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A NETWORK VIEW OF ECONOMIC DEVELOPMENT

by Cesar A. Hidalgo and Ricardo Hausmann

Cloth or wine?

Does the type of product a country exports matter for subsequent economic performance? To take an example from the 19th-century economist David Ricardo, does it matter if Britain specializes in cloth and Portugal in wine for the subsequent development of either country? The seminal texts of development economics held that it does matter, suggesting that industrialization creates externalities that lead to accelerated growth (Rosenstein-Rodan 1943; Hirschman 1958; Matsuyama 1992). Yet, lacking formal models, mainstream economic theory has made little of these ideas. Instead, current dominant theories use two approaches to explain countries' patterns of specialization.

The first approach focuses on the relative proportions in which countries possess productive factors (physical capital, labor, land, skills or human capital, infrastructure, and institutions) and the proportions in which these factors are needed to produce different goods (see Flam and Flanders 1991). Hence, poor countries specialize in goods that are relatively intensive in labor and land, while richer countries specialize in goods that use more human and physical capital and demand better infrastructure and institutions. According to these models, the speed at which each factor (physical capital, say, or skills) is accumulated ultimately determines the change in the type of product the country chooses to export. Underlying these models is the assumption that there always exists some combination of goods through which these factors can be expressed. Thus, controlling for initial factor endowments, the particular products a country produces carry no consequence for future economic performance.

The second approach emphasizes technological differences (Romer 1990) and therefore needs to be complemented with a theory of what may lie behind these differences and how they may evolve over time. The two dominant theories—the varieties model of Romer and the quality ladders of Aghion and Howitt (1992) and Grossman and Helpman (1991)—assume a continuum of products in some technological space. According to this line of thinking, there is always a slightly more advanced product that countries can move to as they upgrade their technology. The world of products is abstracted away and ignored when thinking about structural transformation and growth.

But is the nature of the products involved really unimportant in determining the pattern and speed of development? The abstraction from the space of products in standard economic theory is not an act of naïveté, but a natural consequence of the lack of tools available to describe them. In a recent paper, Hausmann, Hwang, and Rodrik (2007) incorporated the product space into our notions of economic development by introducing a one-dimensional variable—the level of sophistication—to the characterization of products. They show that, controlling for the country's initial level of development, the greater the initial sophistication of its export basket, the faster its subsequent growth. However, a one-dimensional scalar description of the product space may not fully account for the rich structure and pattern of product relatedness—a concept critical to economic development. Here we argue for a network view to describe product relatedness and illuminate various aspects of such development (Hidalgo et al. 2007).

A network view of economic development

Traditionally, economic development has been measured through a host of aggregated variables, mainly gross domestic product (GDP), adjusted by power purchasing parity. Yet, as a concept, development has always been associated with an increase in diversity that cannot be captured by such averages. As the human body develops, cells differentiate into neurons, muscles, bones, and other cell types. Similarly, as nations develop, different industries and products are born. Assessing the health of an economy solely based on its wealth is like assessing the health of a child solely based on its weight. A more nuanced view of development should concentrate on understanding how nations develop different industries and products, rather than trying to predict how they accumulate capital. But how do we describe such a complex process?

A GDP view of development can be seen as a ramp or ladder. Within the confines of such a metaphor, a nation's development is measured by looking at the step on the ladder it occupies, regardless of the products and services that allowed it to get there. Development, however, may not be as one-dimensional as this picture suggests. An alternative metaphor would represent nations as navigating through a rugged landscape rather than climbing up a ladder, searching valleys and crossing mountains and oceans in the search for new products and services. We can represent this landscape with a network.¹

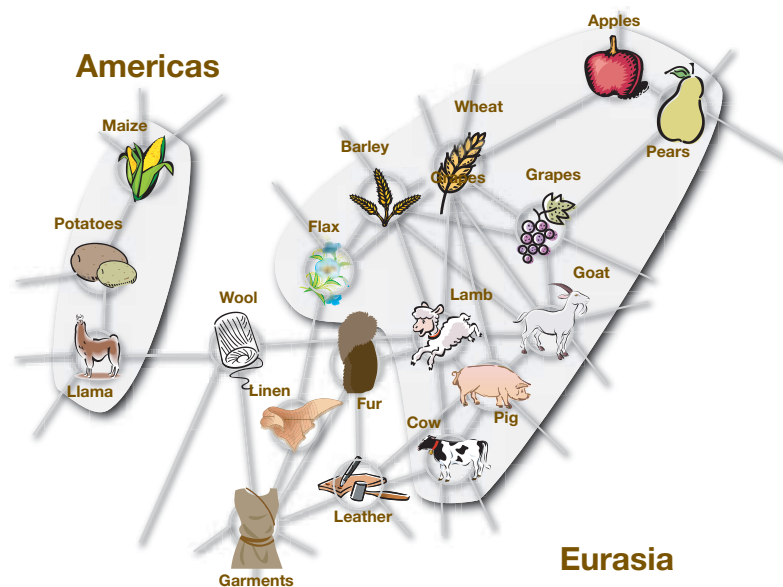
In fact, network representations of physical landscapes are ubiquitous; trivial examples are the subway map or the highway network. And we can illustrate how a network view of economics might look through an example inspired by the view of the world presented in Jared Diamond's *Guns, Germs, and Steel* (1997). Diamond's popular masterpiece is a fascinating view of global development, from our origins as hunters and

gatherers through the long history of plant and animal domestication and beyond. Well documented and rich with fact and anecdote, the book discusses the history of many of our first economic products—such as wheat, barley, pork, flax, and corn—and shows how our world was shaped by a few civilizations that happened to be in the right place at the right time. These civilizations developed farming economies enabling them to produce a surplus that allowed individuals to specialize as, say, soldiers or bureaucrats. Consequently, these tribes dominated their neighbors, physically and/or culturally, and transformed our world from a myriad of independent family groups into a few large, dominant civilizations.

But why did some of these advanced civilizations prevail over the others? To take one element of Diamond's argument, since climate changes little with longitude but greatly with latitude, domesticated plants and animals can diffuse more easily if they travel east or west than if they travel north or south. Since Eurasia is a large expanse spread out on an east-west axis, innovations in one part could travel easily across the continent. However, Africa and the Americas are oriented on a north-south axis, so there are fewer areas with similar latitudes that could readily share new varieties of plants and animals. As a consequence, more products were available to the Eurasians than to the Amerindians and Africans.

We can use a network view of development to describe Diamond's explanation of such disparity. Figure 1 graphically represents the product landscape faced by our ancestors. Civilizations grew by discovering products—that is, domesticating plants and animals. These products in turn allowed them to create more complex products, such as garments, tools, and weapons. Yet not all civilizations started in equally dense parts of the product space. Eurasian populations had access to a broader set of opportunities because of the larger base on which they could experiment and

¹ This approach is far from new, as it was used by the 18th-century Swiss mathematician Leonhard Euler to abstract and solve the famous Königsberg bridge problem. In fact, he showed that the problem had no solution.

FIGURE 1. SKETCH OF THE GUNS, GERMS, AND STEEL PRODUCT SPACE

Note: Links are not scientifically accurate.

then share innovations. They developed wonderful grasses, for example, such as wheat and barley, plus animals that were relatively easy to domesticate, such as goats, sheep, and cows. Eurasian populations—located in a part of the product space where many goods were close to each other—were able to expand quickly over it. On the other hand, civilizations located in the Americas were located in a much sparser part of the product space, where product diffusion was limited by geographical constraints. This limited the economic diversification of early American civilizations and, consequently, their ability to jump to further products in the product space.

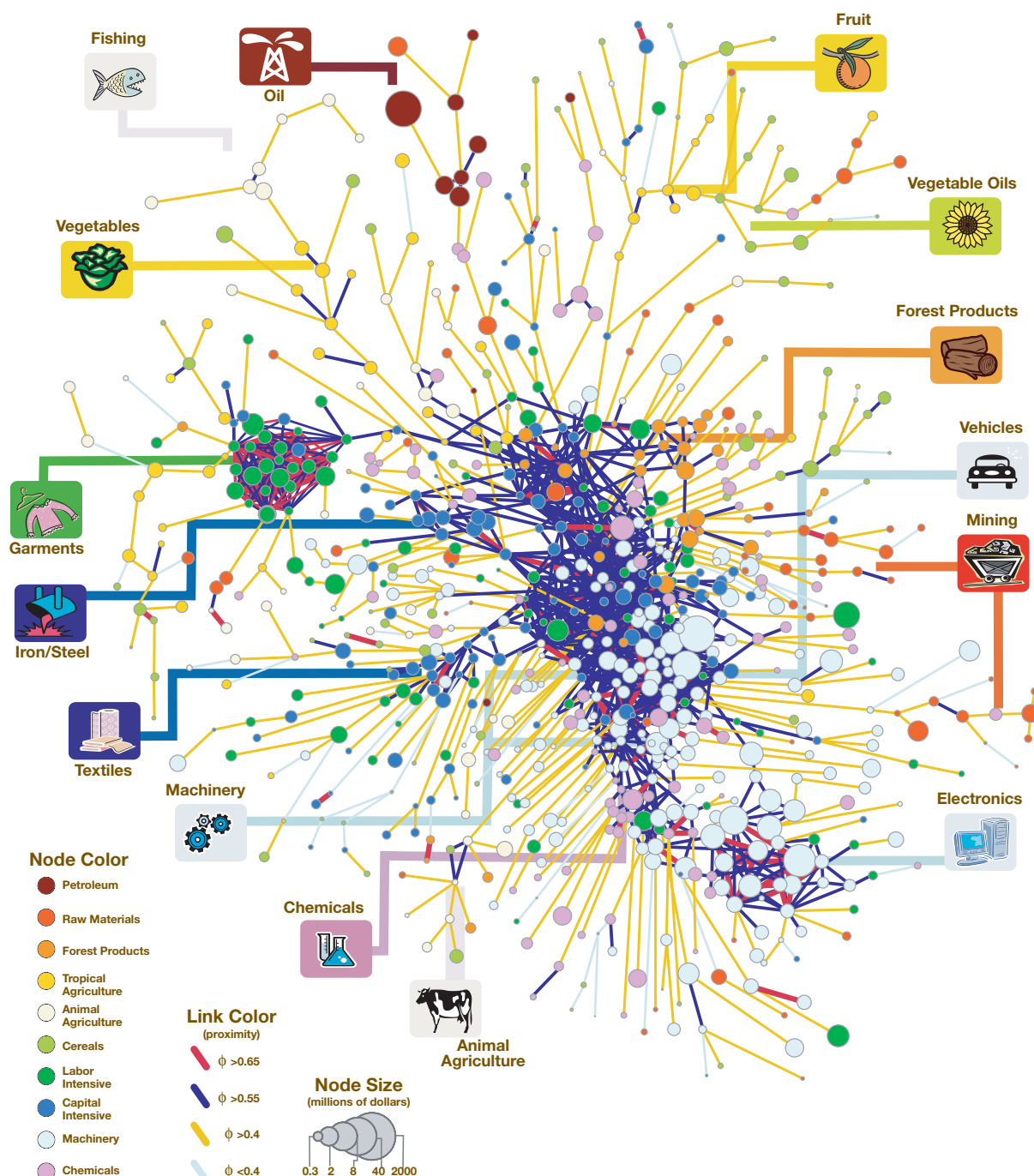
Clues about the nature of the links connecting different products can be gathered by looking at how products are discovered and rediscovered by different populations. Some jumps, like the domestication of apples, can require important technological improvements (in this case, grafting)—improvements that open the door to other developments (in this case, the domestication of pears and plums). Even in ancient times, links between some products or industries were driven by technology. In other cases, some

products or industries may be connected to each other by input/output relationships, such as flax and linen or olives and oil. Yet a third way in which products may be connected is similarity in required infrastructure, such as the silos used to store wheat and barley. A network view of development does not require a unique definition of a link: rather, it requires accepting as a reasonable assumption the fact that there are links connecting some products and not others; links through which knowledge, inputs, and workers can flow; links that may be traversed by endeavor or serendipity.

Exploring the network

In a recent paper, we showed that it is possible to use export data to study development as a diffusion process over a network (Hidalgo et al. 2007). To do this, we first created a measure of distance between a pair of products based on the probability that they were exported by the same countries. This simple method allowed us to construct a network where we showed that countries tend to diversify by developing products that are close in the product space to those they already export. In other words, the network shows empirical association (across countries) of different export products—mapping out the most promising avenues for upgrading. It is easier to move from one product to another within the “forest products” cluster than to leap from there to a product in the electronics group. In that publication, we simplified our discussion by concentrating on cases in which the product space is fixed and countries spread over it, which is a valid assumption for short time scales. We showed that ostensibly similar countries face very different opportunities for diversification because they are at very different distances from other products. Given the structure of the product space today,

FIGURE 2. NETWORK REPRESENTATION OF THE 1998–2000 PRODUCT SPACE



most poor countries can only reach the levels of development enjoyed by rich countries if they are able to jump distances that are quite infrequent

in the historical record (Figure 2). In other words, the “stairway to heaven” presents some very tall steps.

There are many ways in which this analysis can be extended. It may be interesting to study the product space from a labor perspective. One could relate products based on the similarity of the labor skills required to make them. This would allow companies to exchange skilled workers. A new product can more easily be developed if it uses labor skills similar to those used in making existing products. One could also study the patterns of mobility of labor between industries as workers try to adjust to changes in the demand for their skills.

The product space evolves over time, as new products and new ways of making old products are introduced. Cell phones went from not existing, to being made in rich countries, to being assembled in poor countries. Cell phone service is now ubiquitous. The internet allows for an exchange of information that was hitherto unimaginable. Does this development make it easier or harder for countries to transform themselves?

We can also study the robustness of an economy based on its position in the product space and its ability to move in it.²

These are just some of the issues that could be illuminated through study informed by a network perspective. Such analysis opens new avenues to diagnose a country's problems and chart a policy strategy. To do this properly, we will need to redevelop network techniques and concepts developed in other branches of science and adapt them to economics. Additionally, we will need to develop new techniques tailored especially for economic questions and craft a common language to bridge new ideas and more traditional approaches. As large data sets become more common, so will the creation of network maps, as they represent a useful way to surf over new waves of data.

Our own skepticism

Developing a comprehensive description of the world economy as an evolving network is a task requiring many minds and many years, and only time will judge its usefulness. But proposing a network description of the economy is bound to create skepticism. From a theoretical perspective, suggesting that economic development should be seen as a diffusion process over an evolving network is as groundbreaking as proposing that economics could be studied using scalar functions and differential calculus. We often forget that our "Newtonian" view of economics, pioneered by Léon Walras and William Stanley Jevons and continued by Paul Samuelson and others, requires us to assume that the economy can be best described by looking for numerical quantities and functional relationships between them. Most of us forget that assumption because we never made it; we inherited it as college freshmen. Our approach is proposed not to compete against traditional mathematical methods but to complement them, by incorporating tools that can be used to study development from a different perspective.

There are no guarantees that this innovative approach will be useful, just as there were no guarantees for the benefits of using calculus and physically inspired equilibrium processes to describe economics at the beginning of the last century. The proof of the proverbial pudding will have to be revealed by further research.

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² Hausmann, Rodríguez, and Wagner (2008) show that the position of a country in the product space strongly affects the speed at which it recovers from economic crises.

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