

SECTION I

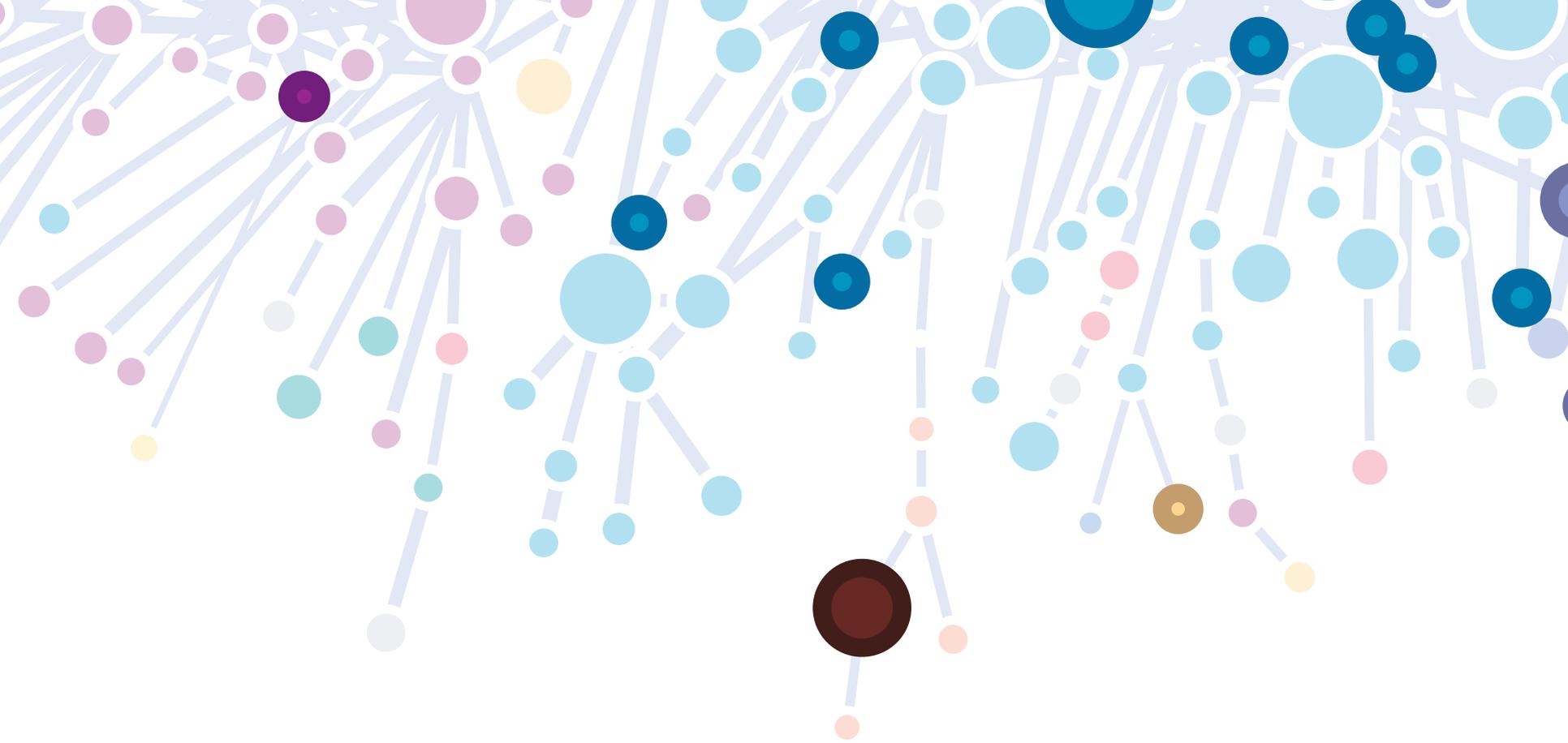
What Do We Mean by *Economic Complexity*?

One way of describing the economic world is to say that the things we make require machines, raw materials and labor. Another way is to emphasize that products are made with knowledge. Consider toothpaste. Is toothpaste just some paste in a tube? Or do the paste and the tube allow us to access knowledge about the properties of sodium fluoride on teeth and about how to achieve its synthesis? The true value of a tube of toothpaste, in other words, is that it manifests knowledge about the chemicals that kill the germs that cause bad breath, cavities and gum disease.

When we think of products in these terms, markets take on a different meaning. Markets allow us to access the vast amounts of knowledge that are scattered among the people of the world. Toothpaste represents knowledge about the chemicals that prevent tooth decay, just like cars embody our knowledge of mechanical engineering, metallurgy, electronics and design. Next time you bite into an apple, consider that thousands of years of plant domestication has been combined with knowledge about logistics, refrigeration, pest control, food safety and the preservation of fresh produce to bring you that piece of fruit. Products are vehicles for knowledge, and the process of embedding knowledge in products requires people who possess a working understanding of that knowledge. Most of us have no idea how toothpaste works, let alone how to make it, because we can rely on the few people who know how to create this molecular cocktail, and who, together with their colleagues at the toothpaste factory, can create a product that we use every day.

We owe to Adam Smith the idea that the division of labor is the secret of the wealth of nations. In a modern reinterpretation of this idea, the reason why the division of labor is powerful is that it allows us to access a quantity of knowledge that none of us would be able to hold individually. We rely on dentists, plumbers, lawyers, meteorologists and car mechanics to sustain our standard of living, because few of us know how to fill cavities, repair leaks, write contracts, predict the weather or fix our cars. Markets and organizations allow the knowledge that is held by few to reach many. In other words, they make us collectively wiser.

The amount of knowledge embedded in a society, however, does not depend mainly on *how much knowledge* each individual holds. It depends, more fundamentally on *the diversity of knowledge* across individuals and on their ability to combine this knowledge, and make use of it, through complex webs of interaction. A hunter-gatherer in the Arctic must know a lot of things to survive. Without the knowledge held by each member of an Inuit community, most people unfamiliar with the Arctic would die. While the knowledge held by each individual, or within each family, is essential for survival and wellbeing, the total amount of knowledge embedded in a hunter-gatherer society is not very different from that which is embedded in each one of its members. The secret of modern societies is not that each person holds much more productive knowledge than those in a more traditional society. The secret to modernity is that we collectively use large volumes of knowledge, while each one of us holds only a few bits of it. Society functions because its members form webs that allow them to specialize and share their knowledge with others.



We can distinguish between two kinds of knowledge: explicit and tacit. Explicit knowledge can be transferred easily by reading a text or listening to a conversation. Yesterday's sports results, tomorrow's weather forecast or the size of the moon can all be learned quickly by looking them up in a newspaper or on the web. And yet, if all knowledge had this characteristic, the world would be very different. Countries would catch up very quickly to frontier technologies, and the income differences across the world would be much smaller than those we see today. The problem is that crucial parts of knowledge are tacit and therefore hard to embed in people. Learning how to fix dental problems, speak a foreign language, or run a farm requires a costly and time-consuming effort. As a consequence, it does not make sense for all of us to spend our lives learning how to do everything. Because it is hard to transfer, tacit knowledge is what constrains the process of growth and development. Ultimately, differences in prosperity are related to the amount of tacit knowledge that societies hold and to their ability to combine and share this knowledge.

Because embedding tacit knowledge is a long and costly process, we specialize. This is why people are trained for specific occupations and why organizations become good at specific functions. To fix cavities you must be able to identify them, remove the decayed material and fill the hole. To play baseball, you must know how to catch, field and bat, but you do not need to know how to give financial advice or fix cavities. On the other hand, to perform the function of

baseball player, knowing how to catch a ball is not enough (you must also be able to field and bat). In other words, in allocating productive knowledge to individuals, it is important that the chunks each person gets be internally coherent so that he or she can perform a certain function. We refer to these modularized chunks of embedded knowledge as **capabilities**. Some of these capabilities have been modularized at the level of individuals, while others have been grouped into organizations and even into networks of organizations.

For example, consider what has happened with undergraduate degrees, which in the United States require four years of study. This norm has remained constant for the last four centuries. During the same period, however, knowledge has expanded enormously. The university system did not respond to the increase in knowledge by lengthening the time it takes to get a college degree. Instead, it increased the diversity of degrees. What used to be a degree in philosophy was split into natural and moral philosophy, the former later splitting into physics, chemistry and biology and later into other disciplines such as ecology, earth sciences and genetics. The Bureau of Labor Statistics' Standard Occupation Classification for 2010 lists 840 different occupations, including 78 in healthcare, 16 in engineering, 35 kinds of scientists – in coarse categories such as economists, physicists and chemists, five types of artists, and eight kinds of designers. We all certainly can imagine an even more nuanced classification in our respective fields. For instance, we could



distinguish between economists that specialize in labor, trade, finance, development, industrial organization, macro and econometrics, among others. If we did this further disaggregation for all occupations, we would easily go into the tens of thousands. The only way that society can hold all of the knowledge we have is by distributing coherent pieces of it among individuals. This is how the world adapts to expanding knowledge.

Specialization allows societies to store more knowledge, but the question becomes how to put the different chunks of specialized knowledge to use. Most products that are used today require more knowledge than can be mastered by any individual. Hence, those products require that individuals with different capabilities interact with each other. We call the amount of knowledge held by one person a *personbyte*. How can you make a product that requires the input of 100 different people, or 100 *personbytes*? Obviously, it cannot be made by a micro-entrepreneur working alone. It has to be made either by an organization with at least 100 individuals (each with a different personbyte), or by a network of organizations that can aggregate these 100 personbytes of knowledge.

Consider how a shirt is made and sold. It first needs to be designed, and then fabric must be procured, cut and sewn. It needs to be packed, branded, marketed and distributed. In a firm that manufactures shirts, different people will hold expertise in each of these knowledge chunks – the shirt business requires all of them. Moreover, you need to finance

the operation, hire the relevant people, coordinate all the activities and negotiate everybody's buy-in, which in itself requires different kinds of knowhow. To make shirts, you can import the fabric and, by doing so, access the knowledge about looms and threading that is embedded in a piece of cloth. Yet some of the knowledge required cannot be accessed through shipped inputs. The people with the relevant knowledge must be near the place where shirts are made.

This does not begin to list all that is required to make and sell a shirt. To operate efficiently, firms rely on a large set of complementary systems, networks and markets. Raw materials need to be shipped in and the final product shipped out using transportation companies, ports, roads, airplanes or airports. Workers need to get to work and back home using some kind of urban transportation system. Machines need to be powered by electricity and processes need access to water and water treatment facilities. To be able to operate, the plant manager needs all of these services to be locally available, but she does not need to organize them herself. Other organizations are responsible for organizing and aggregating the personbytes required to generate power, provide clean water, and run a transportation system. The relevant capabilities to perform all of these functions reside in organizations that are able to package the relevant knowledge into transferable bundles. These are bundles of knowhow that are more efficiently organized separately and transferred as intermediate inputs or services. We can think

of these bundles as organizational capabilities the manufacturer needs. In fact, just as knowhow is modularized in people in the form of individual capabilities, larger amounts of knowhow are modularized in organizations, and networks of organizations.

Ultimately, to make the products that have been invented in the past 200 years, many personbytes have to be put together. These different personbytes have to reside in different people. To utilize the diversity of knowledge in a complex society, many people have to come together in many ways. They form teams we call firms and organizations and these are in turn connected through markets and other forms of interaction. The amount of productive knowledge that a society uses is reflected in the variety of firms it has, in the variety of occupations these firms require and in the extent of interactions between firms. **Economic complexity** is a measure of how intricate this network of interactions is and hence of how much productive knowledge a society mobilizes. Economic complexity, therefore, is expressed in the composition of a country's productive output and reflects the structures that emerge to hold and combine knowledge.

Knowledge can only be accumulated, transferred and preserved if it is embedded in networks of individuals and organizations that put this knowledge into productive use. Knowledge that is not used is not transferred, and will

disappear once the individuals and organization that have it retire or die.

Said differently, countries do not make all the products and services they use and need. They make the ones they can, using the knowledge embedded in their own people and organizations. Some goods, like medical imaging devices or jet engines, require large amounts of knowledge and are the results of very large networks of people and organizations. By contrast, wood logs or coffee beans require much less knowledge and the networks required to support these operations do not need to be as large. Complex economies are those that can weave vast quantities of relevant knowledge together, across large networks of people, to generate a diverse mix of knowledge-intensive products. Simpler economies, in contrast, have a narrower base of productive knowledge and as a result they produce fewer and simpler products, requiring smaller webs of interaction. Because individuals are limited in what they know, the only way societies can expand their knowledge base is by facilitating the interaction of individuals with different knowledge sets in increasingly complex webs of organizations and markets. Increased economic complexity is necessary for a society to be able to hold and use a larger amount of productive knowledge. Because of this, we can measure complexity by looking at the mix of products that countries are able to make. ●