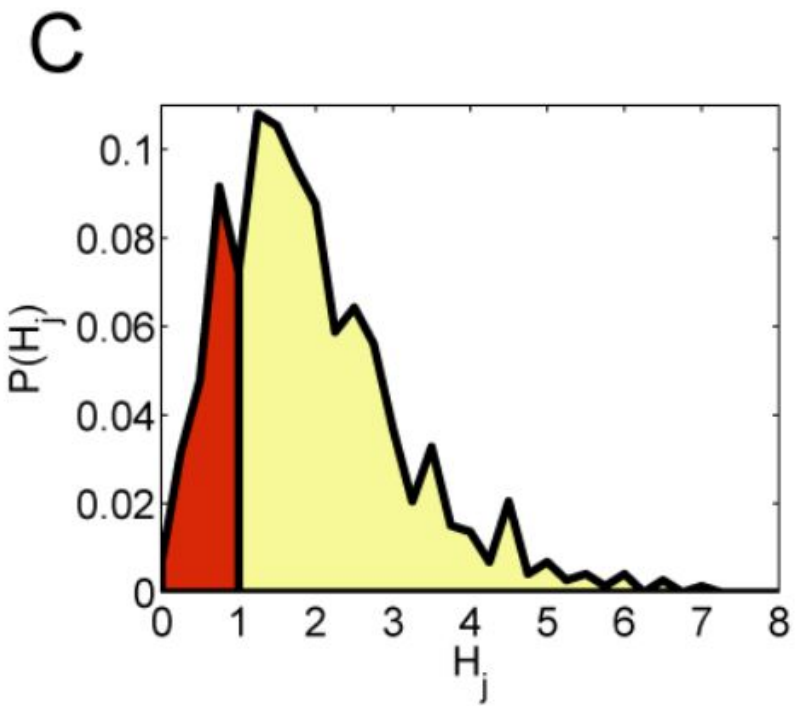
- To evaluate this metric, examine products with RCA < 0.5 in 1990. For each country, products with RCA > 1 in 1995 are transition products, those with RCA < 0.5 are undeveloped products, and values in between are inconclusive.
  - Undeveloped products have a considerably lower density score compared to transition products:

Figure 3B: A graph of the distribution of transition and undeveloped products relative to density.



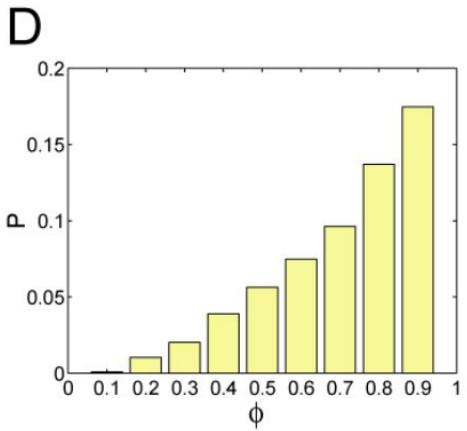
Analyzing How Countries Develop Over Time

Figure 3C: A distribution graph of the ratio H_j of the average density around good j of countries that transitioned to the good to those where it remained undeveloped.



Analyzing How Countries Develop Over Time

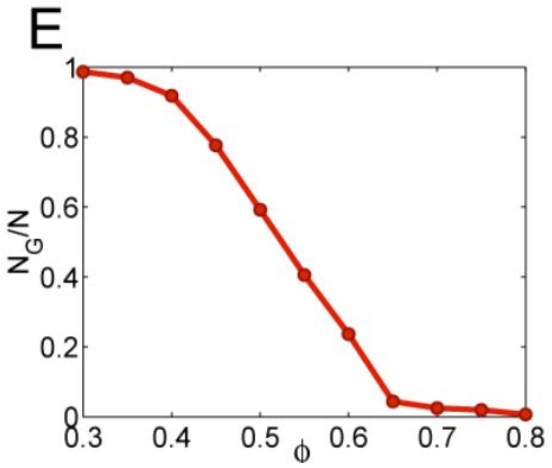
- Approach 2: Consider the probability that a country transitions to good *j* in 1995 relative to the proximity of the most similar good it has an RCA in during 1990.
  - As the proximity of the nearest good increases, the probability of transitioning to that good (shown in Figure 3D) increases monotonically:



Analyzing How Countries Develop Over Time

- Approach 3: Assume a country can only transition between goods if their proximity is at least some minimum proximity ϕ_0, then use this sparse network to simulate which development paths a country can take.

Figure 3E: A graph of the size of the network's largest connected component relative to ϕ_0.

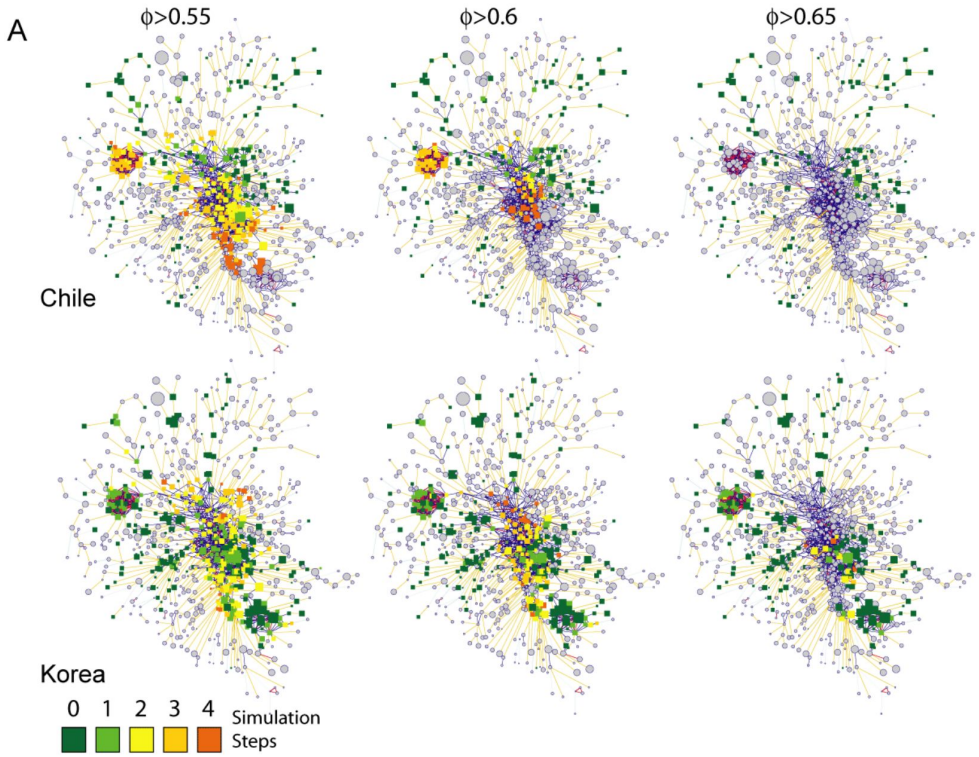


Analyzing How Countries Develop Over Time

- Simulate development potential for a given ϕ_0 by allowing countries to diffuse to all goods where, in the network for ϕ_0, neighboring a good in the country already has an RCA in and count the number of steps needed to develop various products.

Analyzing How Countries Develop Over Time

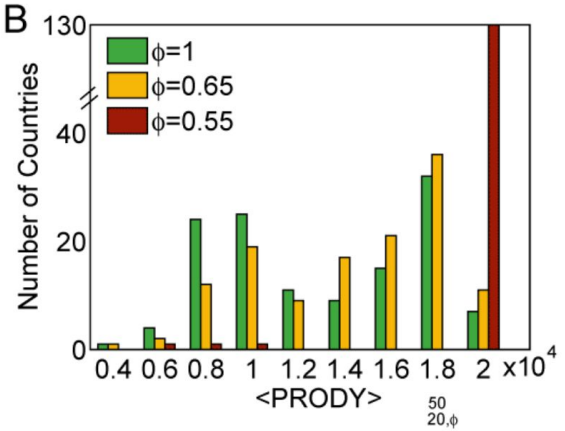
Figure 4A: A diagram showing the various predicted diffusion rates for Chile and Korea at various ϕ_0 values.



Analyzing How Countries Develop Over Time

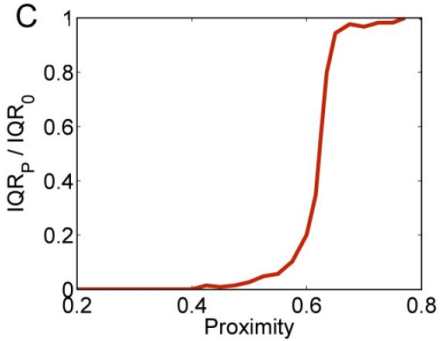
- To generalize this approach to the whole world, we need a value to summarize a country's position in the product space network.
  - First, for each good, mark its income level (PRODY) as the weighted GDP per capita of all countries with an RCA in the good.
  - A country's position in the product space (<PRODY>) is characterized by the average PRODY of the top *N* goods it has diffused to.

Figure 4B: A graph of the distribution of <PRODY> scores for various countries after 20 iterations for various ϕ_0 values. ϕ_0 = 1 is included to show the current global distribution.



Analyzing How Countries Develop Over Time

- For low values of ϕ_0, nearly all countries are able to develop with only a few countries left behind, but for high values of ϕ_0, few countries are able to develop beyond their existing goods.
  - The authors calculate this level of convergence via the Inter-Quartile Range (IQR) for the final <PRODY> scores versus the IQR for the initial distribution. There is an abrupt change in convergence at ϕ_0 = 0.6. This data is illustrated in Figure 4C:



The Paper’s Conclusion

- The paper gives a few noteworthy use cases for its approach:
  - Most countries are likely to transition to products with a strong link to their existing product set, but whether such an approach is effective varies significantly depending on the exact makeup of their product set, even among similar countries.
  - For low-income countries, this approach can be used to determine whether a country would benefit from policies that encourage the development of radically different industries or from policies that promote industries related to existing industries.

Evaluation

- Modeling a nation’s economic state via a network of goods produced is a major improvement over the simpler models that preceded the paper.
  - A conventional approach requires a level of abstraction that is vulnerable to authors making incorrect assumptions about which industries are grouped together or outright eliminating types of goods produced from the equation altogether.

Evaluation

- The model ignores domestic production and consumption, which are major forces in economic development, especially in countries that are relatively self-sufficient.
    - A caveat here is that reliable data on international exports is inherently easier to collect than data on domestic production/consumption, especially in countries without reliable institutions to measure that data.
- The model also completely excludes the service sector, which accounts for a large proportion of GDP in most developed economies.
- The model relies on a binary threshold for RCA, which fails to take into account subtle changes in production levels that would otherwise reveal a trend of growth or decline in a particular good.

Evaluation

- In their predictive model, the paper limits diffusion to links between goods exceeding a certain ϕ_0, but the data in Figure 3D shows that diffusion is possible (at least, in the years they selected) for goods with low proximities to existing industries, albeit less common than transitions to goods with a higher proximity.
  - Rather than search for an ideal ϕ_0 value, simulating a reduced rate of diffusion for goods with lower proximities to existing goods based on real-world data may yield better results.

Any Questions?

Hidalgo, C. A., Klinger, B., Barabási, A. L., & Hausmann, R. (2007). The product space conditions the development of nations. *Science*, *317*(5837), 482-487.