Cloth or wine?

Does the type of product a country exports matter for subsequent economic performance? Going back to 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 fathers of development economics held that it does matter, suggesting that industrialization creates externalities that lead to accelerated growth. Yet, lacking formal models, mainstream economic theory has not been able to make much of these ideas. Instead, current dominant theories use two approaches to explain the pattern of specialization of countries. The first approach focuses on the relationship between the relative proportions in which countries possess productive factors (i.e. physical capital, labor, land, skills or human capital, infrastructure, and institutions) and the proportions in which these factors are needed to produce different goods. 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. In these models the speed at which each factor (e.g. physical capital, skills, etc.) 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 carries no consequence for future economic performance. The second approach emphasizes technological differences 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 approaches – the varieties model of Romer and the quality ladders of Aghion and Howitt and Grossman and Helpman – assume a continuum of products in some technological space. As a consequence, there is always a slightly more advanced product that countries can move to as they upgrade their technology. The world of products is therefore abstracted away and ignored when thinking about structural transformation and growth.

But how is the world of products like? Is it 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, as the fathers of development economics held they should matter, but a natural consequence of the lack of tools available to describe them. In a recent paper Hausmann, Hwang and Rodrik incorporated the product space by introducing a one-dimensional variable – the level of
sophistication – to the characterization of products. They show that, controlling for the initial level of development of a country, the greater the initial level of sophistication of its export basket, the faster the subsequent growth. However, a scalar description of the product space may not allow for the richness in the structure and pattern of relatedness of products to emerge. Here we comment about the use of networks to describe product relatedness and economic development.

A network view of economic development

Traditionally, 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 several 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 as correct as assessing the health of a child solely based on its weight. A more detailed view of development should ultimately 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. In such a metaphor, development is measured by looking at the step on the ladder in which each nation is at, regardless of the products and services that allowed them to get there. Development, however, may not be as one dimensional as this picture suggests. An alternative metaphor would represent nations as being spread on a rugged landscape rather than a ladder, searching for new products in its valleys and crossing mountains and oceans in search for new products and services – a Sewall Wright type of metaphor, for those familiar with the great geneticist.

Although inspiring, assuming an entire landscape to study development may seem unpractical. We can overcome this by replacing the landscape with a network. This approach is far from new, as it was used by Euler to abstract and solve the famous Konigsberg bridge problem. In fact, network representations of physical landscapes are ubiquitous. Trivial examples are the subway map or the highway network. Hence, if describing economies as a set of nomadic tribes wondering on a product landscape is as valid an analogy as describing it as a progression over a scalar function, then a network view of development is at least as valid as a scalar one-dimensional representation.

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 masterpiece Guns, Germs and Steel (GG&S). For those not familiar with the book, it is a fascinating view of our civilization’s origins, as it arose from our origins as hunters and gatherers through our long history with plant and animal domestication. The book is full of beautifully documented facts and anecdotes disclosing the history of many of our civilization’s first economic products, like wheat, barley, pork, flax and corn. Through a careful and well documented discussion, the book shows how our world was shaped by a few civilizations, which
happened to be on the right place at the right time. These civilizations were able to develop primitive farming economies enabling them to produce enough surplus to allow individuals to specialize into soldiers and bureaucrats. Consequently, these tribes dominated their neighbors, physically and/or culturally, and transformed our world from a myriad of thousands of independent family groups, into a few large dominant civilizations.

But why did some of these advanced civilizations prevail over the others? According to Diamond’s argument, since climate changes little with longitude but a lot 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 whole continent. However, Africa and the America’s are spread on a North – South axis and consequently there are fewer areas with similar latitudes that could share new varieties of plants and animals. As a consequence, there were more products available to the Eurasians than to the Amerindians and Africans.
We can use a network view of development to describe Jared Diamond’s explanation of such disparity. Figure 1 shows a graphical representation of the product landscape faced by our ancestors. Civilizations grew by discovering products, i.e. domesticating plants and animals. These 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 share. They developed wonderful grasses, like wheat and barley, plus animals that were relatively easy to domesticate, such as goats, sheep and cows (12). Omitting details on the nature of the links connecting different products, it is accurate to say that Eurasian populations were located in a denser part of the product space -- where many goods were close to each other -- allowing them 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 – that once achieved, opened the door to other fruits like pears and plums. Hence, even in the most ancient of 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, like flax and linen or olives and oil. Yet a third way in which products may be connected is similarity in required infrastructure, like the silos used to store wheat and barley. A network view of development does not require a unique definition of a link, but rather 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 could 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 diffusion process over a network (9). 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 (Error! Bookmark not defined.). This simple method allowed us to construct a network were we showed that countries tend to diversify by developing products that are close in the product space to those they already export (9). In that publication, we simplified our discussion by concentrating on the case in which the product space was fixed and countries spread over it, which is a valid assumption for short enough time scales. We showed that apparently similar countries face very different opportunities for diversification because they are at very different distances from other products. We also showed that, given the structure of the product space today (Figure 2), most poor countries can only converge to the levels of development of rich countries if they are able to jump distances that are quite infrequent in the historical record. In other words, the “stairway to heaven” has some very tall steps that are hard to overcome in one move.
Figure 2 Network representation of the 1998-2000 product space.
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 that are similar to products already in production, as new firms can poach trained workers from older firms. 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 in the world. The internet allows for an exchange of information that was hitherto unimaginable. Does this facilitate or make it 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\textsuperscript{13}.

These are just some examples of the perspectives that could be studied from a network perspective. It opens new avenues to diagnose a country’s problems and chart a policy strategy. To properly do this, we will need to redeploy 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 develop a common language that can be used to bridge new ideas and more traditional approaches. As large data sets become more ubiquitous, the creation of network maps will also become more common, as they represent a useful way to surf over new waves of data.

**Our own skepticism**

Proposing a network description of the economy is bound to create skepticism. Time will judge its usefulness, as the creation of a sensible and complete description of the world economy as an evolving network is a task requiring many minds and years. From a theoretical perspective, suggesting that economics should be described as a spreading 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 Walras and Jevons and continued by Samuelson and many 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 not against the use of traditional mathematical methods. On the contrary, it looks to complement them by incorporating tools that can be used to study development from a different perspective.
There are no guarantees that this approach will be useful, 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. Yet, markets have taught us the importance of leaving room for innovation. A network view of development may be just one such innovation.

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