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NETWORK POWER

Complexity and the Wealth of Nations

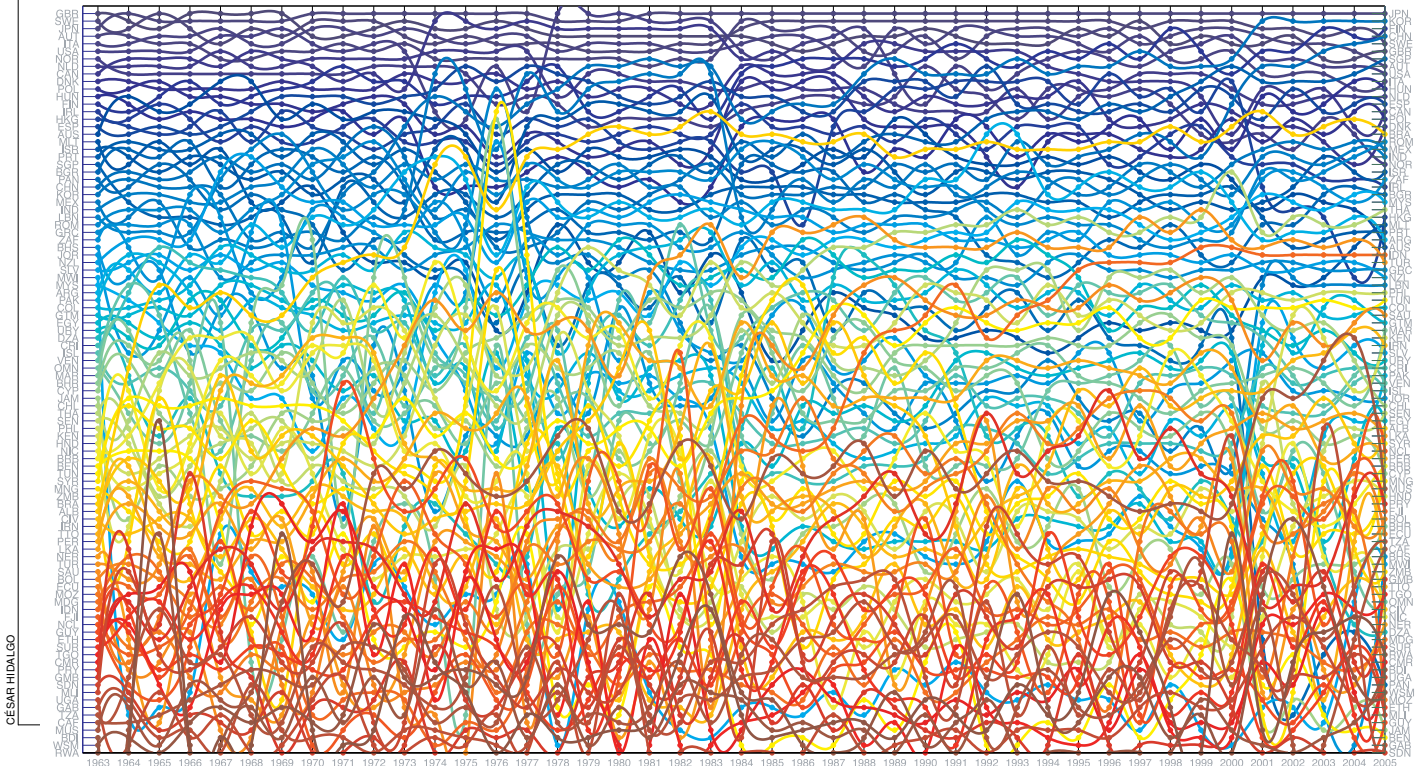
A TRUISM ABOUT the benefits of international trade holds that countries that specialize in producing goods that they are best at manufacturing will enjoy the greatest prosperity. But a recent study of economic complexity provides a different take on the wealth of nations. Using “network science,” a method of analysis that examines

webs of connections in complex systems, Ricardo Hausmann, professor of the practice of economic development and director of Harvard’s Center for International Development, and CID research fellow César Hidalgo, a physicist by training, have shown that the richest countries are those with the most complex economies—and actually produce the greatest diversity of goods.

“Firms and individuals specialize, countries diversify,” emphasizes Hausmann.

Why is complexity correlated with wealth? “Suppose countries differ in the variety of capabilities they possess, while products differ in the variety of capabilities their production requires,” says Hausmann. “Then you would expect countries with more capabilities not only to be able to make more products, but also to make products that few other countries can make.” Rich countries do just this, the data show, accumulating capabilities (in so-

The complexity of nations’ economies changes over time. César Hidalgo used network science to graph the phenomenon, as shown below for 99 nations between the years 1963 and 2005.



phisticated electronics, for example) and then developing new products that require mastery of their use.

In order to gauge a country's economic complexity, Hausmann and Hidalgo used as a proxy the number, variety, and rarity of goods that it exported. Though this metric doesn't include services, it nevertheless provides a much more granular view of an economy than traditional measures such as GDP (gross domestic product), or capital and labor.

Hidalgo and Hausmann say they were not surprised to find that their measures of economic complexity weren't perfectly correlated with each country's level of income. "What really surprised us," Hidalgo

says, "was that the imperfections actually predicted future growth. Countries that we expected to be richer at a given point in time exhibited faster growth in subsequent years. It is as if countries converge to the level of income that their complexity can support." Among countries catching up to their own complexity, he cites India, China, and Ukraine.

But countries whose economies are not already complex face a chicken-and-egg problem. "Developing the capacity to make new, more complex products is difficult because the requisite capabilities may not be present," explains Hausmann. "By the same token, accumulating new capabilities is difficult because the products that require them may not yet exist."

The current research builds on earlier work by Hausmann that mapped "product space" by depicting clusters of product groups according to their relatedness (see graphic at left). As an analogy, he says, "Think of a product as a tree and firms as monkeys. There are rich and poor parts of the forest. What you want is to have the monkeys jump from the poor part to the rich part. But in some places, the trees are close together, so it is easy for the monkeys [firms] to move around. In other places, the trees are far apart—this is where the capabilities that go into making one thing don't help much in making the next thing." Thus his map of product

goods such as machinery and chemicals, with similarly dense clusters around electronics and garments. Rich countries are active in these clusters. Mining, by contrast, is an isolated industry. "Africa is only in the sparse part of the forest," explains Hausmann. "Countries get trapped because they are in a sparse part of the product space."

When a country with many complex capabilities adds a new capability, that can create a range of new possible products. But adding a single new capability in a country that has few to begin with won't leverage an existing matrix of capabilities in the same way—it might not produce any new products at all.

The field of economics has dealt with the obvious complexity of the world by summing things up with aggregate measures such as GDP. But "as you aggregate, you destroy information about the structure," Hausmann points out. "In some sense, what we are finding is that the level of production is explained by the structure of production." Their research implies that economic-development strategies should focus on helping countries find ways to coordinate the generation of linked capabilities and products—preferably by establishing clusters in the denser parts of the product forest.

—JONATHAN SHAW

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The international "product space"

space shows a large cluster around capital-intensive

TORMENT AND GUILT

The Power of Torture

NOWHERE IN THE pages of the *Malleus Maleficarum* (The Hammer of Witches), a fifteenth-century German book that served as a kind of witch-hunt manual, is there any guidance on what one should do if the witch is innocent. "The idea, apparently, was to keep going until the witch confesses, at which point, you burn her," says Kurt Gray, a Ph.D. student in social psychology.

Modern victims of torture face similarly poor odds of convincing their tormentors

of their innocence, says Gray. In a recent study published in the *Journal of Experimental Social Psychology*, he and professor of psychology Daniel Wegner found that subjects who underwent "torture" and expressed pain appeared guiltier to those complicit in their torment.

Research participants who showed up for what they believed was a study on morality were introduced briefly to a "partner" (an actress) and then escorted, alone, to a nearby room, where they were told the woman might have cheated in a die-roll

experiment to win more money for herself than for her partner. They were also told that the truth is often admitted under stress, and that they'd hear the woman being "tortured" by having her hand immersed in ice water for 80 seconds.

Participants heard one of two scenarios. In the first version, the actress remained stoic throughout, noting the cold, but showing no pain. In the second, she expressed increasing pain: at 10 seconds, she hissed; at 20 seconds, she complained that the water was much colder than she'd expected; at 40 seconds, she "couldn't wait for it to be over"; at 60 seconds, she "didn't know how much more she could take."

Neither version featured a confession, but participants who heard the woman in pain reported a higher likelihood of guilt