



# Economic Premise

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## Global Connectivity and Export Performance

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*The World Bank has developed a novel method for measuring countries' connectivity in global networks and has applied it to the global air transport network. "Connectivity" in this context is defined as a country's relative position in that network in terms of the total "push" and "pull" it exerts on air traffic, taking account of all possible links with other countries. Well-connected countries that are strongly connected to other well-connected countries are considered "hubs" in this definition. Less well-connected countries are "spokes." The Air Connectivity Index (ACI) shows that connectivity is highly concentrated in North America and Europe ("hubs"); most developing countries are relatively poorly connected ("spokes"). Developing countries looking to increase their participation in global value chains need to improve their connectivity as part of their overall competitiveness strategy, including the progressive liberalization of their air transport sectors.*

### What Is Connectivity?

One of the most salient features of the international economy over recent years has been the rise of networked production through global and regional value chains. In many parts of the world, intermediate inputs are manufactured at a location different from the place of final assembly, which means that goods cross borders frequently before finally being shipped to a remote consumer. Electronics is the sector for which global value chains are most well-known, including products such as the iPhone. But global value chains also exist in other sectors, such as textiles and clothing, and even processed agriculture. As a result, a wide range of countries at various income levels are all involved in globalized or regionalized production platforms.

For countries still on the edge of global value chains, the key question is how to effectively integrate them to reap the economic benefits that come with increased trade and foreign investment. Because goods move so frequently and so far within the value chain model, a country's ability to connect to

global and regional networks in areas such as transport, finance, and trade is a key determinant of its degree of integration into the international economy. "Connectivity" in this note refers to a country's ability to effectively connect to others within a particular network. The concept of connectivity is thus key in the context of global and regional value chains. Put another way, looking at traffic patterns, is a country a "hub" or a "spoke," and does it trade with "hubs" or "spokes"? Countries that are becoming more competitive in this context are also working hard to improve their connectivity. In some parts of the world, regional cooperation—such as the Asia-Pacific Economic Cooperation's Supply Chain Connectivity Initiative—is used as a specific platform to improve connectivity.

The most important innovation in viewing economic activity through the twin lenses of global and regional production networks and connectivity is that production and consumption are no longer viewed as a point-to-point economic interaction. Instead, the unit of analysis becomes the network, which is inherently a nonlinear framework. An important aspect of the competitiveness agenda therefore becomes im-

proving a country’s position in global networks not just of trade and production, but also in networks that support those processes, such as air and maritime transport and finance, among others.

Connectivity is a difficult concept to formalize and assess in a useful way across countries. One example is provided by Arvis and Shepherd (2011), who analyzed connectivity in the global air transport industry. This note builds on their analysis and provides a robust methodology for measuring connectivity, firmly grounded in economic theory. It also shows that connectivity is a key determinant of important economic outcome variables, such as the percentage of parts and components in total exports, which is one indicator of the extent of a country’s integration into global supply chains.

### Measuring Connectivity

A number of different disciplines have considered the concept of connectivity, but few have applied it to international trade. Definitions change according to the perspective taken and the end use envisaged. In applied mathematics (“network theory”), for example, the purpose of measuring connectivity is primarily to describe the overall hierarchy of a network, such as a subset of the Internet, and identify the most central points (“nodes”). The core techniques are based on linear algebra, such as the widely used eigenvector centrality (a modification of which is used to run Google’s Page Rank algorithm), which is primarily a way of summarizing an important characteristic of real-world networks. However, network theory literature does not have any direct economic policy application.

By contrast, the policy literature—such as the United Nations Conference on Trade and Development’s (UNCTAD) Liner Shipping Connectivity Index—targets policy makers and analysts for its main audience. The UNCTAD approach consists of taking a weighted average of a certain number of countrywide indicators of economic and shipping activity connectivity, which are then summarized in a single index. This heuristic approach has proved very useful in applied work, but is not rooted in theory and is not explicitly grounded in network analysis.

The challenge for policy-relevant work on connectivity in the context of international economics is therefore to develop a concept that provides a network understanding in which the interaction between two countries depends on all other interactions in the network. Unlike linear models from standard “network theory,” the concept should also include the existence of links between countries, as well as the mechanism that explains the intensity of transport or trade flows along those links.

### Air Connectivity Index

Moving from the more general concept of connectivity as a country’s ability to effectively connect to others within a par-

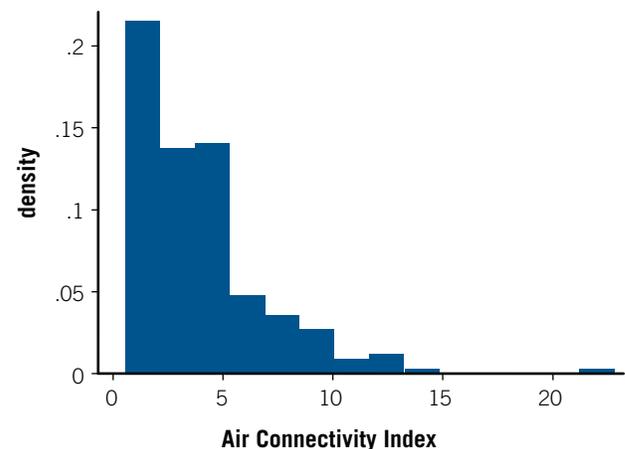
ticular network, Arvis and Shepherd (2011) defined connectivity as the total “push” or “pull” exerted by a country on the global air transport network, taking into account all possible connections—even those where there are no actual flights available. The World Bank summarizes connectivity in a single number, the Air Connectivity Index (ACI). Countries have a higher ACI score and are better connected to the network if they have strong connections to other countries that are themselves well connected, and if the dispersion of their connectivity scores is low. Thus, countries with relatively strong connections to a wide range of countries that are themselves well connected tend to have higher ACI scores. Those countries with relatively weak connections to countries that are themselves poorly connected record lower ACI scores. The ACI itself is normalized as a percentage of the theoretically maximum global push or pull: zero indicates that a country has no connections whatsoever, and 100 percent indicates that it is strongly and directly connected to all other countries in the network.

The theoretical background for the ACI is a standard gravity model, taken from the trade and regional science literatures. The formulation used is very flexible and is consistent with a variety of microeconomic underpinnings. As such, the ACI represents the first attempt to measure connectivity in a global network using a theoretically grounded approach. The same approach could conceivably be applied in other areas such as maritime transport, trade, and finance.

### Connectivity in the Global Air Transport Network

Application of the ACI model to data on global air transport flows covering 211 countries and territories for the year 2007 produces stylized facts that are highly consistent with expectations. As figure 1 shows, there are a small number of relatively well-connected countries, but most countries remain

**Figure 1. Few Countries Have High ACI Scores (Hubs), Most Are Poorly Connected (Spokes)**



Source: Authors’ calculations.

relatively poorly connected. This finding matches the hub-and-spoke nature of the global air transport network, a feature that has been widely emphasized in industry literature.

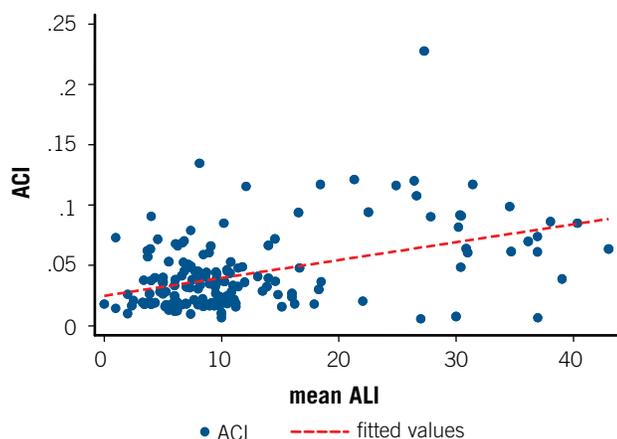
The ACI shows that the United States is the most connected country, with a score of around 23 percent. There is then a substantial gap between the United States and the next group of countries, namely Canada and the main European hubs. Third-ranked Germany, for example, has an ACI score of just over 12 percent. The developing country with the highest score is Algeria, with just under 7 percent, because of its strong connections with European hubs. The main hubs in Asia and the Middle East do not score as highly as might be expected, because they are more distant from the major markets of the United States and Europe.

### Connectivity, Policy, and Trade Outcomes

How do countries become better connected in the global air transport network? Policy is of course a major factor. Building infrastructure and putting in place well-functioning markets for backbone services are crucial. But so too is the degree of liberalization of air transport markets. Figure 2 shows that there is a strong positive correlation between liberalization as measured by the World Trade Organization’s (WTO) Air Liberalization Index (ALI) and connectivity, as measured by the ACI.

In line with the view advanced earlier, that connectivity is a key determinant of competitiveness in the context of global and regional value chains, evidence also shows a strong connection between the ACI and an important trade indicator of value chain participation (figure 3). Although there is no direct evidence on the extent to which different countries participate in production based on global value chains, a common proxy measure is the percentage of machinery parts and components in total exports. As expected, there is a strong positive correlation between air connectivity as

**Figure 2. The Positive Correlation between Air Transport Liberalization and Connectivity**



Source: Authors’ calculations.

measured by the ACI and this proxy for participation in global value chains.

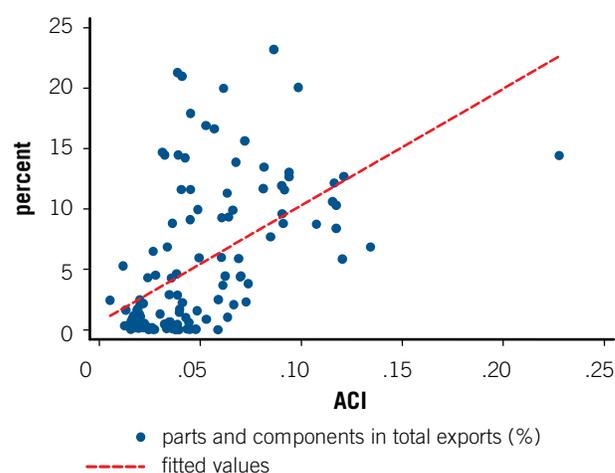
In line with this finding, recent work by Arvis et al. (2013) shows that air and maritime connectivity are important determinants of the level of trade costs between countries. Global and regional value chains can only flourish in environments with low trade transaction costs. New data on trade costs in the developing world for 1995–2010 show that connectivity and logistics performance are at least as important as geographical distance in determining the level of trade costs between countries.

### Conclusion and Policy Implications

Trade policy, particularly “trade and transport facilitation,” the set of policies designed to reduce trade transaction costs, increasingly needs to focus on networks of trade and production as the analytical unit of primary interest. Such an approach naturally leads to increased attention on connectivity as a determinant of competitiveness in a networked world. Improved connectivity can substantially reduce the transaction costs associated with exporting and importing, and thereby improve a country’s ability to take full advantage of the benefits offered by global and regional value chains.

In the context of the air transport network, the World Bank’s ACI provides a robust and theoretically grounded methodology for measuring connectivity. Its structure suggests that policy makers need to be concerned with two primary factors when it comes to connectivity: (i) building stronger links with global and regional hubs and (ii) increasing the number and quality of connections with a wide range of countries to improve their place in the global network. Liberalization of air services markets—which takes place primarily on a bilateral basis—has an important role to play in im-

**Figure 3. ACI Positively Correlated with Trade in Global Value Chains**



Source: Authors’ calculations.

Note: Trade in global value chains is proxied by the percentage of machinery parts and components in total exports.

proving connectivity, as does the improvement of infrastructure and capacity building in the area of aviation and related services. Moving forward on connectivity in developing countries requires policy action on a number of fronts, but it has the potential to provide a powerful boost for efforts to improve export competitiveness.

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