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Evaluation of Value Chain Connectedness in the APEC Region

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EXECUTIVE SUMMARY

Exchanges of value added between firms in different economies represent the core activity of global and regional value chains. However, these exchanges are relatively poorly understood due to the lack—until recently—of trade data in value added terms. This report uses such trade data to map the activity of value chains, with particular reference to the Asia-Pacific region. In addition to describing the network of value added trade that is present in the region and beyond it, the report also uses sophisticated network analysis techniques to provide a quantitative evaluation of Value Chain Connectedness.

This report is the output for Phase Three of APEC's project on Value Chain Resilience. That four phase project aims to examine the following interconnected issues, which affect the decision of value chains to establish themselves in particular APEC economies, and their subsequent ability to grow and prosper:

1. Phase One involved a quantitative analysis of Value Chain Risk in the APEC region.
2. Phase Two evaluated Value Chain Strength in the APEC region.
3. Phase Three focuses on Value Chain Connectedness in the region.
4. Phase Four will involve the creation of a comprehensive model to evaluate the possible impact of Value Chain Resilience by utilizing results from the earlier three phases on Value Chain Risk, Value Chain Strength, and Value Chain Connectedness.

This report moves beyond existing work on Connectedness, which adopts a linear, point-to-point approach. Instead, its methodology is firmly grounded in value chain activity as a complex, nonlinear, network phenomenon. To operationalize the concept of Connectedness, a concept is drawn from the network analysis literature in the social sciences and applied mathematics. Concretely, the connectedness of each economy is a weighted average of the connectedness of all other economies to which it is connected by a value added export flow. The weights in the average are export shares, namely the proportion of each economy's total exports that go to each other economy.

Connectedness calculated in this way has a second, economic interpretation that is of interest to policymakers. Economies that are more connected in the sense in which this report uses the term are both more susceptible to the effects of economic shocks elsewhere in the trade network, and better able to recover from those shocks as activity picks up elsewhere. Concretely, an economy's Connectedness score is the positive economic impact in dollars of a $100 increase in value added trade at a random point in the trade network. Conversely, its negative is the negative economic impact of a $100 decrease in value added trade at a random point in the trade network.

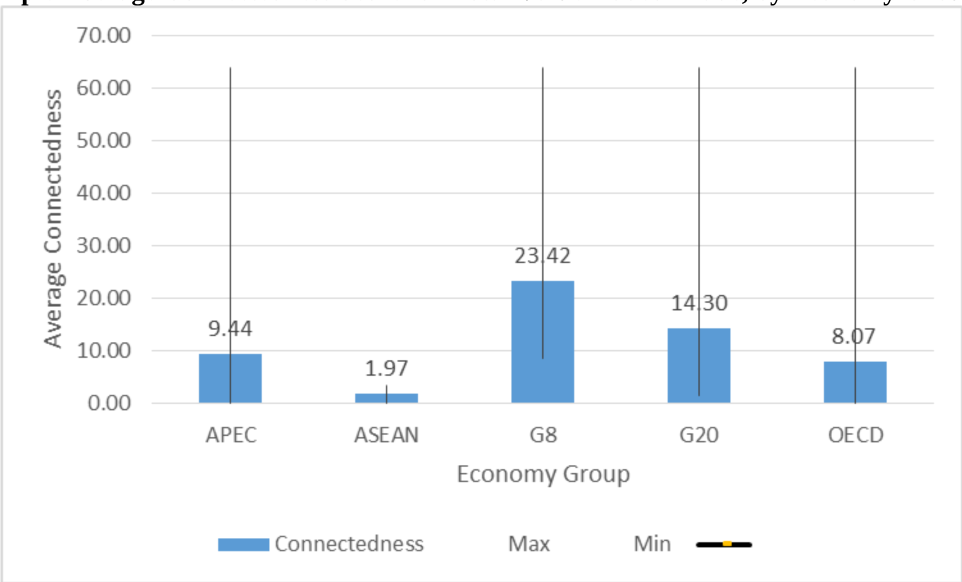
Recently collected value added trade data, examined through the lens of the methodology developed in this report, make it possible to map value chains at the global and regional levels. This exercise is entirely novel, and places APEC at the cutting edge of research into value chains.

Results using total value added trade as well as sectoral trade in electrical equipment, transport equipment, and business services show that the Asia-Pacific is relatively well placed in terms of its position in the global value added trade network. In particular, there is evidence that the region to some extent plays the role of a bridge connecting other parts of the world with each other, in addition to being an engine of value addition and trade in its own right. Although APEC economies are present in a variety of geographical, social, and economic settings, there is a certain cohesion among them in terms of the network of value added trade in the Asia-Pacific. This cohesion is consistent with the fact that the early development of value chains as a business model took place in the Asia-Pacific, and many have been operating and growing for a considerable period of time.

By comparison with other economic groups, APEC performs reasonably well in terms of Connectedness (see figure). The average level of Connectedness among APEC members is considerably in excess of that of ASEAN, and is comparable to—indeed slightly greater than—that of the OECD. The G-8 and G-20 groups perform noticeably more strongly, however, largely due to the presence of European hubs that trade intensively among themselves, and, in some cases, with other regions of the world.

As the figure shows, however, APEC's is also notable for the very large degree of heterogeneity among member economies when it comes to Connectedness. APEC contains some of the best connected economies in the world, but also some relatively isolated ones. Moreover, there is a significant performance gap between developed and developing economies. Closing this gap, and ensuring that all APEC economies can participate fully in value chain activity, will be a policy priority going forward.

Simple Average Connectedness Score for Total Value Added Trade, by Economy Group.



Source: Authors.

In addition to describing the network of value added trade and providing a quantitative evaluation of Connectedness, this report also looks at some of the policy factors that influence Connectedness. The results from the first two phases of PSU's Value Chain Resilience project—indices of Value Chain Risk and Value Chain Strength, respectively—are shown to be highly relevant.

As expected, value chains appear to have a strong preference for operating in environments where risk is relatively low, and there are sophisticated systems for risk management and response in both the public and private sectors. From a policy point of view, these results highlight the fact that it is important for the public sector to put in place appropriate policies to deal with the occurrence of risks, such as those identified in Phase One of this project.

Although some risks are a factor of geography and geology, and thus cannot be controlled directly by policy, others are much more amenable to policy action. In addition, strength and resilience can be developed even in areas where the occurrence of risk is a purely natural phenomenon. The lesson from this report is that limiting and managing risk can potentially bring significant benefits in terms of improving an economy's position in global and regional value chains.

Two other sets of policy factors are found to have a significant impact on Value Chain Connectedness: trade facilitation and logistics; and behind the border issues, such as contract enforcement. Both sets of policies reduce the cost of doing cross-border business for value chains, and create a trade and investment environment where transactions are efficient, reasonably priced, rapid, and certain. Economies looking to improve their position in terms of Value Chain Connectedness could consider redoubling efforts in areas such as connectivity (which covers trade facilitation and logistics), and Ease of Doing Business (which covers many behind the border issues). APEC's initiatives in this regard are welcome, and provide the basis for productive work going forward.

Although Connectedness can bring many economic benefits, it is not without its risks. In particular, this report shows that economic downturns are transmitted more fully to more connected economies. On the flipside, those same economies recover more fully from those same downturns, because they are better able to take advantage of improving market conditions abroad. The presence of risk is not, of course, a reason for limiting Connectedness. It is an incentive for policymakers to adopt appropriate systems to manage the risks that greater economic integration bring. In policy terms, measures such as social safety nets are important to ensure that markets can operate efficiently, but workers and their families are cushioned from some of the most negative impacts that some market events can have. More generally, sound macroeconomic policies—accounts at or close to balance, adequate but not excessive foreign reserves, appropriately flexible exchange rates, and reliable domestic consumer demand—can help manage the risks, and maximize the benefits, that come with greater Value Chain Connectedness.

1. INTRODUCTION AND PROJECT OVERVIEW

Value chains are fundamentally a network phenomenon, based on trade and investment relations that crisscross regions and the globe in extremely complex ways. Unlike traditional supply chains that are usually conceptualized as a linear set of links from producer to consumer, value chains integrate a wide variety of activities, centered on the rapid and seamless movement of goods and services, often taking place simultaneously, with redundancy loops built in to deal with risk.

In the Asia-Pacific, value chain activity has spread from core manufacturing sectors such as motor vehicles, to electronics, and now to services sectors. Most regional economies are integrated in value chains to at least some extent, and so economic output, crisis resilience, and jobs depend on the ability of value chains to function efficiently.

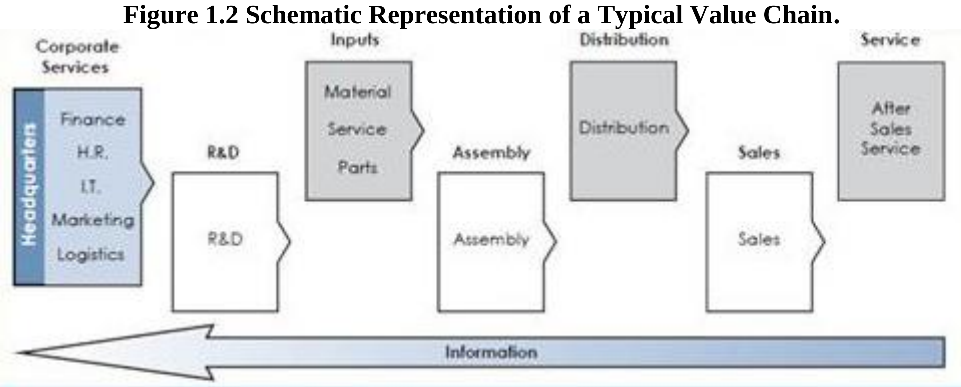
From a policy perspective, one crucial question is where exactly an economy is placed within global and regional value chain networks. Figure 1.1 provides a well-known example of a value chain, namely selected Apple suppliers in the Asia-Pacific region. The numbers indicate the number of firms involved in each economy, and the size of the circle is proportional to the number of firms. As the example shows, the level of value chain activity varies greatly across economies: large numbers of firms and employees are involved in some places, but very few in others. Some economies have a wide range of connections to others, and participate in value chains through high value added activities like research and design. Others are still well connected, but produce component parts that are less intensive in human and financial capital. Still others are connected to a large number of other economies because they are labor-intensive assembly hubs, focusing largely on low value added activities. Figure 1.2 provides a schematic representation of these various functions.

Policymakers currently have little information with which to assess the relative location of their economy within global and regional value chains. The research presented in this report goes some way towards remedying that situation.

Figure 1.1 Selected Apple Suppliers in the Asia-Pacific. Numbers Indicate Numbers of Firms.

Source: http://appleinsider.com/articles/13/02/15/supply-chain-visualization-shows-how-apple-spans-and-impacts-the-globe. Note: Apple's value chain also includes approximately 80 companies in North America (not reproduced due to scaling reasons.)

Figure 1.2 Schematic Representation of a Typical Value Chain.



Source: http://www.tradecommissioner.gc.ca/eng/gvc-guide.jsp.

This report presents results from the third phase of PSU's Value Chain Resilience project. The first two phases analyzed Value Chain Risk and Value Chain Strength, factors that firms consider when choosing to invest or trade with an economy as part of a global or regional value chain. Phase Three, by contrast, analyzes how economies are linked within networks of trade relations comprising global and regional value chains within APEC.

The analytical approach taken in Phase Three is fundamentally different from the first two phases. Phases 1 and 2 used publicly available data to conceptualize various categories of Value Chain Risk and its inverse, Value Chain Strength. The analysis created f indices with convenient summary measures of APEC's performance and comparisons with performance in other parts of the world (ASEAN, the G-8, the G-20, and the OECD).

Value Chain Connectedness, by contrast, has no ready-made metrics that can be drawn upon and summarized. Indeed, even the contours of the concept need to be mapped out, in light of the current state of research in international trade. A number of preliminary points can be made in terms of what is necessary to measure Value Chain Connectedness. The first is that it should be based on an analysis of the type of activity that takes place within value chains. The fundamental characteristic of value chains is they are exchanges of value added between economies. The analysis therefore needs to be grounded in new data available from the OECD and WTO, which measure trade in value added. Traditional trade data are likely to provide misleading information, as they measure exports in gross value terms, rather than value added terms (i.e., they do not net out intermediate inputs).

The second key characteristic of the concept of Connectedness that needs to be accounted for is its basis in the network structure of value chains, and indeed, the increasingly networked structure of international trade in general. Research on networks in international trade is in its infancy, and this report represents the very first application of network analysis techniques to trade in value added. It is therefore a novel piece of research in terms of the analysis of value chains, and the place of economies within them.

The first three phases of the Value Chain Resilience project, although independent pieces of research, are all inter-related. Risk and strength have a circular relation: economies at greater risk of the occurrence of particular negative events have an incentive to develop greater response capacities, i.e. increased strength. Over time, this tends to reduce their risk profile, as even though negative events occur, their economic and human costs are smaller. Moreover, risk and strength both influence Connectedness, because all other things being equal, firms prefer to invest and create value chains in economies where risk is low and strength is high. Such economies therefore tend to become more connected. However, more connected economies are themselves at greater risk of feeling the effects of systemic risk, as shocks in one economy are more likely to be felt at a distance in better connected economies. Although the causal relations are complex, the various strands will be brought together in Phase Four of the project, which will examine economic impacts.

Against this background, the report proceeds as follows. The next chapter provides a literature review. Chapter 3 discusses the methodology used to examine and measure Value Chain Connectedness in this report. The following chapter contains results of the quantitative analysis, providing graphical representations of Value Chain Connectedness in the region relative to the world as a whole, as well as numerical information on APEC’s relative performance. Section 5 concludes, and discusses policy implications of the report’s findings.

2. LITERATURE REVIEW

Value Chain Connectedness is not a well-defined concept in the literature. It is therefore necessary to reach out more broadly to examine related areas in which the concept of connectedness has been examined, and the methodologies used to do so. Three areas are of particular relevance:

- The general literature on connectedness in the world economy.
- The literature on value chains, and trade in value added.
- The literature on network analysis.

The review of the contributions presented in the following subsections shows that there is no ready-made solution to the problem of measuring Value Chain Connectedness in the context of this project. The general literature on connectedness is linear in nature, and does not capture the network effects that are crucial to value chains and their resilience. The literature on value chains does not measure connectedness, nor does that on trade in value added. The literature on network analysis is more promising, because it focuses on mathematical concepts that can be interpreted in terms of connectedness, but it has not dealt specifically with value chains, nor has it discussed policy applications and implications. The methodology put forward in Chapter 3 of this report is a synthesis of these various approaches, focusing on an application of network analysis methods to the specific problem of measuring Value Chain Connectedness. It represents a novel approach to the problem, but one that builds on and extends previous work in the academic and policy literature.

GENERAL LITERATURE ON CONNECTEDNESS

General economic connectedness is the subject of Ghemawat and Altman (2012) (DHL's Global Connectedness Index). Those authors define global connectedness as "the depth and breadth of an economy's integration with the rest of the world as manifest by its participation in international flows of products and services, capital, information, and people" (p. 13). The Global Connectedness Index constructed on that basis covers 140 economies over the 2005-2012 period. It is important to note, however, that the Index is essentially a data aggregator: it does not contain any new material, but rather takes data from other sources and combines them in an original way. The result is a very comprehensive and complex index, covering over one million data points.

Although the Global Connectedness Index is useful as an overall measure for indicative purposes, it only provides a limited degree of sectoral detail. In particular, it does not provide any information specific to the operation of value chains. It is not possible to tell from aggregate trade statistics, for example, whether the value chain business model is expanding or contracting in a particular area, because changes in trade could be associated with other business models—such as bulk commodities or linear supply chains—instead. Similarly, the DHL approach of aggregating a very large number of pre-existing data series necessarily results in the inclusion of some data—such as tourist and student movements—that are not relevant to the analysis of value chain connectedness. Clearly, a different approach is called for.

Indices of globalization, such as the KOF Index (Dreher, 2006), take a largely similar approach to the DHL work. They aggregate a number of pre-existing series into an overall measure, either using statistical methods (KOF) or the authors' subjective judgment (DHL). All indices in this class have similar advantages and disadvantages to the DHL index discussed in the previous paragraph: they provide useful overall summary measures, but capture numerous elements that are not of any special relevance to Value Chain Connectedness.

An important limitation of the DHL Index, the KOF Index, and similar work is that they are linear in conception. They are made up of data on point to point relations (at best), or (more commonly) of data for an economy vis-à-vis the rest of the world. They therefore cannot say anything about the role that network structures play in determining Connectedness, and in allowing its effects to play out, for example through the transmission of risk. They can only speak to traditional, linear interactions, not the nonlinear interactions of network structures. This feature again means that these kinds of data aggregation methods are not suitable for the analysis of complex networks like value chains.

LITERATURE ON VALUE CHAINS

Much of the literature on value chains is qualitative in nature. It focuses on describing the relevant business models, analyzing the ways in which economies have become part of value chains, and discussing the ways in which their firms have moved up within them to higher value added activities. Cattaneo et al. (2010) is a representative contribution. This stream of work focuses on identifying the roles played by lead firms and their suppliers. To the extent that quantitative information is introduced, it is typically limited to consideration of a particular economy-sector value chain, and an analysis of the way in which value added is divided up among the various member firms of the chain. Although there is typically a consideration of factors that make it more or less likely that value chain development takes place within a particular economy—the components of risk and strength—there is no cross-economy quantification.

The problem facing cross-economy quantitative work on value chains is the difficulty of identifying value chain activities in international data. One approach is to comb international trade classifications, such as the Harmonized System, to search for products such as parts and components that are more likely to be traded within international value chains. That is the approach taken by, for example, Saslavsky and Shepherd (forthcoming). Although useful as a starting point, it misses the fact that many products are dual use: they can either be intermediate inputs or goods for final consumption, depending on the purchaser's intention. Also, any list of products compiled in this way is likely to be partial at best. Such analyses can therefore only focus on part of the activity that is taking place within value chains. In particular, they miss all activities related to services, which are not captured at all in international goods trade data.

Another strand of the academic literature has focused on identifying the position of economies within value chains by calculating the "upstreamness" of industries, and relating that information to the export product mix of each economy. An industry that is more upstream is one that tends to be relatively further from final demand, in terms of the number of processing stages required before its output reaches the final consumer. A representative contribution is Antras et al. (2012), which provides a unifying framework for a number of previous papers.

A final strand of the quantitative literature on value chains focuses on trade in value added. The key contribution of this literature has been to combine trade data and input-output tables to obtain estimates of value added trade. Johnson and Noguera (2012) propose using the ratio of value added trade to gross exports (VAX) as a measure of the (true) domestic content of exports, i.e. after netting out the effects of imported intermediates that are included in exported production. A number of refinements have subsequently been proposed (e.g., Koopman et al., 2012; and Wang et al., 2013). The essence of this literature is measurement, although Noguera (2012) examines the determinants of value added trade in a modified gravity model framework. As yet, there is no work in this literature examining the issue of Connectedness in relation to value added trade. For a general overview, see Mattoo et al. (2013).

LITERATURE ON NETWORK ANALYSIS IN INTERNATIONAL TRADE

There is an emerging body of work on applying network methods to the analysis of international trade flows. However, much of it is outside the mainstream economics literature, and tends to be published by applied mathematicians and physicists, or economists with that type of prior training. The word "Connectedness" is rarely used, but the concept of centrality is crucial. It can be defined in various ways, but it generally refers to the importance of an economy in the network, based on a range of factors according to the particular definition being used. Although this literature provides useful tools and approaches, it is generally descriptive, focusing on applications of concepts from network analysis to global economic networks, such as trade (e.g., Schiavo et al., 2010).

Arvis and Shepherd (2011) apply centrality reasoning to calculate a measure of connectivity—a synonym in this case for Connectedness—in the global air transport industry. They develop their own measure, because none of the pre-existing measures applies well to a flow matrix that is both global in terms of its connections, and close to symmetric (the number of flights out of an economy approximately equals the number of flights into it). The problem of a global network also applies in the case of value chains, but the problem of symmetry does not. As Arvis and Shepherd (2011) note, under those circumstances, eigenvector centrality is an attractive measure.

A recent contribution that is representative of the trend, and which reviews a wide variety of methods in detail, is De Benedictis et al. (2013). Those authors use a comprehensive dataset of world trade to analyze its network structure. They focus on the concept of centrality, as operationalized in a variety of ways, including eigenvector centrality. The focus of the paper is not on drawing policy conclusions, but on describing methods in language accessible to economists, and demonstrating the potential of the methods in question to provide usable insights. They explicitly consider eigenvector centrality—the concept of Connectedness proposed in Chapter 3 of this report.

To show more clearly the link between centrality and connectedness, it is useful to step out of the strict sphere of international trade to consider Minoiu et al. (2013). This paper deals with crises in the global financial system. It addresses the question whether an economy's degree of Connectedness with that system is a predictor of crises. To operationalize the concept of Connectedness, the authors turn to network analysis, and in particular to centrality measures.

Of particular interest from the point of view of this project is the recognition that economies with higher Connectedness (more central economies, in the authors' terminology) tend to feel more strongly the effects of exogenous shocks elsewhere than do less connected economies. There is therefore a link between Connectedness in the sense in which it is used in this report, and the way in which shocks are propagated through a complex network, such as the international financial system.

Another IMF working paper, Errico and Massara (2011) adopts similar reasoning, and applies it to both the global trade and financial networks. There are considerable similarities between the two cases. To measure Connectedness in each network, the authors take the average of four measures, one of which is eigenvector Connectedness—the measure proposed in Chapter 3 of this report. Their analysis differs from the one here in that they use IMF DOTS data to assess Connectedness—which means that there is no sectoral analysis, but only a consideration of aggregate effects. Also, their paper is limited to goods trade only, and does not consider services. This report using OECD-WTO TiVA data considers both goods and services, and identifies particular sectors for special attention, given the highly specific context of value chain development.

3. METHODOLOGY

Value Chain Connectedness is not a well-defined concept in economics. At its base, it is suggestive of a concept that measures how well value chains are linked between economies. In terms of measuring Connectedness at the level of economies, rather than individual business, Connectedness indicates a concept that is concerned with how well economies are "plugged into" global and regional value chains. Similarly, Connectedness of economies can be seen as giving an indication of their relative positions and importance in value chains. Economies that are highly connected (hubs) are vital for the performance of numerous value chains, in the sense that they are central to the operation of those business models. Those that are poorly connected (spokes) are more peripheral, and either deal with smaller value chains, or a smaller number of shorter value chains, which, in the aggregate, have less activity flowing through them than the value chains that crisscross hubs.

As this discussion shows, an important aspect of value chains that needs to be considered when analyzing Connectedness is the fact that they are network-based. In some ways, the term "chain" is a misnomer, as it suggests a linear series of links running from producer to consumer, much in the same way that a traditional supply chain does. Modern value chains are much more complex, however, with goods and services sourced from numerous locations for use in the production of the final product. Rather than hold inventory, lead firms frequently build redundancies into the value chain, in the sense that they source the same intermediate input from more than one location. That approach to value chain structuring allows for greater resilience in the face of unforeseen shocks. However, it adds greatly to the complexity of the analysis, because it is important to take into account "loops" in the value chain, that look less like the straight lines of traditional supply chains, and more like complex, nonlinear networks.

MEASURING CONNECTEDNESS: A NETWORK ANALYSIS APPROACH[1]

As noted in the literature review, most previous attempts to measure connectedness and related concepts have not taken a network-based approach. They have used aggregations of simple point-to-point measures, which are fundamentally linear in outlook. This report takes a different approach by drawing on the established body of knowledge in network analysis. Network analysis is a field of applied mathematics that is well-suited to the examination of Value Chain Connectedness. It provides simple methods for analyzing even very large and complex networks. Operationalizing one of those concepts here makes it possible to measure Value Chain Connectedness in a new, rigorous, and highly meaningful way.

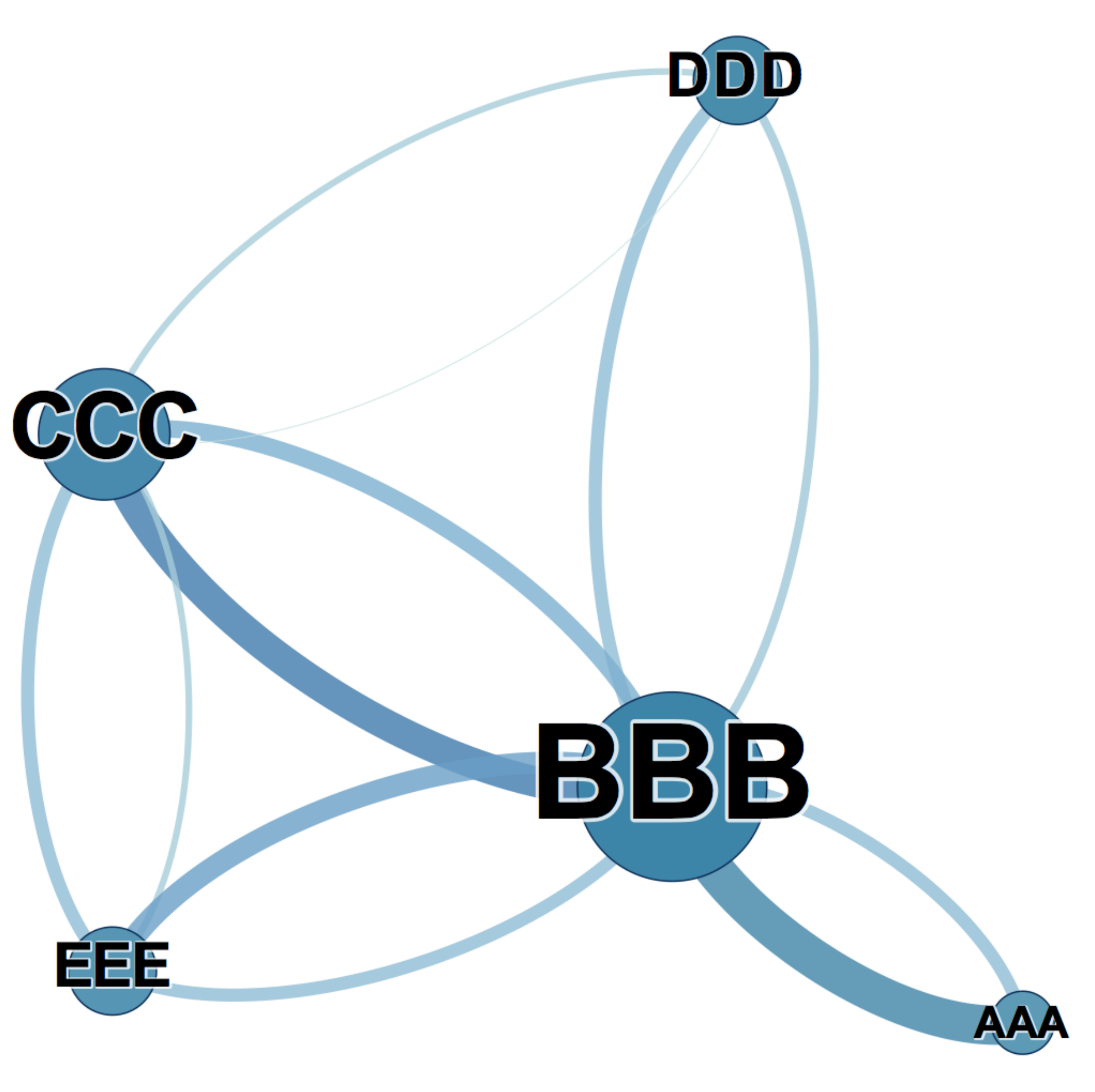
Network analysis provides a very general set of mathematical tools that can be applied to any economic or social interaction that takes place within a network structure. All that is needed is a set of flows or connections ("edges") between points in the network, known as "nodes". For example, network analysis tools have been used to analyze interactions in social media, such as Facebook and Twitter. They also form the basis of Google's search engine, through its famous Page Rank algorithm, which sorts search results in part by their importance in the global network of web pages. Security services also use these methods to analyze networks of

[1] This section provides an intuitive overview of the report's approach to measuring Value Chain Connectedness. For full details, see the Technical Appendix.

hostile forces, and identify interventions that can have the most impact based on individuals' importance within the network.

To see the way in which network analysis works, it is useful to consider an example network (Figure 3.1). The network consists of five economies that trade with each other. Each economy is represented by a circle. Each trade flow is represented by a curved line. The combination of the lines and circles is the network, in a highly schematized representation. There are many ways of presenting networks graphically, so this report adopts the convention that the size of each circle is proportional to the economy's Connectedness, and the thickness of each line is proportional to the size of the trade flow between the two economies in question. In Figure 3.1, for example, economy BBB is the best connected economy, followed by economy CCC. The other economies are less well connected. The largest trade flow is between AAA and BBB, closely followed by the flow between BBB and CCC. There is only a very small flow between CCC and DDD. The distance between economies in the figure is not related to geographical distance—which is not even defined for the example in Figure 3.1—but instead captures "neighborhoods" of closely linked economies, and contrasts them with groups of economies with which they are less well-linked. Again, it is important to emphasize that there is no unique way of representing this information visually. The report adopts standard network analysis conventions in the visual representation of data, but other approaches are also possible to emphasize various features of the network.

Figure 3.1 Graphical Representation of a Simple Network.



Source: Authors.

In this report, one common method of measuring importance from the network analysis literature is used to measure Value Chain Connectedness: eigenvector centrality. To construct the eigenvector centrality measure, the connectedness of each economy is calculated as a weighted average of the connectedness scores of all other economies to which it is connected by a value added export flow. The weights in the average are export shares, namely the proportion of each economy's total exports that goes to each other economy. The problem of finding a set of Connectedness scores that simultaneously satisfies the definition of each economy's Connectedness score sounds complex, but it is in fact a well-known mathematical problem that can be easily solved using standard methods. In mathematics, the solution to such a problem is known as an "eigenvector", hence the term eigenvector centrality for the measure of Connectedness used here.

Of course, network analysis provides many potential methods for measuring concepts related to Connectedness. The approach chosen here is based on two considerations: it is global, rather than local, in the sense that it considers all possible connections in the network; and it has a second, important interpretation in terms of the propagation of economic shocks. If the Connectedness Index is calculated using value added export shares, rather than raw, value added export flows, it produces a number for each economy that ranges between zero and one. It can be mathematically proven that the number is the economic value of an extra dollar of trade added to the network at a random point, and allowed to flow through all possible connections. In other words, an economy that is more highly connected is also more vulnerable to economic shocks. At the same time however, it is also able to recover from them more quickly as activity picks up anywhere else in the network. This property of the Connectedness measure used here is very appealing in terms of the objectives of the broader Value Chain Resilience project, as it provides information that is directly relevant to that subject.

Another appealing feature of the Connectedness measure used in this report is it is not directly or uniquely determined by size, because export shares are used to calculate the weighted average definition of Connectedness. For example, Australia exported $18.2bn of value added to the United States in 2009. New Zealand exported $3.4bn. Although the size of Australia's export flow is much larger, it enters into the calculation as 11%, compared with New Zealand's 13%, because the relative importance of the trade flows in each economy's total export pattern is different. The numbers that are used to calculate Connectedness in this report are 11% and 13% respectively, not the raw flow numbers. Use of raw flows for a Connectedness measure would automatically result in the finding that large economies, which have larger flows, are better connected. The measure adopted here avoids that potential problem, and allows for the possibility that small economies can be well connected.

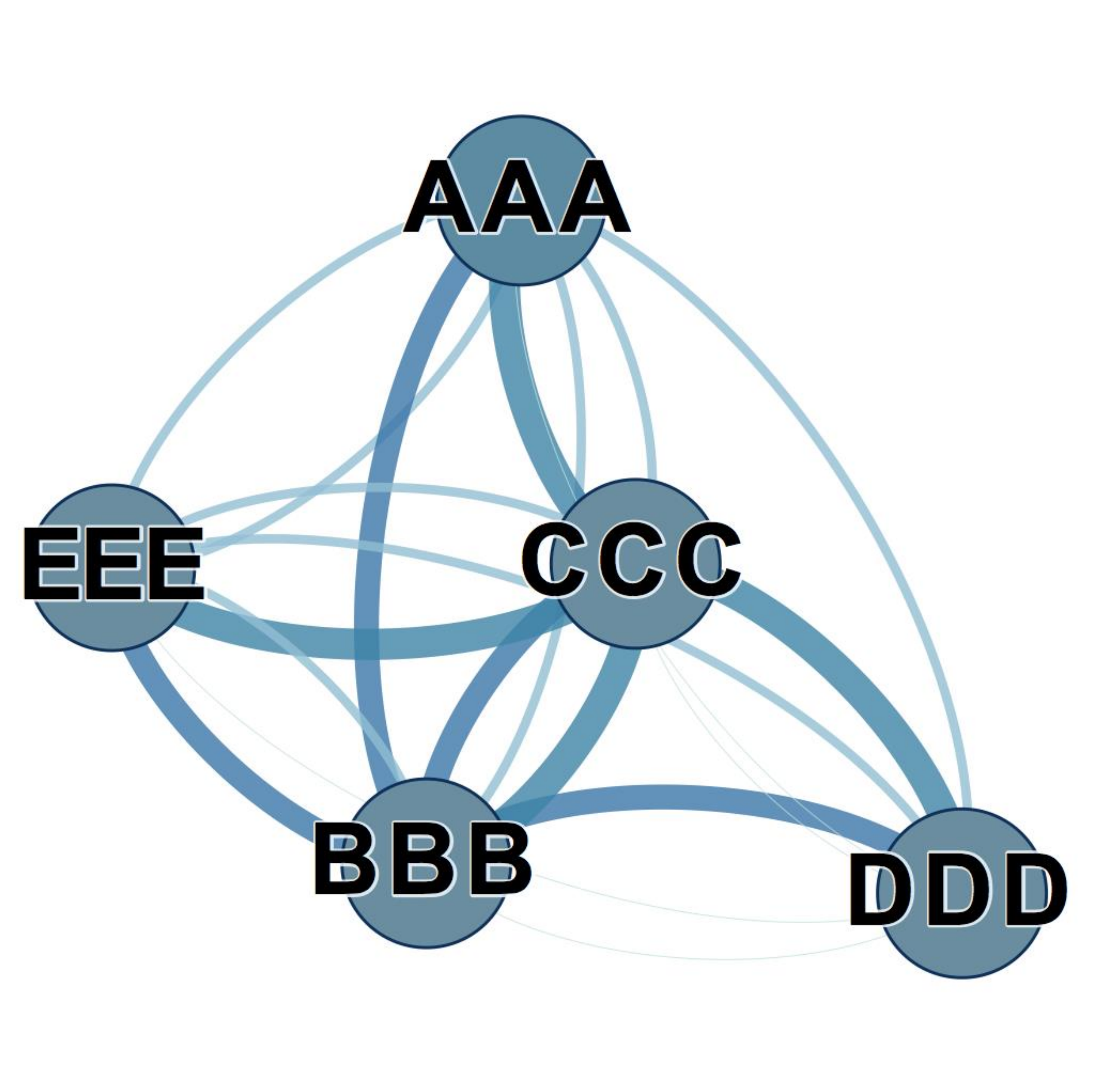
Of course, this feature of the Connectedness measure used here does not mean that the result is completely independent of size. Larger economies have more ports and airports, and thus are able to connect with a wider range of economies than are many smaller economies. Larger economies also have greater resources to invest in improving Connectedness, for example through building gateway infrastructure. Because of these factors, it is likely that the resulting Connectedness scores are correlated with size—and with many other factors—even though size is not directly used to calculate them. But that correlation is a function of the accumulation of Connectedness over time, and the allocation of resources to that purpose.

CONNECTEDNESS IN SIMPLE NETWORKS

Although the intuition behind Connectedness is not complex, it is perhaps difficult to see how it can be implemented in concrete settings. To make the transition to the next chapter easier, this section presents some simple examples of networks with full details on the results provided by a Connectedness analysis.

One simple case to consider is an equally connected network. In such a network for five economies, each economy exports a quarter of its traded value added to each other economies. In other words, trade flows may differ in size according to the size of each trading economy, but trade shares—the proportion of each economy's exports that goes to each other economy—are constant for all economies in the network. Intuitively, each economy should therefore have the same Connectedness score, even though the flows are of different sizes, based on the consideration that it is most important to analyze network position rather than raw size. Indeed, that is exactly the result that the methodology produces: each circle in Figure 3.2 is the same size, because each economy has the same Connectedness score (44.7, on a scale ranging from zero to 100). This result holds true even though the curved lines connecting economies, which represent trade flows, are of very different sizes. As noted above, a second interpretation of these Connectedness scores is that economies in this simple example are equally subject to economic shocks and recoveries: the value to each of a $100 increase in value added trade at a random point in the network is $44.70, and the negative of that number is the economic loss associated with a $100 decrease in value added trade.

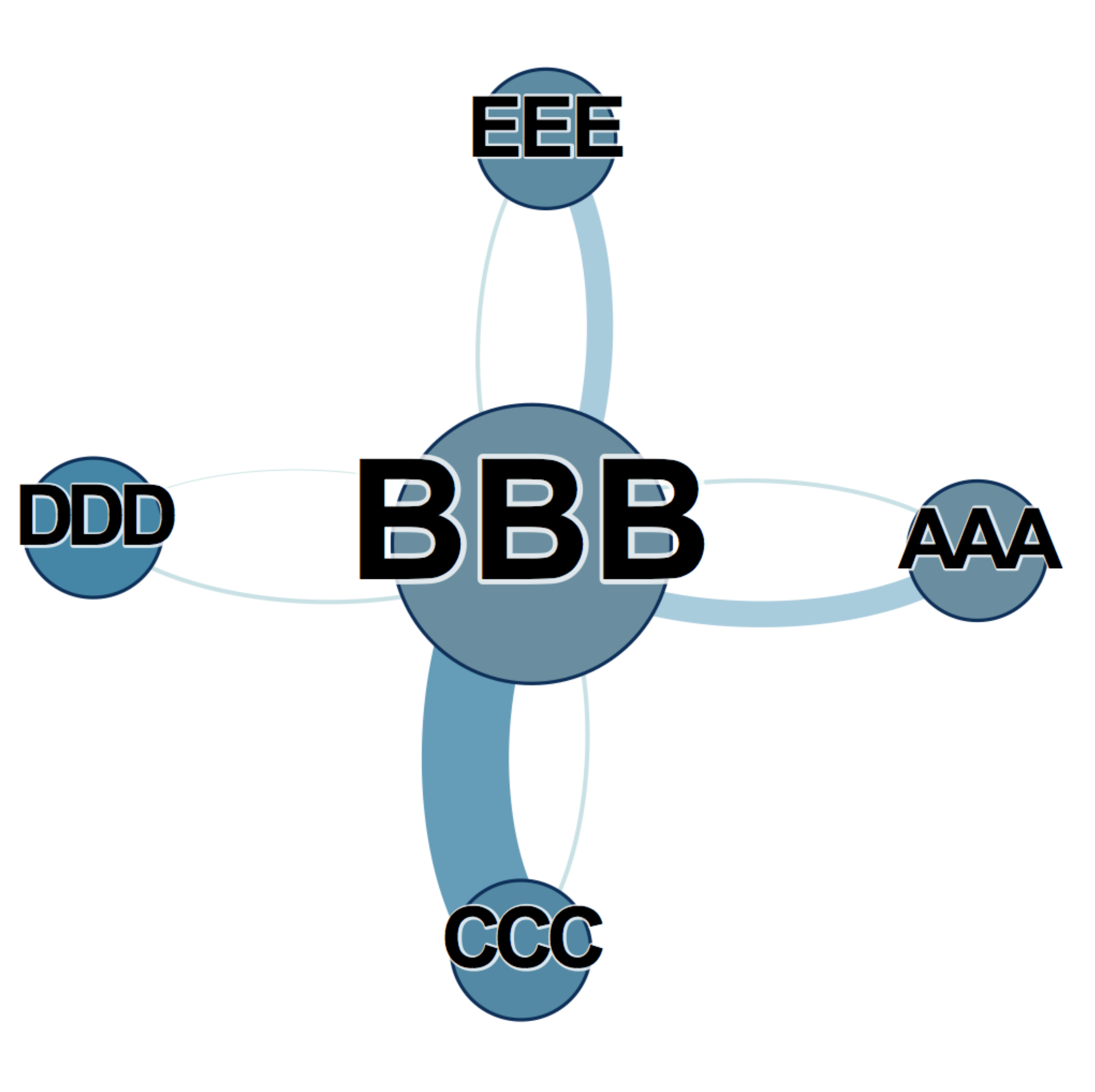
Figure 3.2 Graphical Representation of an Equally Connected Network.



Source: Authors.

Another simple example is a hub and spoke network (Figure 3.3). In such a network, one central economy—the hub—receives exports from all other economies, and exports in equal proportions to them. The other economies export all of their tradable value added to the hub, and are not connected among themselves. Intuitively, analysis of the example hub and spoke network should give a high Connectedness score for the hub, as it is the core economy in the trading network. It has strong connections to all other economies, and the other economies depend on it as their major export destination. The other economies should have much lower, but equal, scores, as they are peripheral. Indeed, that is exactly the outcome that this report's methodology produces: the hub (BBB) has a Connectedness score of 89.4, while each of the spokes has a Connectedness score of 22.4. Again, it is important to note that the flows, represented by the curved lines, between economies are of different sizes, but their raw scale does not determine Connectedness.

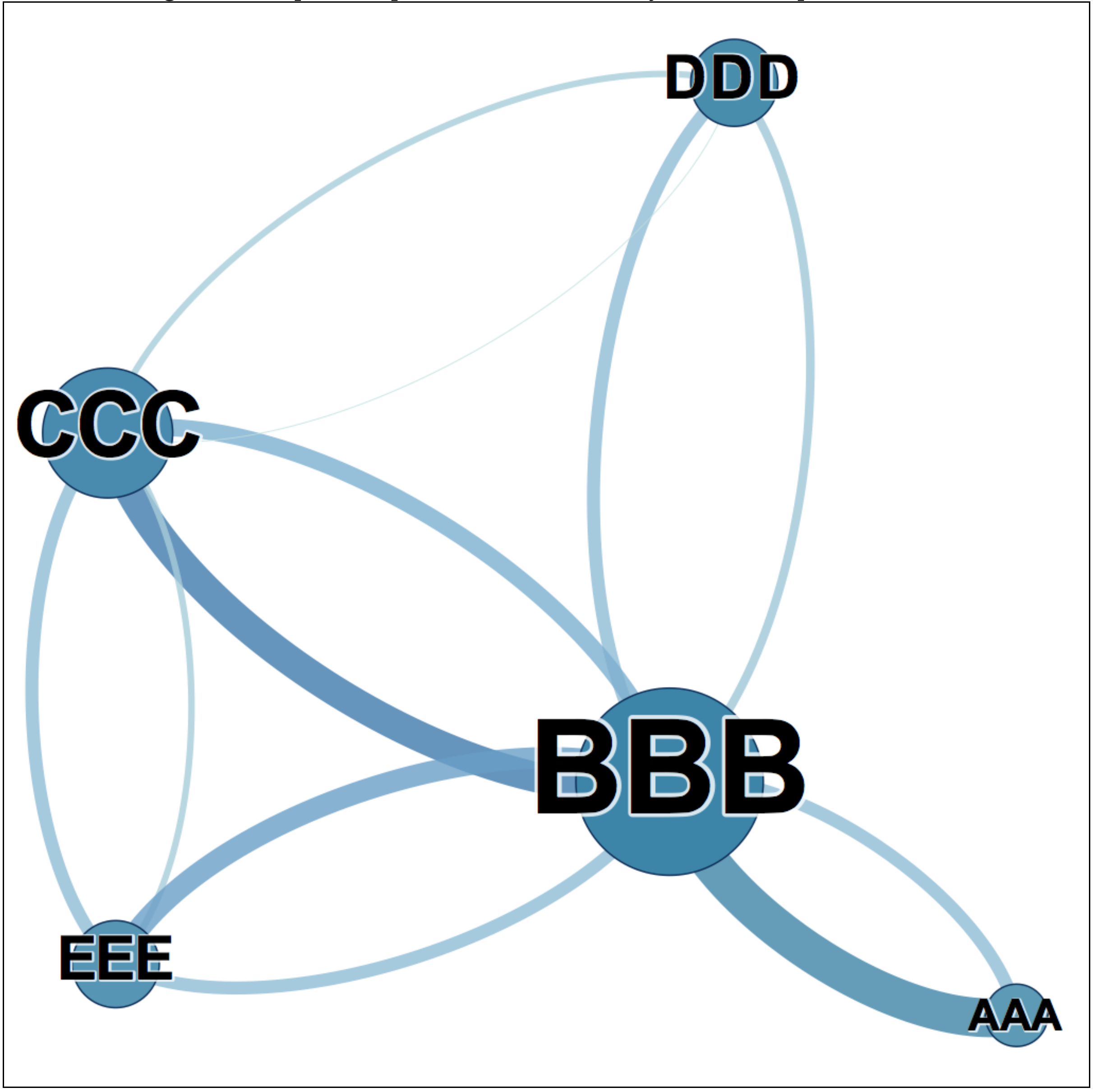
Figure 3.3 Graphical Representation of a Hub and Spoke Network.



Source: Authors.

A more complex variation on the single layer hub and spoke network examined in the previous example is the two layer hub and spoke network (Figure 3.4). In such a network, there is a primary hub, a secondary hub, and a number of peripheral economies. Analysis of this case, which can be seen as a small- scale model of the types of networks that are really observed in the trading system in practice, is more complex. The primary hub should be the most connected economy, and the secondary hub should be the second most connected economy. The scores of the peripheral economies should vary according to the strength of their connections with each hub, and with each other. Although the general intuition is clear, this example shows the need, even in a five economy network, for a rigorous, quantitative approach. Again, results are very much in line with expectations. Economy BBB has a Connectedness score of 76.8, and economy CCC has a score of 48.6. The peripheral economies have considerably lower scores: 27.5 for DDD and EEE, and 15.4 for AAA, which is only connected to one other economy. Again, it is important to note that size does not determine connectedness: the largest export flow in the network in terms of raw scale is from AAA to BBB, yet AAA is the least connected economy due to its position relative to other economies in the network.

Figure 3.4 Graphical Representation of a Two Layer Hub and Spoke Network.



Source: Authors.

These simple examples have demonstrated that the Connectedness methodology used in this report produces consistent, intuitive, and easily interpretable results. They have also served to introduce policymakers to network analysis techniques used to represent complex phenomena, such as trade flows in value added. The net result of the methodology proposed in this section is a score for each economy in the network—its Connectedness score—that ranges between zero and 100. Zero represents a completely unconnected economy, one that does not trade at all with others. 100 represents a perfectly connected economy. In practice, all economies will have scores between these two bounds: better connected economies will have higher scores, and worse connected economies will have lower scores. By comparing average scores across economy groups, it is possible to get an approximate idea of relative performance, which is a useful tool for benchmarking, and identification of policy priorities going forward.

UNDERSTANDING THE CONCEPT AND INTERPRETATION OF RESULTS

Having precisely defined the concept of Connectedness, it is now important to discuss how it will be implemented in the context of value chains in this report. As noted in the literature review, there is already some academic literature that applies network analysis methods, including the concepts discussed in the previous section, to the global trade network. However, such applications do not specifically deal with the case of value chains. Implementation has dealt only with standard trade data, which are measured in gross value terms, i.e. without netting out intermediate inputs, and are not sector specific. To deal properly with value chains, both areas need to be dealt with.

To measure Value Chain Connectedness, therefore, this report applies the concepts discussed in the previous section to bilateral trade data from the OECD-WTO Trade in Value Added (TiVA) Database for the latest year available (2009).[2] TiVA data differ from standard trade data in that the measure final consumption in the importing economy of value added from the exporting economy. They therefore net out all intermediate input use, and eliminate the multiple counting that occurs in standard trade data.

Consider, for example, a simple piece of electrical equipment that contains a hard drive from Thailand and a processor designed in Japan and manufactured in Korea, and where final assembly takes place in China before being exported to the United States. Standard goods trade data would record exports from Thailand to China (the hard drive), from Korea to China (the processor), and from China to the United States (the final product). All flows are taken at their full market value, so the final product exported from China to the United States includes the value of all other components that were necessary to its production. Intermediate inputs are effectively counted more than once, and the design services supplied by Japan are not counted at all.

The TiVA data, by contrast, capture flows from Thailand to the United States (the hard drive embodied in the final product), from Japan to the United States (the design services embodied in the processor), from Korea to the United States (the processor), and from China to the United States (the assembly services).

Value chain trade tends to work on just such a basis, and so it is important to use data that are well adapted to its study in this case. The TiVA data are specifically designed for the analysis of trade in value added, such as the exchanges that value chains facilitate. They are therefore perfectly suited to the task at hand.

As a starting point, the analysis of the value added trade network using Connectedness as defined in the previous section is conducted at the level of total trade. This approach makes it possible to have a general idea of the network's characteristics, and provides a first idea of economies' relative Connectedness. In the interests of dealing more specifically with value chains of interest in the Asia-Pacific, the report then zooms down to give sectoral details. Specifically, three sectors are examined: electrical and optical equipment; transport equipment; and business services. All of these sectors have well developed value chains in the Asia-Pacific, and indeed have been sectors in which value chains have been implemented

[2] The TiVA data were assembled by OECD and WTO using a number of sources, including standard trade data, national accounts statistics, and international input-output tables. They cover 57 economies, including an aggregate ROW (rest of the world) category for flows that cannot be imputed to a single economy. The TiVA data cover 19 of the 21 APEC economies, namely all except Papua New Guinea and Peru.

early and extensively by the private sector. The use of business services as an example is a particularly interesting feature of the report's approach—made possible by the scope of the TiVA data—as value chains in services are less well understood than value chains in goods.

The TiVA data, examined through the lens of the methodology developed in this Chapter, make it possible to map value chains at the global and regional levels. This exercise is entirely novel, and places APEC at the cutting edge of research into value chains. The approach described here also makes it possible to analyze the Connectedness of each economy within the global and regional value added trade networks, which is again a novel exercise.

In interpreting results, however, it is important to keep in mind that the Connectedness measure and the TiVA data used in this report effectively focus on value chain activity as seen from the downstream point of view (i.e., that of the final consumer). Scores have a number of possible interpretations and explanations, a number of which are examined in Chapter 4. In particular, a high Connectedness score may be evidence of strong connections with global or regional hubs, or of specialization in relatively high value added activities. A low score may indicate relatively weaker connections with global or regional hubs, or specialization in relatively low value added activities, such as the production of simple component parts, or assembly.

4. RESULTS OF QUANTITATIVE ANALYSIS

This Chapter presents the results of a quantitative analysis of Value Chain Connectedness undertaken using the methodology set out in Chapter 3. The first section undertakes a mapping exercise using graphical techniques, with the aim of generally describing networks of value added trade in the region and in the world. The second section provides a detailed analysis of Connectedness scores, putting results for APEC in comparative perspective by also calculating scores for the G8, the G-20, and the OECD.

VALUE CHAIN CONNECTEDNESS IN THE ASIA-PACIFIC

This section presents results from the Connectedness analysis, focusing first on graphical representations of the relevant networks, and then on group average scores that are presented for comparative purposes. It adopts the same conventions as for the example network graphs in the previous section. Each economy is represented by a circle, with the size of the circle proportional to the economy's Connectedness score. APEC economies are represented by heavier shading. Trade flows between economies are represented by curved lines, the width of which is proportional to the size of the flow (measured in dollars). All information is based on a Connectedness analysis of the OECD-WTO TiVA data for 2009, as discussed in the previous section.

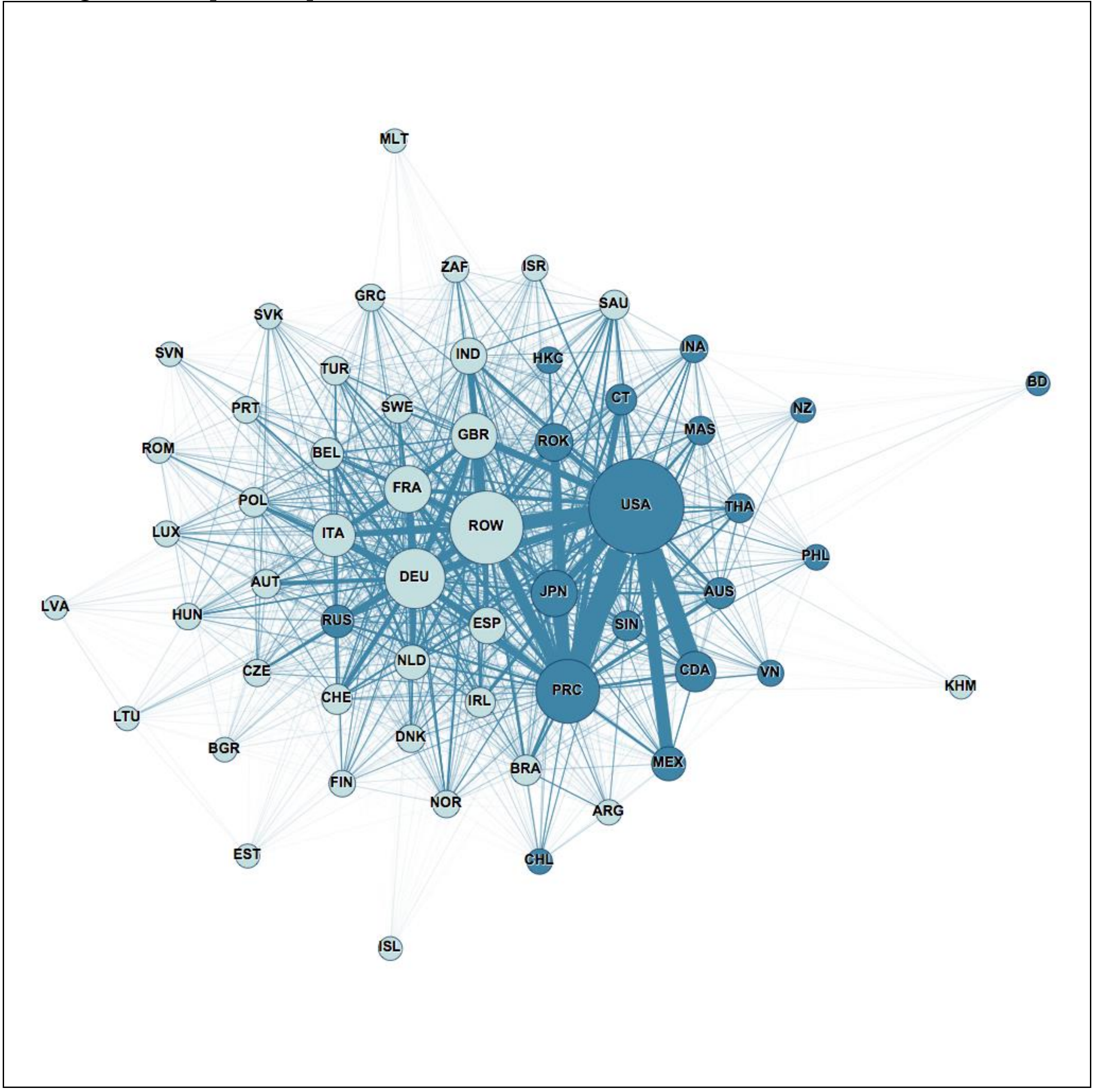
Total Trade

To provide a first overview of trade relations in APEC, as well as to sketch the region's links with the broader world economy, the TiVA data are first analyzed using their information on gross value trade flows. These trade flows are standard trade data, i.e. not value added trade. They represent the total value of all exports flowing from one economy to another, and do not adjust for intermediate input use. They are the data with which policymakers are familiar, and the network presented is therefore likely to be similarly more familiar to policymakers than the value added networks that are the main focus of this report.

Figure 4.1 presents the global (57 economies, including an aggregate rest of the world, ROW) trade network in gross value terms. The network is complex, and is open to a variety of interpretations. One point to emerge is that the Asia-Pacific as a region is generally quite central to the gross value trade network. A number of Asia-Pacific economies are represented by large circles, which means that they are very strongly connected in terms of the global network. However, it is clear that other parts of the world are also highly connected, particularly Europe.

Another point that emerges from the figure is that trade relations crisscross the globe, both within and among regions. Although the representation in the figure is not the only way of representing the network, it highlights the fact that the Asia-Pacific functions partly as a bridge between regions of the world: it is relatively central in the network, and well connected to most other parts of the world. For example, economies such as the People's China; Hong Kong, China; and Korea are located at the intersection of Asia, North America, Europe, and the aggregate Rest of the World region. Europe, by contrast, forms more of a self-contained unit, with strong links within the region, and strong links between some key economies and other regions, but many economies that exist primarily within a European space.

Figure 4.1 Graphical Representation of the World Trade Network in Gross Value Terms, 2009.



Source: Authors.

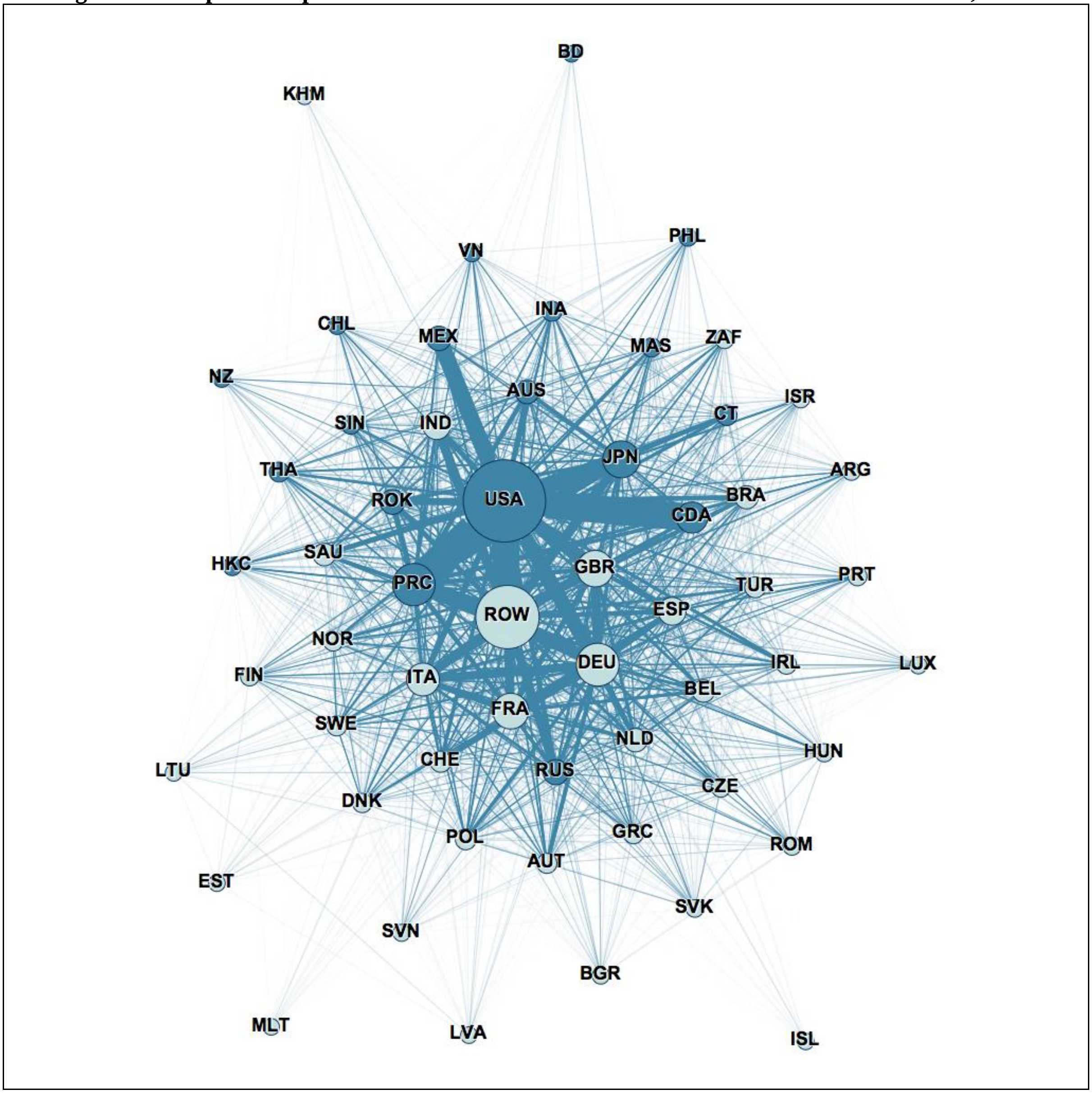
Figure 4.1 was based on trade data in gross value terms. As a result, it provides a good starting point for analyzing global trade networks. However, it does not focus on value added trade, and therefore does not provide the clearest possible picture of the way that value chains work in different regions. Figure 4.2 focuses in on that question by providing the same type of network representation, but for trade based on value added exports, rather than gross value exports. Figure 4.2 therefore excludes trade in intermediate inputs.

A number of points of distinction are apparent between the gross trade network and the value added trade network. First, although the overall structure of both networks is quite similar, the value added network appears denser than the gross trade network, even though the trade values involved are smaller because intermediate input use is netted out. In the case of some economies that have large amounts of entrepot trade, value added exports are less than 50% of gross value exports. There is a noticeable difference in the size of the circles representing such economies between the gross value and value added trade figures: they are smaller in the latter, meaning that their Connectedness is less for value added trade than for gross trade.

Second, the average level of Connectedness in the value added trade network is lower than for gross trade, even though the Connectedness score of the best connected economy is higher. This finding likely again has to do with the nature of the flows being captured. In particular, it is noticeable that the average Connectedness of APEC economies is lower in the case of value added trade than in the case of gross trade. However, performance relative to the world average is approximately the same in both cases: APEC economies are, on average, about one-third more connected to global trade networks than the world average.

Third, the dispersion of Connectedness scores is slightly lower in the case of gross trade than in the case of value added trade, again despite the fact that the top score is higher for the latter than for the former. This finding suggests that the value added trade networks displays even stronger hub and spoke characteristics than the gross trade network: some economies are very well connected to the rest of the world, but others are relatively isolated.

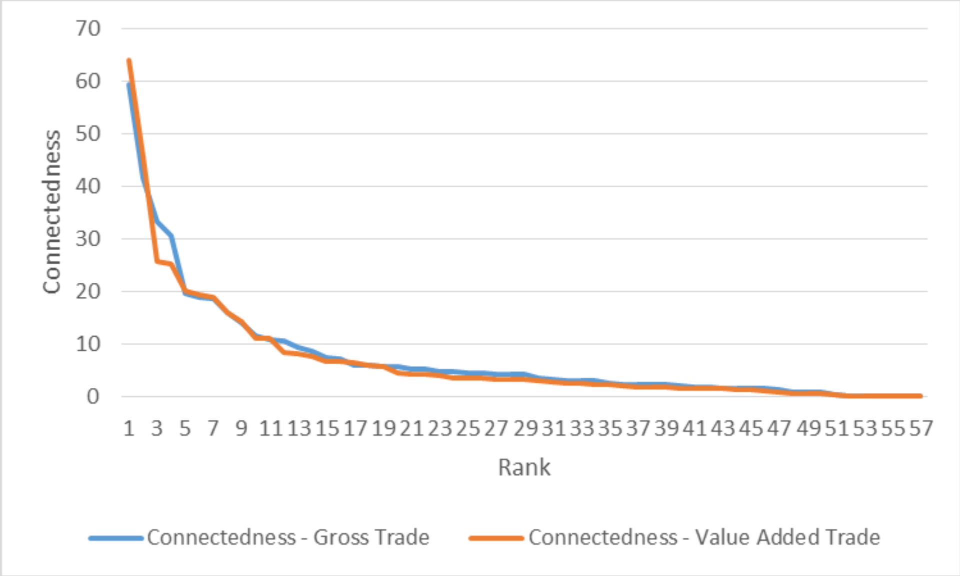
Figure 4.2 Graphical Representation of the World Trade Network in Value Added Terms, 2009.



Source: Authors.

Despite the points of distinction set out above, the general pattern of Connectedness scores observed in the two cases is quite similar (Figure 4.3). In analytical terms, the general picture is of a rapid fall off in scores from a few very well connected economies, to a large number of less well connected economies. Economists and mathematicians refer to a graph like Figure 4.3 as following a "power law". Such laws are common in economics, but are indicative of a certain degree of polarization among economies. In the present context, a power law of the type observed in Figure 4.3 is consistent with a hub and spoke network containing more than one hub. This type of network is common in international transportation, including maritime shipping and air transport networks, so it is unsurprising to find it replicated in the trade network more broadly.

Figure 4.3 Connectedness Scores vs. Rank for the Gross Trade and Value Added Trade Networks.

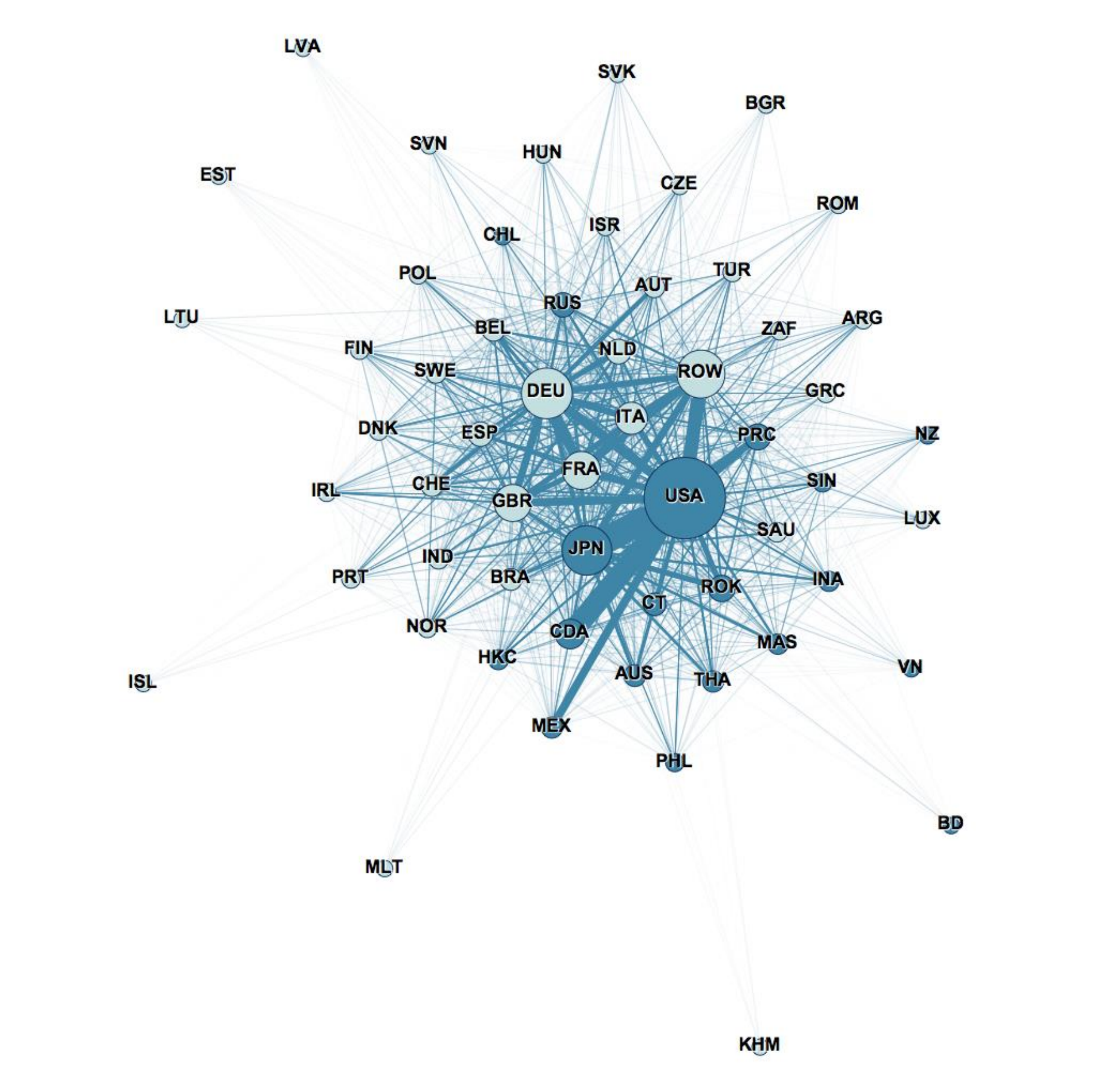


Source: Authors.

It is of policy interest to provide an idea of the way in which the global value added trade network has evolved over time. To do that, Figure 4.4 provides a graphical representation of the network using the earliest available TiVA data, namely 1995. There is thus nearly a 15 year gap between Figures 4.3 and 4.4, during which significant changes have taken place in terms of policy, technology, and business models.

Comparing Figures 4.3 and 4.4 reveals a number of points of similarity and contrast. In overall terms, the network is quite stable over the period considered, which is remarkable given the changes that have taken place in the world economy. Average Connectedness for the world as a whole has increased by nearly 2.5%, but this average obscures considerably larger changes at the level of individual economies. One APEC economy that is now one of the world's largest traders has more than doubled its Connectedness score between 1995 and 2009, due to the importance of an export-led growth strategy, backed up by significant liberalization at- and behind-the-border. Another APEC economy has increased its Connectedness score by about 50%, undoubtedly in part due to implementation of a free trade agreement with the largest hub in the global trading system (also an APEC economy). As these examples show, although the overall structure of the network appears relatively stable over time, there is considerable scope for policy reforms to bring concrete benefits to economies individually and to the region as a whole in terms of increased Value Chain Connectedness.

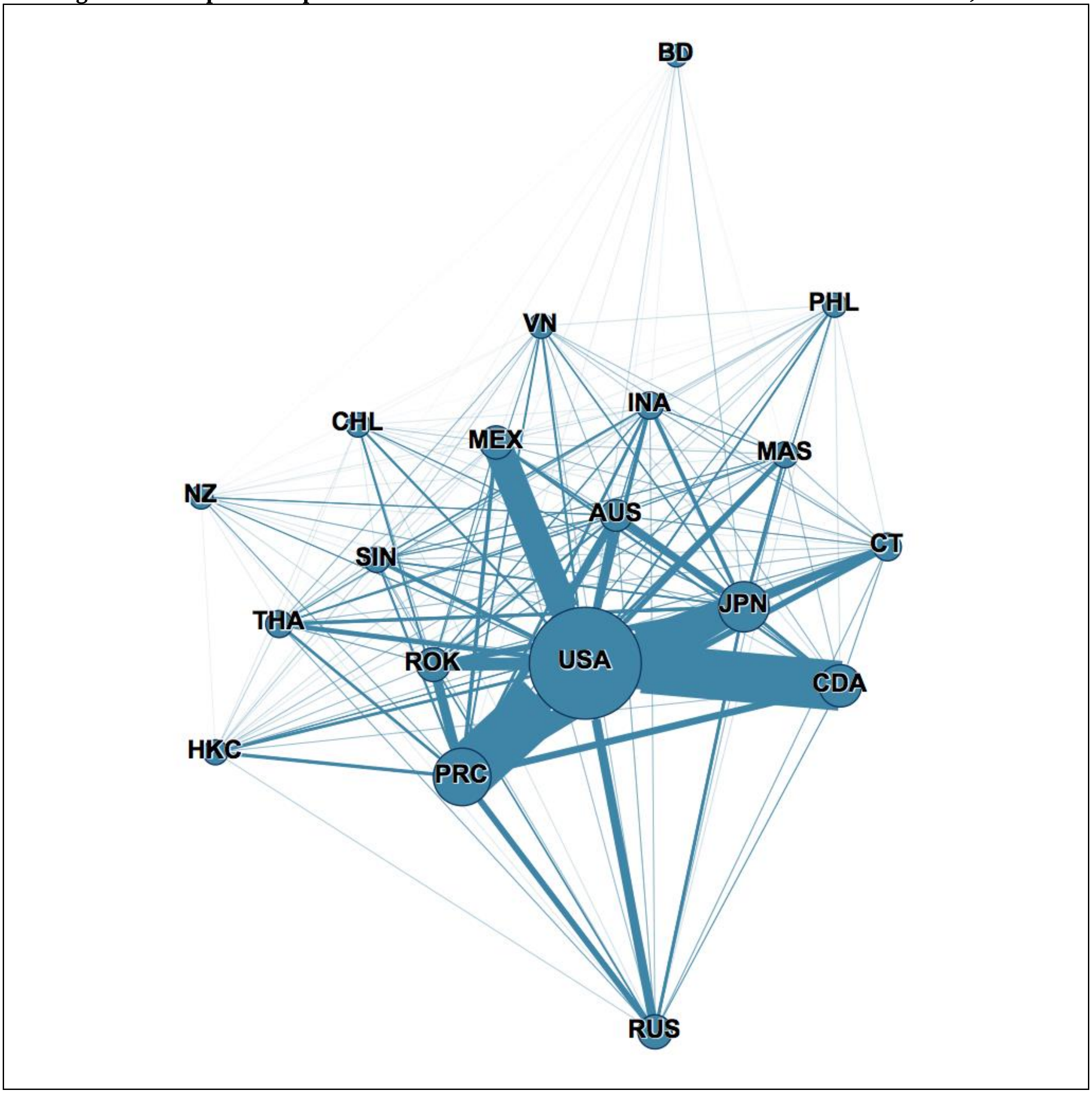
Figure 4.4 Graphical Representation of the World Trade Network in Value Added Terms, 1995.



Source: Authors.

Having presented results for the global network of trade in value added, attention now turns to a zoom on the APEC-specific part of that network (Figure 4.5). The first aspect of the zoomed figure is the number and strength of connections among APEC economies. The second notable point of the figure is the considerable heterogeneity among APEC economies: some economies are very strongly connected to others, and play a central role in the network of value added trade. Others are less strongly connected, and in some cases the overall level of Connectedness is very weak, as evidenced by the small diameter of the circles used to represent them. On the whole, the APEC graph is consistent with the existence of a number of hub and spoke systems within the region.

Figure 4.5 Graphical Representation of the APEC Trade Network in Value Added Terms, 2009.



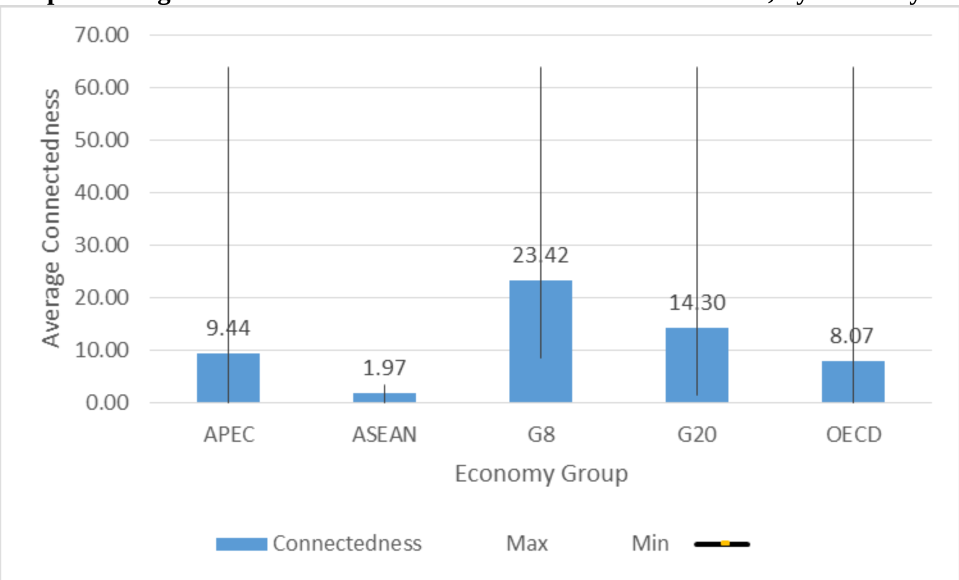
Source: Authors.

The analysis now turns to Connectedness scores specifically, in order to compare APEC's performance with that of other world economic groups. Figure 4.6 shows Connectedness scores for total trade in value added. APEC is a strong performer compared with other regions, with an average score much higher than that of ASEAN, and a little higher than that of the OECD. The G20 performs somewhat more strongly, due to the presence of well-connected European economies in the group. Similarly, the G8 group of developed economies also performs more strongly. APEC's average score is about one-third higher than the world average, which provides further evidence that seen in comparative perspective, the Asia-Pacific is relatively well placed in terms of its connections to global and regional value chains.

APEC's score in part reflects its heterogeneity as a group. As the line in Figure 4.6 shows, the range of Connectedness scores is very wide. APEC includes some of the most connected economies in the world, but others that are less well-connected. The range in the G8, by contrast, although still broad, is much narrower than that observed in APEC.

Indeed, the difference in Connectedness scores between developed and developing APEC economies is striking.[3] For total value added trade, the average for the developed economies is 21.26, which is very close to the average score for the G8. The developed APEC economies are therefore some of the best connected economies in the world. By contrast, the average score for the developing APEC economies is 5.78, which is still substantially higher than the ASEAN average, but lower than that of all other groups. These findings suggest that integrating developing and developed economies into a cohesive regional and global trade network may be an area in need of further policy attention going forward. It is perhaps also reflective of the fact that most lead firms in value chains are headquartered in developed economies, which is also where they perform most of their high value added functions, such as research and development, and design. Developing economies have considerable scope to "move up" in value chains towards higher value added activities. Doing so is complex and requires reforms in many areas of policy and private sector development. The emergence of a more cohesive trade network, however, depends on such steps being taken over the medium-term.

Figure 4.6 Simple Average Connectedness Score for Total Value Added Trade, by Economy Group, 2009.



Source: Authors.

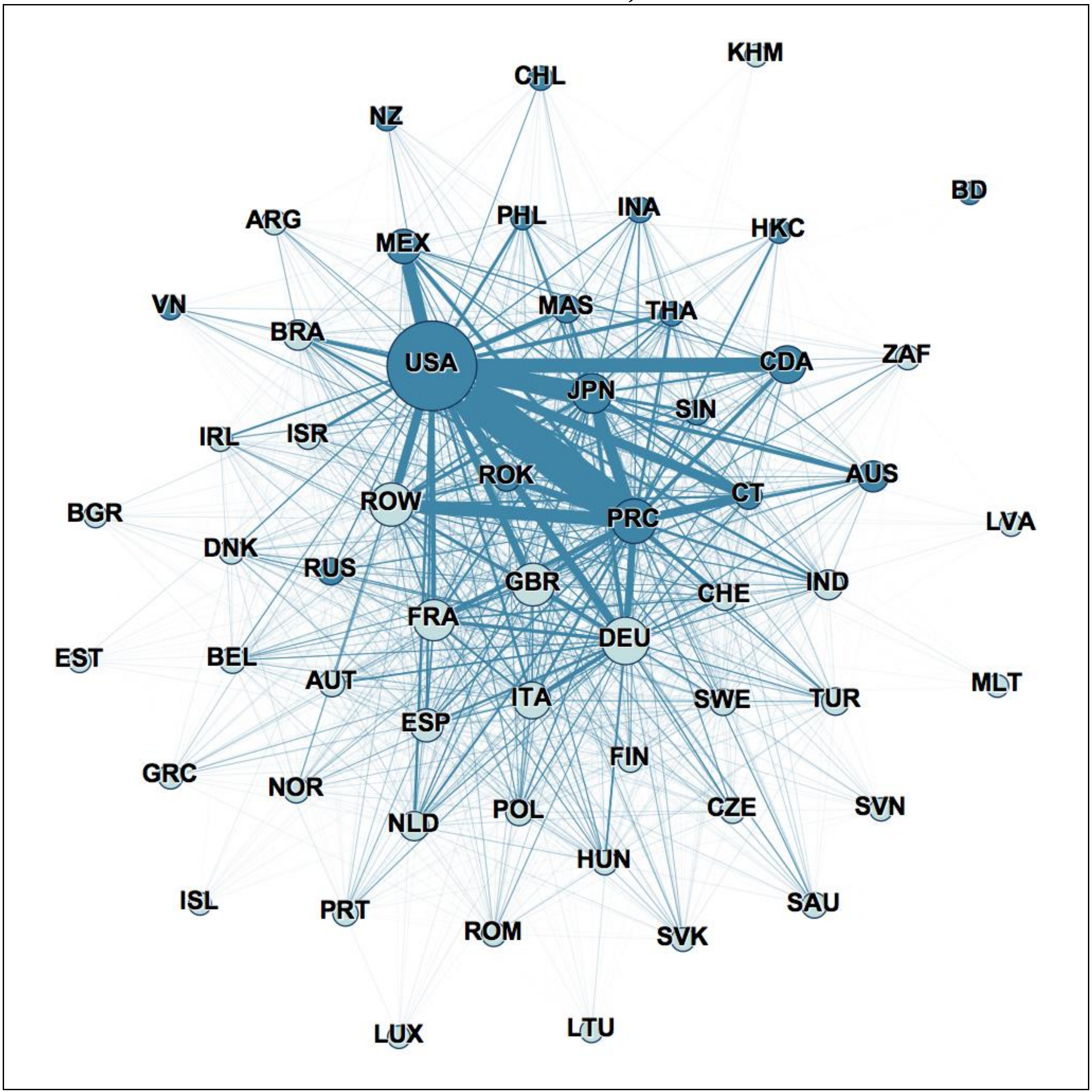
Electrical and Optical Equipment

To gain a fuller understanding of value chain trade and Connectedness, it is important to use the data to examine particular sectors where value chains are known to be of particular importance in the Asia-Pacific region. Electrical equipment is one such sector. Figure 4.7 provides a graphical representation of the global network of value added trade in electrical equipment. Although the general correlation between results for total trade and results for this sector is high, a number of features are striking by comparison with Figure 4.2. First, some economies are heavily involved in the network and central to it—they are highly connected hubs— while a number of other economies are much more peripheral spokes that scarcely

[3] Standard APEC practice is used to distinguish between developed and developing economies. Developed economies are Australia, Canada, Japan, New Zealand, and the United States. All other economies are considered to be developing.

engage in this type of export activity at all. Second, links across geographical regions are more evident in the case of electrical equipment than for total trade, although APEC in particular still plays a noticeable bridging role. Third, APEC economies are more evenly distributed throughout the network, as opposed to the more obvious grouping dynamic at play in Figure 4.2. This feature suggests that particular APEC economies operate not just in the Asia-Pacific, but also in other geographical regions that overlap with it, such as North and Latin America, and other parts of Asia.

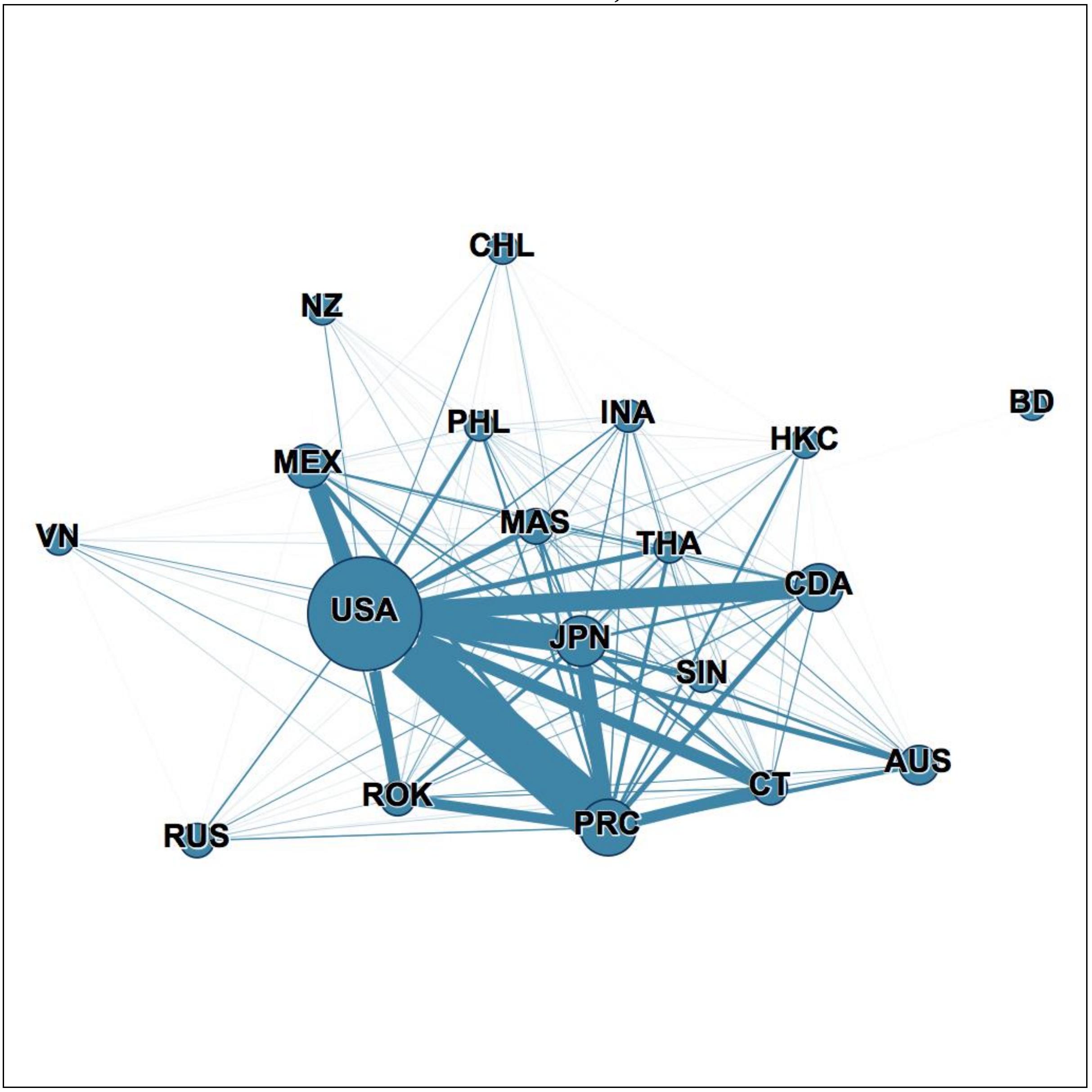
Figure 4.7 Graphical Representation of the World Trade Network for Electrical and Optical Equipment in Value Added Terms, 2009.



Source: Authors.

To provide further detail on the APEC network of value added trade in electrical equipment, Figure 4.8 provides a zoom of the graph in Figure 4.7, with only APEC member economies included. The figure is suggestive of a multi-layer hub and spoke network in operation in this sector. Considerable heterogeneity is evident among APEC economies, both in terms of the volume of trade (represented by the thickness of the lines), and their degree of Connectedness (represented by the size of the relevant circle). There are close sub-networks that bring together groups of economies, but other economies are distant from them in economic terms.

Figure 4.8 Graphical Representation of the APEC Network for Electrical and Optical Equipment in Value Added Terms, 2009.

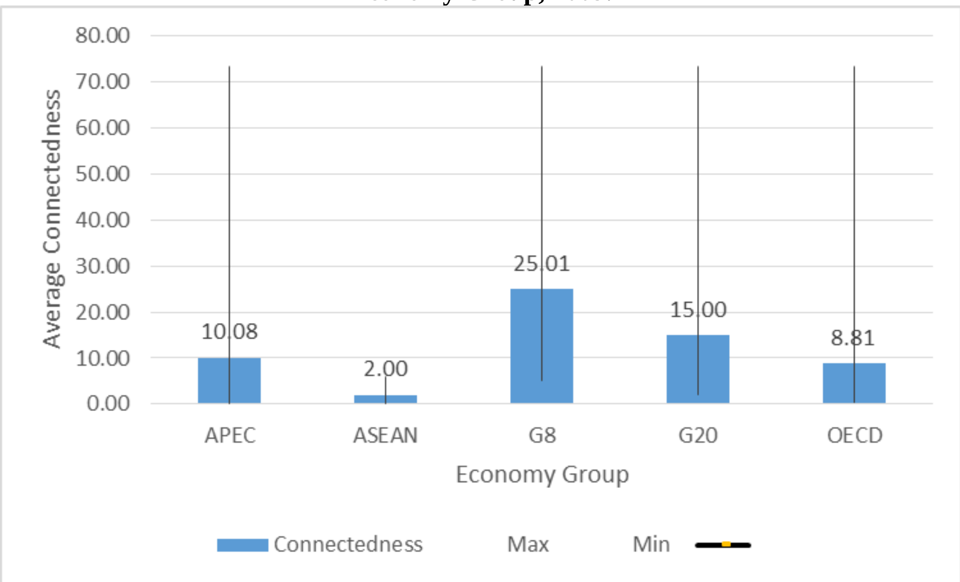


Source: Authors.

Results for average Connectedness scores and ranges are in Figure 4.9. As was the case for total trade, the data show that APEC is a relatively well-connected region, performing noticeably more strongly than ASEAN, and a little better than the OECD. However, the G-20 and the G-8 perform more strongly. The performance gap is narrower for electrical equipment than for other sectors, which perhaps reflects the strong development of electrical equipment value chains in the Asia-Pacific. One important driving force behind this result is the presence of well-connected European economies in the G-20 and G-8 groups, with the effect that their intra-regional trade boosts average connectedness. On a global basis, however, APEC's average Connectedness score is nearly 43% higher than the worldwide average. Taking all of these results together, it is clear that APEC is a well-connected region when it comes to value chains in the electrical equipment sector.

As for total trade, dispersion of scores is very large compared with the average, and it is particularly the case in APEC. APEC again counts among its member economies some of the best-connected economies in the world, as well as some economies with much weaker connections. The contrast between developed and developing member economies is striking: the former have average scores that are four times as high as the latter in electrical equipment. Indeed, electrical equipment have the highest observed economy-level Connectedness score of any sector considered in this report. The gap is therefore particularly striking in this case, and worthy of further examination in light of the importance of the sector for trade and economic activity in the Asia-Pacific region.

Figure 4.9 Simple Average Connectedness Score for Value Added Trade in Electrical Equipment, by Economy Group, 2009.



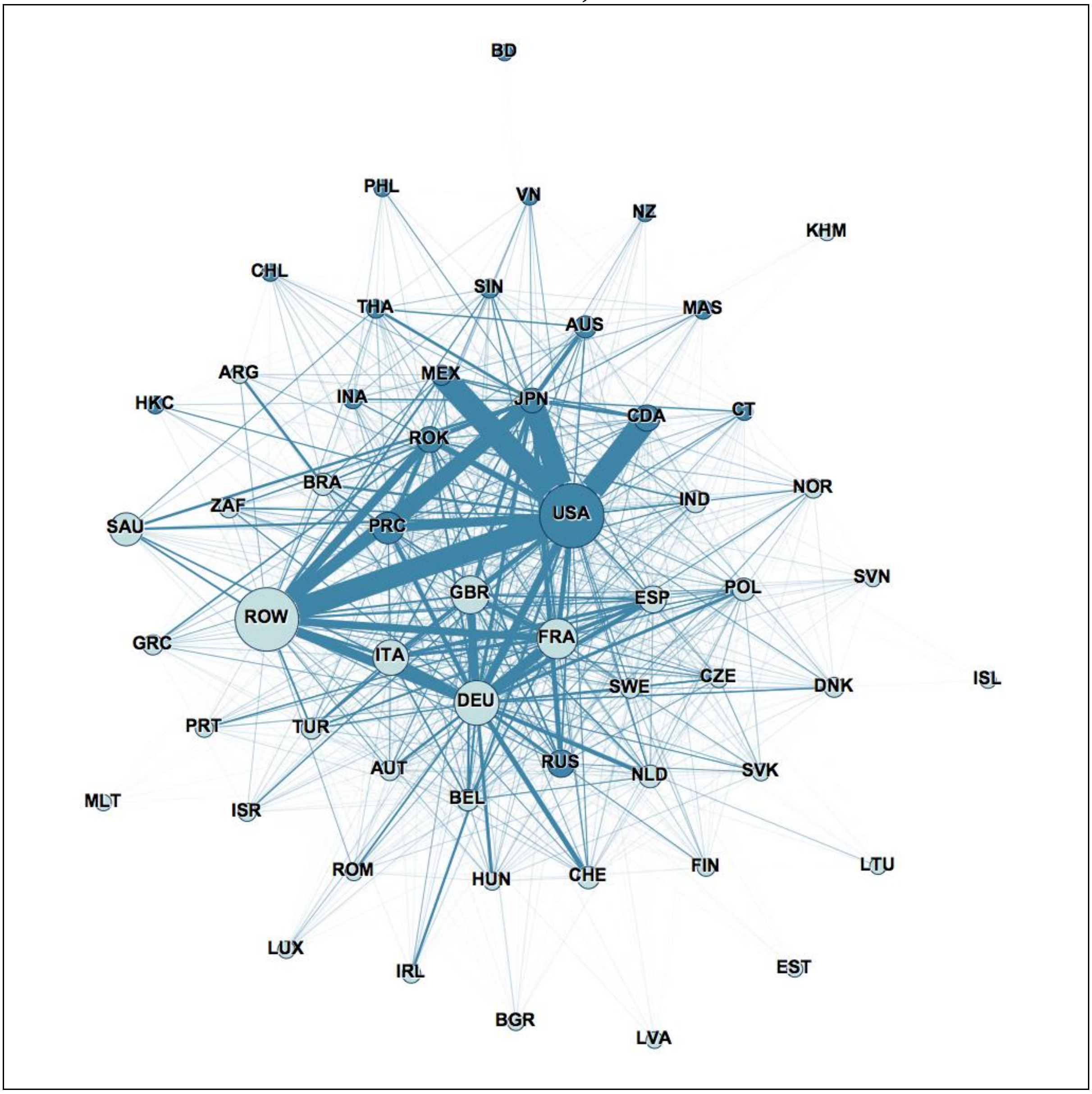
Source: Authors.

Transport Equipment

As was the case for electrical equipment, results for the transport equipment sector correlate strongly with results for total trade in value added. However, graphical representations of the network again make clear that value chains in this sector operate in distinctive ways.

Figure 4.10 presents the global network of value added trade in the sector, and Figure 4.11 presents a zoom limited to APEC economies, as in the previous section. The first figure is notable for the fact that APEC again plays a bridging role, and as a region is generally quite central to the global network. Although the central network is relatively tightly formed, there are nonetheless a few economies that are very distant from the main nexus of activity in this sector.

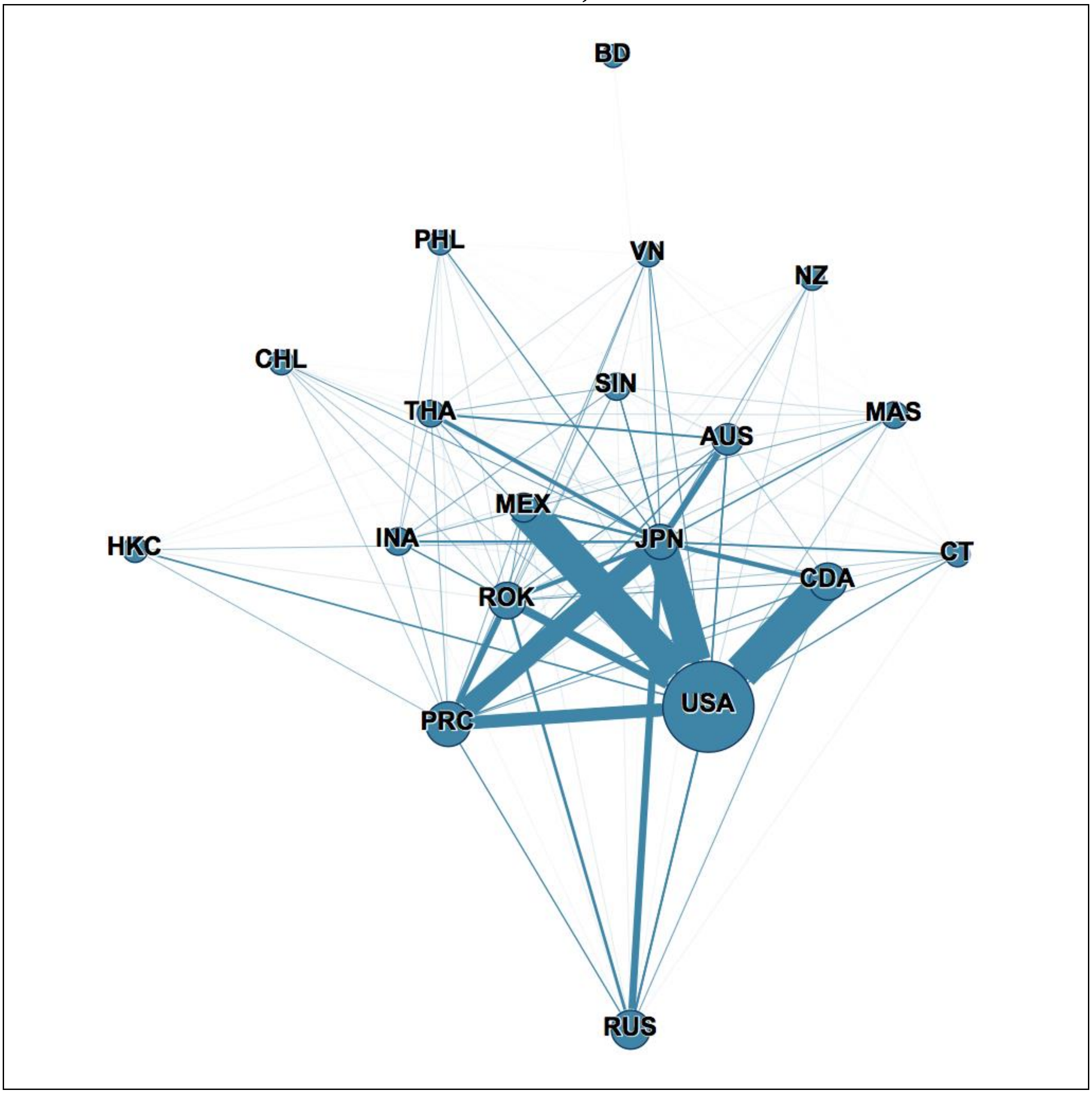
Figure 4.10 Graphical Representation of the World Trade Network for Transport Equipment in Value Added Terms, 2009.



Source: Authors.

The APEC zoom in Figure 4.11 discloses a well-developed network of trade in transport equipment, with a number of highly connected hub economies. Some other economies are relatively distant from the otherwise dense trade taking place in this sector. By contrast with electrical equipment, the transport equipment network is generally more tightly packed within the region. This finding suggests that the economic distance between economies—at least those in the central part of the network—may be smaller in this sector.

Figure 4.11 Graphical Representation of the APEC Trade Network for Transport Equipment in Value Added Terms, 2009.



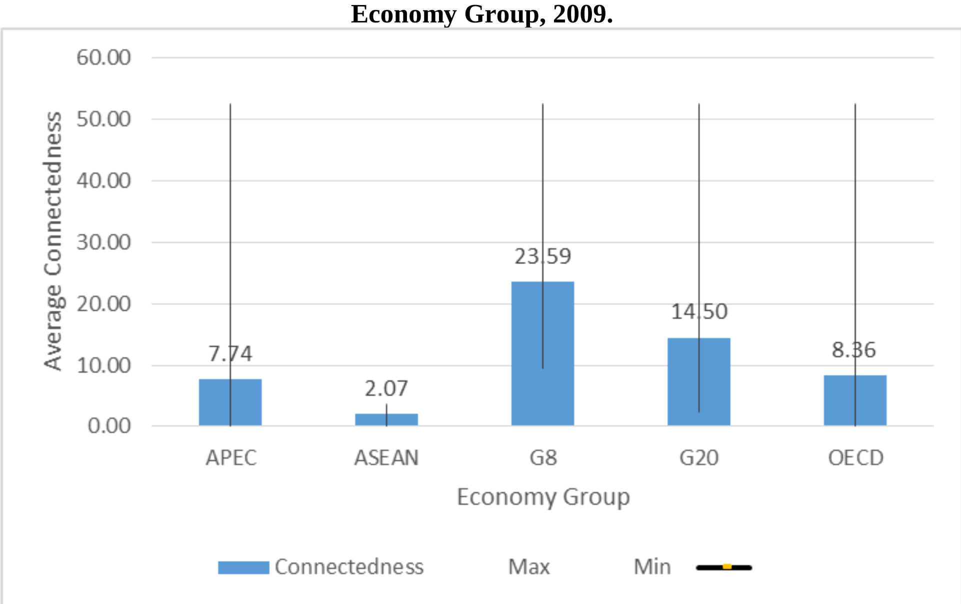
Source: Authors.

As was the case for total trade, the data show that APEC is a relatively well-connected region, performing in all cases more strongly than ASEAN, and comparably to the OECD (Figure 4.12). In all cases, however, the G-20 and the G-8 perform more strongly. The gap is widest for transport equipment than for other sectors. Again, the main driving force is the presence of well-connected European economies in the G-20 and G-8 groups, with the effect that their intra-regional trade boosts average connectedness. In global terms, APEC's average score is higher than the world average, but only by 3%. The difference in relative performance between this sector and the others is striking. APEC's average score is quite similar in all cases, so the implication to be drawn is that value chains are comparatively better developed elsewhere in the world in transport equipment than in other sectors. Competition among and within value chains is therefore particularly strong. Issues of value chain governance may also be relevant.

In terms of the observed range, transport equipment again follows the pattern established for total trade: in all groups, dispersion of scores is very large compared with the average, and it is particularly the case in APEC. APEC counts among its member economies some of the best-connected economies in the world, as well as some economies with much weaker connections. As was the case for total trade, the contrast between developed and developing member economies is striking: the former have average scores that are over twice as high as the latter in transport equipment. In addition to the points made earlier in relation to total trade, this result is interesting from a policy point of view because of the relatively superior performance of developing member economies in the case of transport equipment. A detailed sectoral study would be needed to analyze the precise value chain dynamics that have enabled developing economies to become relatively better integrated into that sector compared with others. There are possible implications to be drawn for other sectors from the experience of the transport equipment sector.

Average connectedness for the world as a whole is highest for transport equipment, but the data also disclose the lowest observed Connectedness score at the economy-level. These results again highlight the very large range of scores that is evident in the data. It is this range that is the most notable feature of the data.

Figure 4.12 Simple Average Connectedness Score for Value Added Trade in Transport Equipment, by Economy Group, 2009.



Source: Authors.

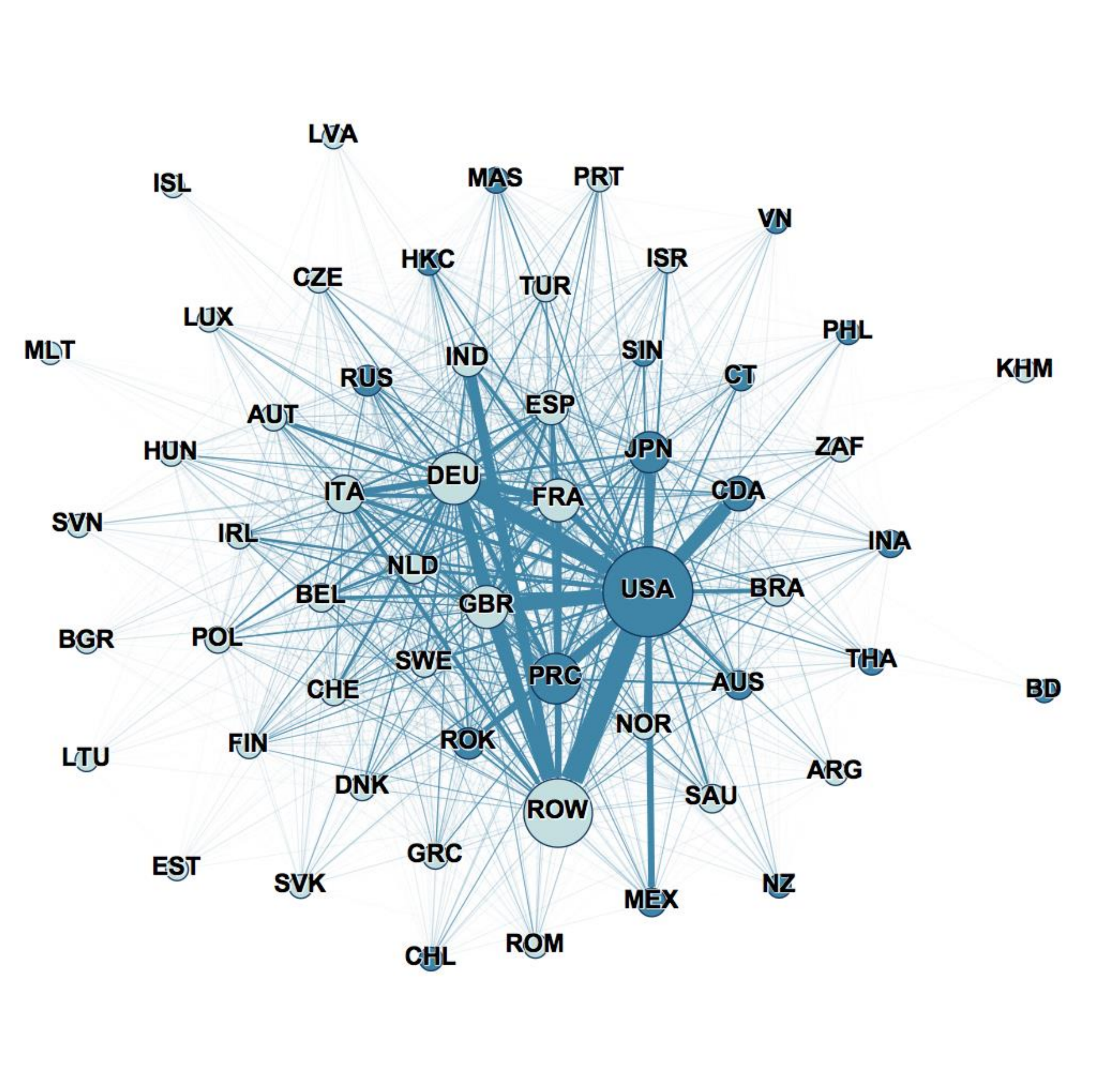
Other Business Services

Although value chains are better known in goods sectors, such as those examined in the two previous subsections, they are also becoming an increasingly important way of doing business in services. The business services sector is one in which value chain trade plays an important role, both in APEC and more broadly in the global economy. Figure 4.13 presents a graphical representation of the global network of value added trade in this sector, and Figure 4.14 provides an APEC-specific zoom.

The layout of the global business services trade network in Figure 4.13 is quite distinctive compared with the others examined above. Average connectedness is somewhat less than for the denser network of trade in transport equipment, and is also lower than for total trade.

Although dispersion of Connectedness scores in an overall sense is comparable, there are more economies with mid-range scores in this sector. As the layout of the graph makes clear, economies are not as tightly connected to each other in business services compared with other sectors, a fact which undoubtedly reflects the relatively recent expansion in value chain business models in services compared with goods.

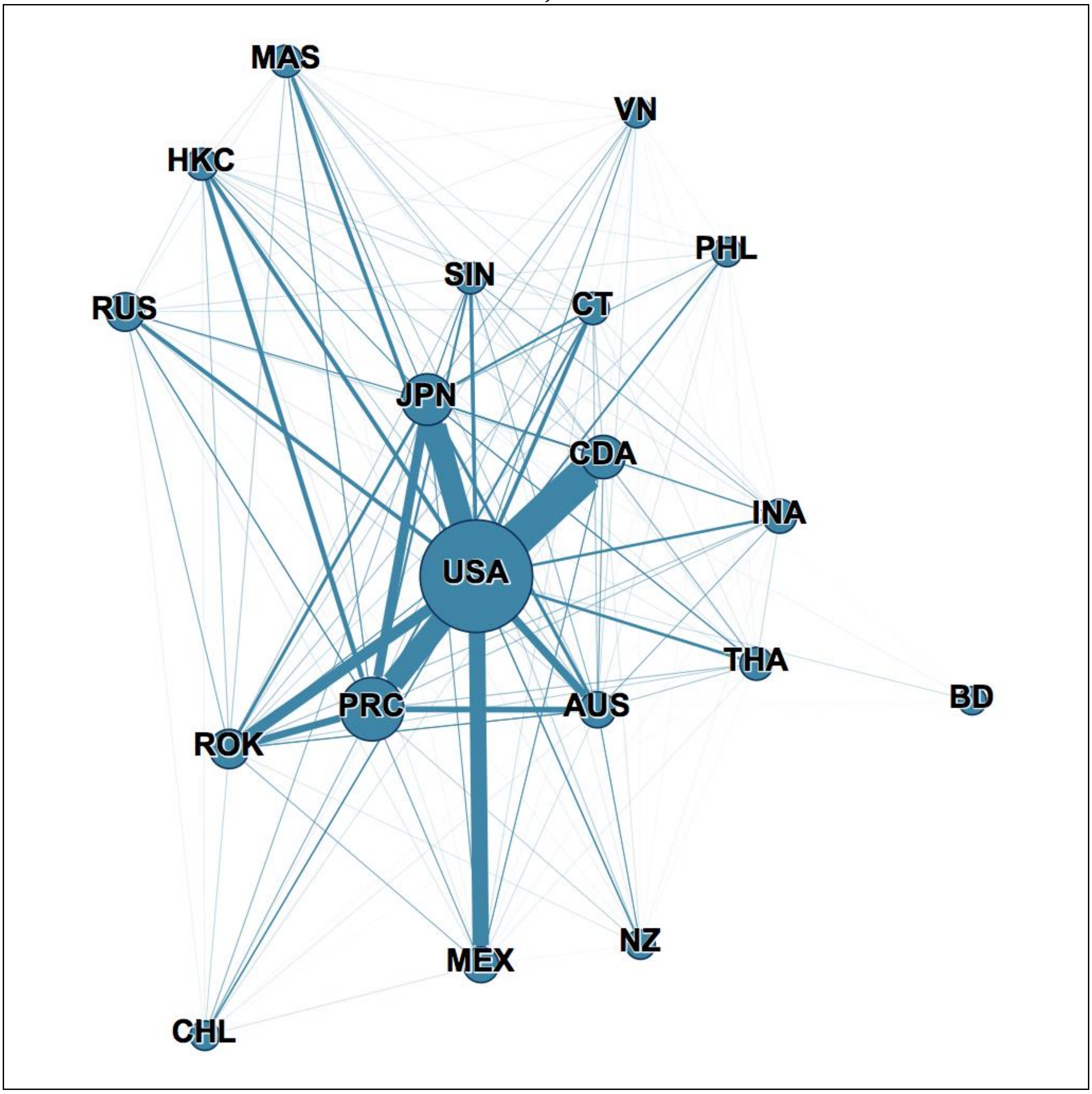
Figure 4.13 Graphical Representation of the Global Trade Network for Business Services in Value Added Terms, 2009.



Source: Authors.

In Figure 4.14, the APEC zoom of the global network discloses a number of interesting features. First, it is notable for the concentration of flows in a few key places in the figure, which means that very strong trade links between a relatively small number of economies account for the bulk of value added trade in the business services sector. The concentration of flows seems to be more significant than for the goods sectors examined above. Second, a number of economies are distant from the economic center in this sector, perhaps to a greater degree than in the goods sectors considered above. This finding may reflect the fact that trade costs are typically higher in services markets than in goods markets, perhaps by a factor of as much as two (Miroudot et al., 2013).

Figure 4.14 Graphical Representation of the APEC Trade Network for Business Services in Value Added Terms, 2009.

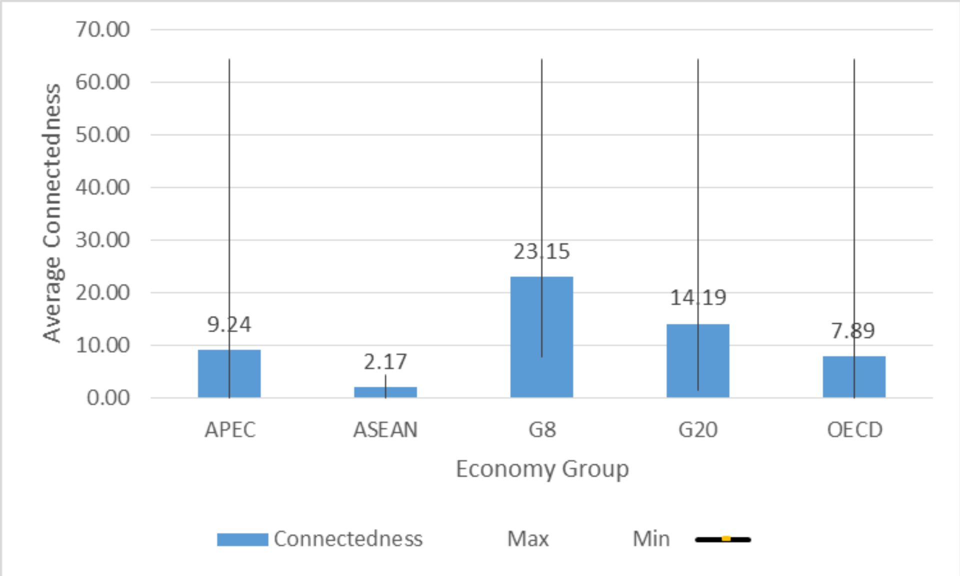


Source: Authors.

As was the case for total trade, the data show that APEC is a relatively well-connected region, performing more strongly than ASEAN and the OECD (Figure 4.15). In all cases, however, the G-20 and the G-8 perform more strongly. Again, the main driving force is the presence of well-connected European economies in the G-20 and G-8 groups, with the effect that their intra-regional trade boosts average connectedness. In global terms, APEC's average score is over 30% higher than the global average, which suggests that Asia-Pacific value chains in business services—although still in a relatively early stage of development—are well positioned relative to those in other parts of the world.

In terms of the observed range, this sector again follows the pattern established for total trade: in all groups, dispersion of scores is very large compared with the average, and it is particularly the case in APEC. APEC counts among its member economies some of the best-connected economies in the world, as well as some economies with much weaker connections. As was the case for total trade, the contrast between developed and developing member economies is striking: the former have average scores that are nearly four times as high as the latter in business services.

Figure 4.15 Simple Average Connectedness Score for Value Added Trade in Business Services, by Economy Group, 2009.



Source: Authors.

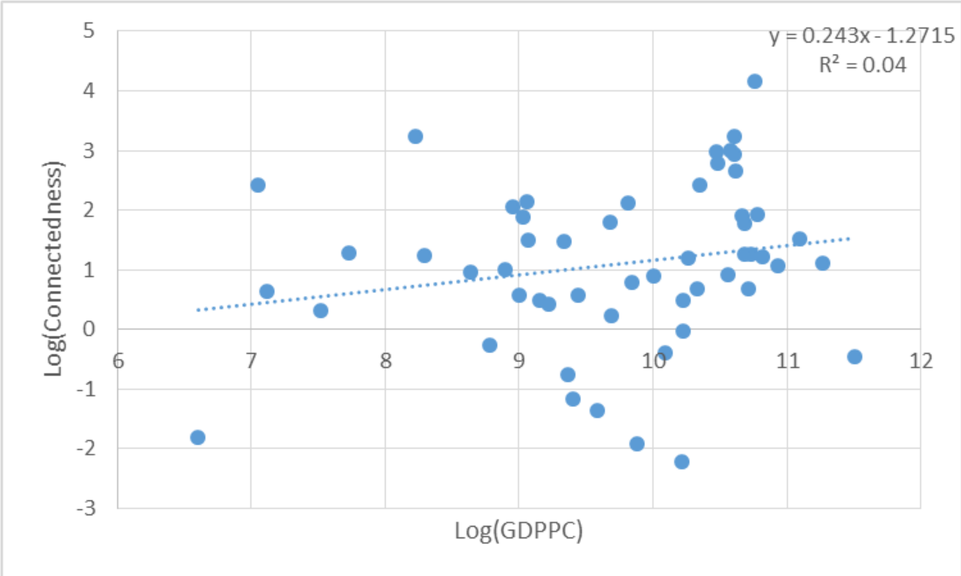
POSSIBLE DETERMINANTS OF VALUE CHAIN CONNECTEDNESS

The previous sections have presented and analyzed Value Chain Connectedness for the Asia-Pacific, and have compared performance with other important economic groupings. From a policy perspective, however, it is also important to know which factors potentially allow an economy to develop greater connectedness. Examining that question is the purpose of this section. The analysis uses graphical methods, which represent simple correlations between two variables. The results presented here therefore do not control for external factors that might drive the correlations observed. Before drawing strong conclusions on the determinants of Connectedness, it would be important to develop fully-specified econometric models to analyze these questions in greater detail. However, this report is the first attempt at understanding the determinants of Connectedness based on network analysis methods, and as such is limited in scope to providing some suggestive results. Future research work will examine these questions in greater detail.

Attention is first given to the question of income level: do more developed economies tend to have better Connectedness scores? That appears to be the case from the analysis above of APEC developing and developed member economies. An income effect of this type could also explain why some large economies have high Connectedness scores in the network graphs discussed above: economic size is not just a function of population, but also of average income, and thus more developed economies tend to have larger GDPs. Indeed, such an effect seems likely based on the network graphs presented in this report, because as Chapter 3 and the Technical Appendix make clear, economic size itself does not enter at all into the calculations that produce the Connectedness index.

Figure 4.16 shows the correlation between per capita GDP as in indicator of development level and Connectedness. Indeed, there is a positive correlation in the figure, with an upward-sloping trend line. It is apparent that at least part of any apparent association between economic size and Connectedness is due to an income effect: more developed economies tend to be better connected.

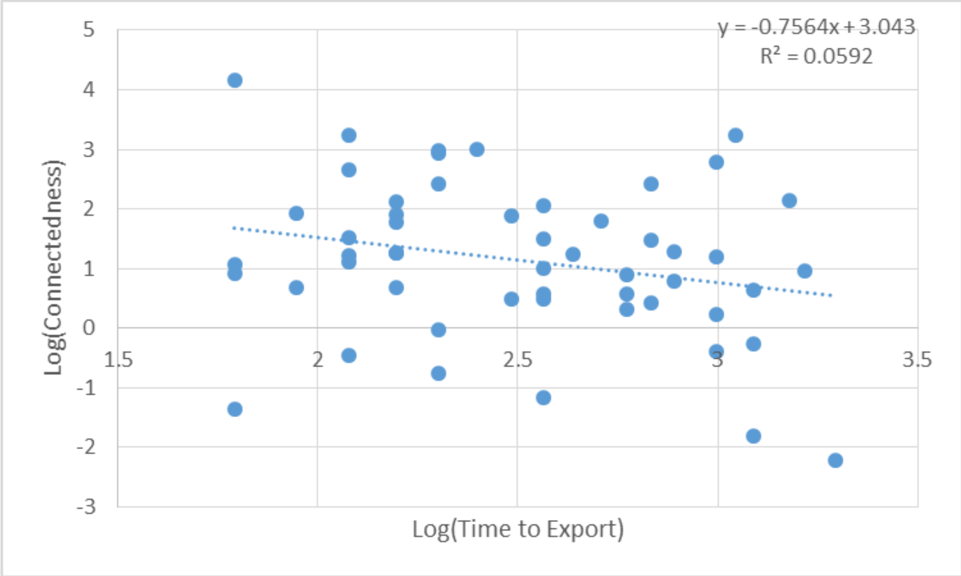
Figure 4.16 Correlation between Income Level and Connectedness Score for Total Value Added Trade.



Source: Authors. GDPPC data are in nominal USD for 2009 (World Development Indicators).

In terms of policies that could directly promote greater Connectedness, it is important to examine trade facilitation and logistics. There is already evidence that better logistics performance is associated with particularly strong trade boosting effects in sectors where value chains are active (Saslavsky and Shepherd, Forthcoming). One measure of trade facilitation performance that focuses particularly on red tape barriers is time to export in the World Bank's Doing Business dataset. Figure 4.17 shows the association between that measure and Connectedness. It is expected to be negative—weaker trade facilitation performance inhibits Connectedness—and that is exactly what is observed.

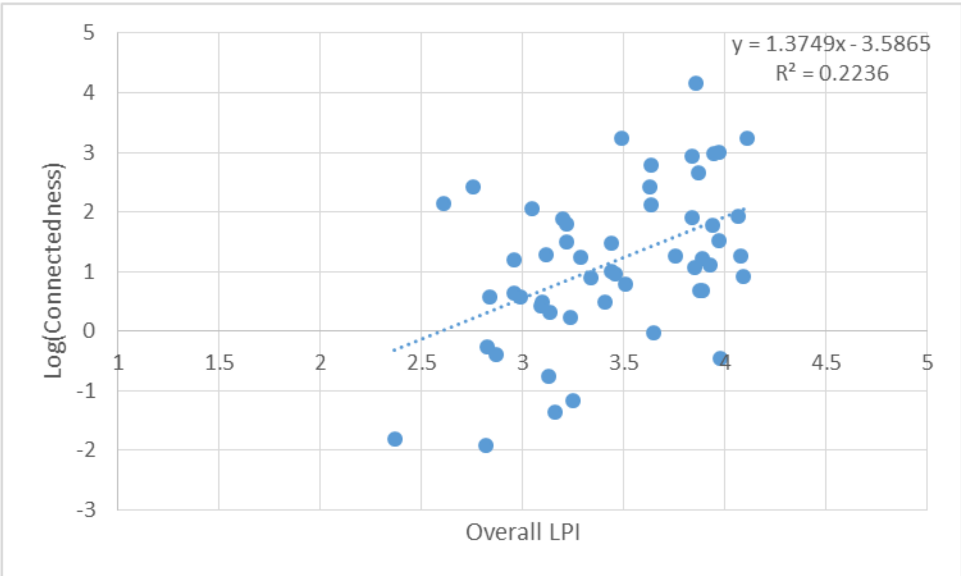
Figure 4.17 Correlation between Time to Export and Connectedness Score for Total Value Added Trade.



Source: Authors. Time to export data are in days for 2009 (Doing Business).

Another common measure of trade facilitation performance that captures more transactional data, in addition to red tape barriers, is the World Bank's Logistics Performance Index. In this case, a positive correlation with Connectedness is expected: better logistics performance should improve an economy's ability to connect with global and regional value chains. Figure 4.18 shows that this is indeed the case. Trade facilitation and logistics performance are therefore key policy drivers of an economy's ability to connect to value chains.

Figure 4.18 Correlation between Logistics Performance and Connectedness Score for Total Value Added Trade.

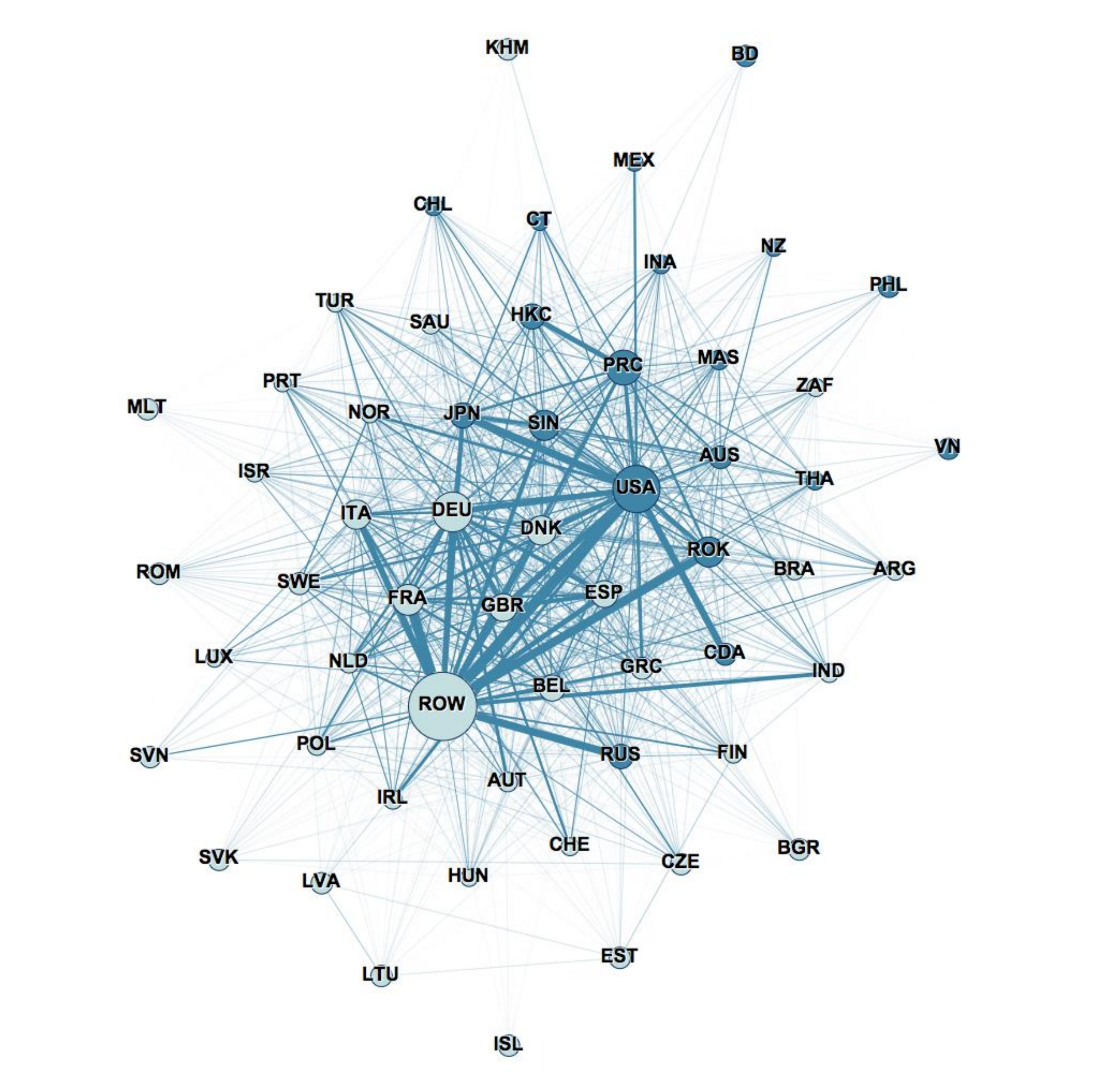


Source: Authors. Logistics performance is measured by the Overall LPI for 2010, index from one to five (World Bank).

A broader context for examining issues such as trade facilitation and logistics is Connectivity, a policy area in which APEC is particularly active. Measuring Connectivity and tracking performance over time is a complex issue. However, one approach that may be of policy interest is to consider a measure such as the one referred to as Connectedness in this report, but focusing on the transport services sector. Connectivity in transport services—defined as the export weighted average of the Connectivity scores of all economies a given economy is connected to—is a convenient summary measure of the way in which economies are connected to global and regional transport networks.

Figure 4.19 provides a network map for transport services, where the size of each economy's circle is proportional to its Connectivity score, and the lines are proportional to trade flows (in gross value terms). The main notable feature, and point of contrast with the other network figures presented above, is that some small APEC economies perform extremely well in this sector. For example, one economy that is a global transport hub but relatively small in economic terms has a Connectivity score that is nearly seven times higher than its overall Value Chain Connectedness score. Results such as this one show that the measure is capturing an important aspect of economies' Connectivity profiles.

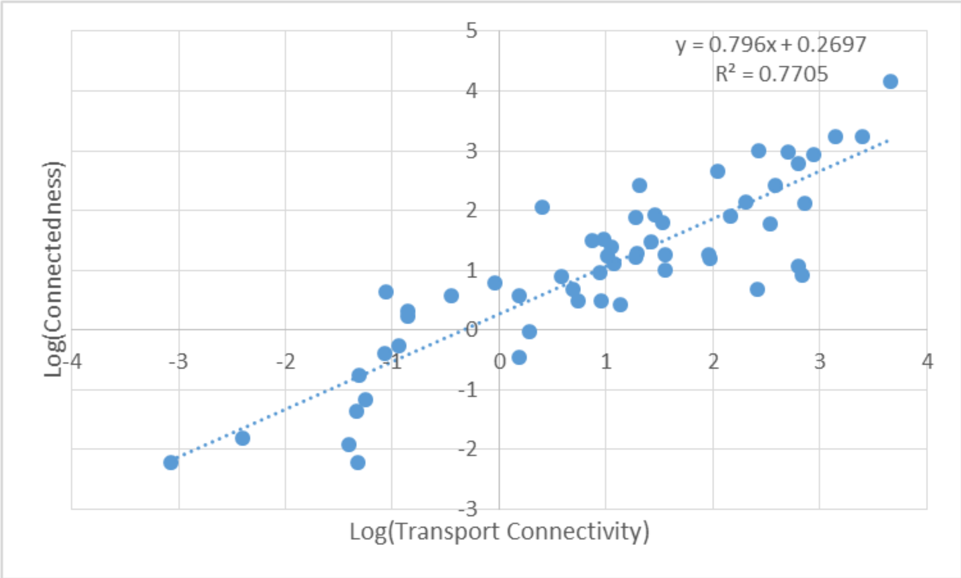
Figure 4.19 Graphical Representation of the Global Trade Network for Transport Services in Gross Value Terms, 2009.



Source: Authors.

In the same way that trade facilitation and logistics are likely determinants of Connectedness score, so too is transport Connectivity. Figure 4.20 makes this point clear: the correlation line is positively sloped, which indicates that economies with higher Connectivity scores also tend to have higher Connectedness scores. APEC's policy agenda on Connectivity is therefore of particular importance in terms of improving Value Chain Connectedness in the region.

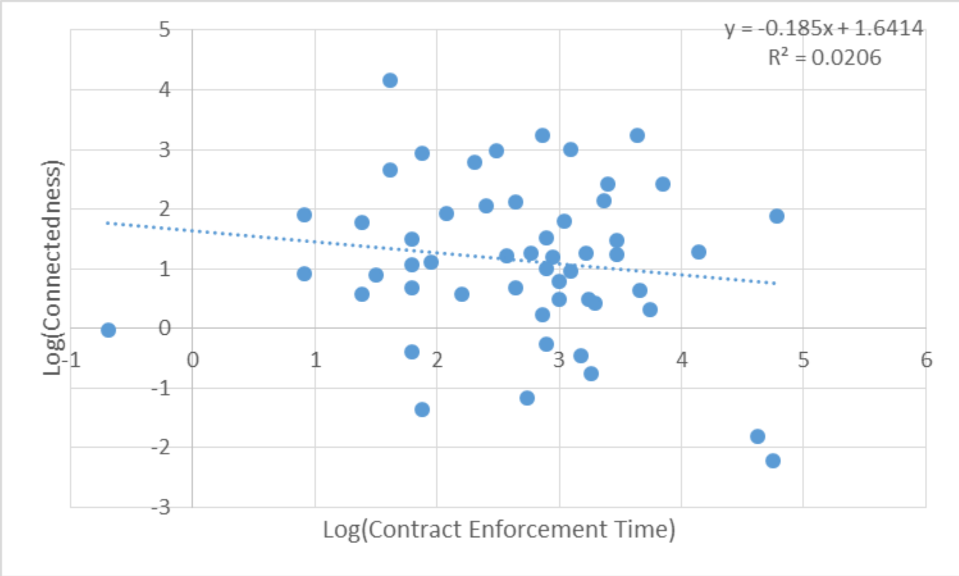
Figure 4.20 Correlation between Transport Connectivity and Connectedness Score for Total Value Added Trade, 2009.



Source: Authors.

Trade facilitation, logistics, and transport connectivity are not the only policy areas that potentially affect an economy's ability to connect to global and regional value chains. Behind the border measures are also important. In particular, value chains rely heavily on the ability to reliably enforce contracts between suppliers and customers. The rule of law is therefore generally important for value chain trade. More specifically, however, it is possible that contract enforcement is of particular importance for Value Chain Connectedness. Figure 4.21 examines this hypothesis using Doing Business data on the time required to enforce a contract, and finds that the data support it. There is a clear negative correlation between the length of time required to enforce a contract, and an economy's Connectedness score. On this basis, it is likely that other behind the border measures that affect the general business and investment climate may also have an impact on Connectedness.

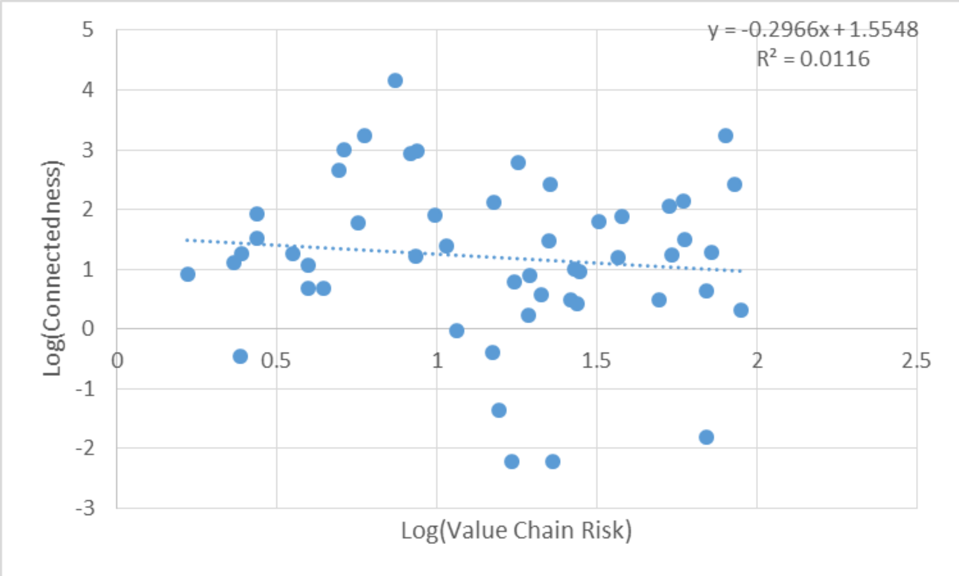
Figure 4.21 Correlation between Time to Enforce a Contract and Connectedness Score for Total Value Added Trade.



Source: Authors. Time to enforce contracts data are in days for 2009 (Doing Business).

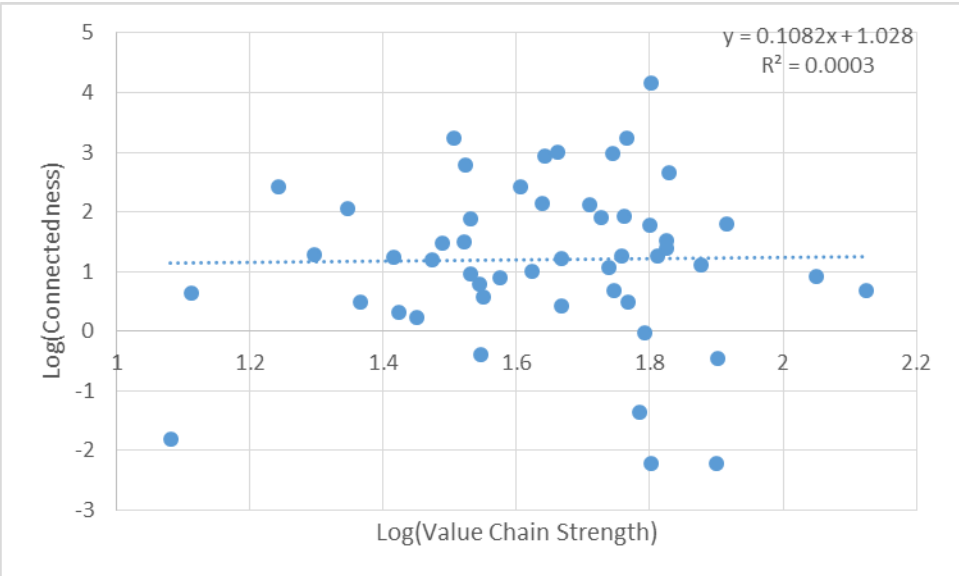
Many other factors also potentially affect an economy's Connectedness score. Two important sets of factors are Value Chain Risk, and Value Chain Strength. Indices for both have been produced as part of the first two phases of this project. Figures 4.22 and 4.23 show the correlations between the two indices and Value Chain Connectedness. Both have the expected signs. Connectedness is higher when risk is lower, and it is higher when strength is higher. The reason in both cases is most likely that lead firms want to minimize risk, and therefore choose to build strong trade and investment links with the most resilient economies where it is easiest and most stable to do business. These two results, together with the preceding ones, suggest that there is a large role for policy and private sector development in promoting Value Chain Connectedness. The policy implications of these findings is discussed in greater detail in the next Chapter.

Figure 4.22 Correlation between Value Chain Risk and Connectedness Score for Total Value Added Trade.



Source: Authors. Value Chain Risk is sourced from the Phase One report for this project, index from one to ten (APEC PSU).

Figure 4.23 Correlation between Value Chain Strength and Connectedness Score for Total Value Added Trade.



Source: Authors. Value Chain Strength is sourced from the Phase Two report for this project, index from one to ten (APEC PSU).

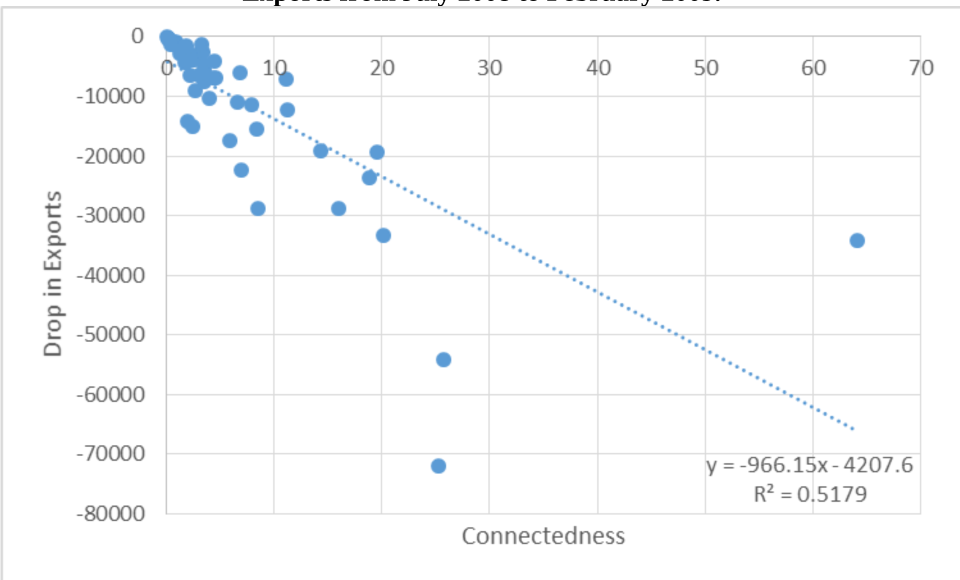
VALUE CHAIN CONNECTEDNESS AND TRADE RESILIENCE

In Chapter 3 and the Technical Appendix, it was shown that the measure of Connectedness used in this report is not only a weighted average of the Connectedness scores of all other economies with which a given economy trades. It is also a measure of the economic value of an extra (or a lost) dollar of traded value added after it has been transmitted in a potentially complex way through the network. For example, the economic value to the United States of an additional $100 in traded value added introduced into the network at a random point is about $64.

As a result of this interpretation, it is expected that better connected economies are both more susceptible to the transmission of shocks through the channel of trade relations, and also better able to recover from such shocks as activity picks up elsewhere around the world. It is therefore expected that there is a positive correlation between Connectedness and the effect of economic shocks coming from elsewhere in the network, and between Connectedness and the speed of recovery from those same shocks. Connectedness is thus both a risk and an opportunity. This section examines that hypothesis using the same graphical techniques as in the last section, and is therefore subject to the same caveats in terms of interpretation.

A good example of the role of Connectedness in the transmission of economic shocks is the Great Trade Collapse that accompanied the Global Financial Crisis of 2008-2009. World merchandise exports dropped from a peak of $1.3 trillion in July 2008 to a trough of $795 billion in February 2009, a fall of over 40%. Figure 4.24 shows the correlation between the export drops suffered by economies during that period, and their Connectedness scores.[4] There is a negative relationship, which indicates that better connected economies suffered greater export declines as a result of the crisis. Value Chain Connectedness was clearly a factor that influenced the way in which the Great Trade Collapse was transmitted among economies.

Figure 4.24 Correlation between Connectedness Score for Total Value Added Trade and Change in Exports from July 2008 to February 2009.



Source: Authors. Trade data are in million USD for the time period indicated (WTO).

Following the Great Trade Collapse, exports recovered relatively slowly all across the world. Total world exports only exceeded their previous peak again in March 2011. The dual interpretation of Connectedness that was put forward in Chapter 3 suggests that highly connected economies should have experienced larger export increases during that time, just as they experienced larger falls when the world economy was in crisis. Figure 4.25 shows that just such an effect appears to have been at play: the line of best fit is upward sloping, and the correlation between export growth and Connectedness is strong.

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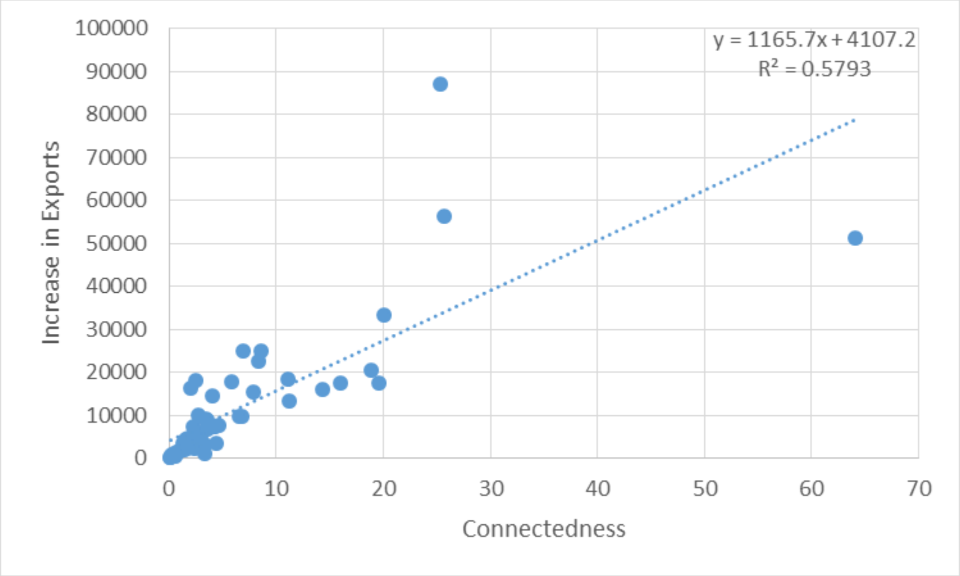
[4] Logarithms are not used in this case, because the interpretation of Connectedness in dollar terms provided earlier is an absolute number, not a percentage of a baseline. The expected relationship is therefore in levels, rather than in logarithms.

Figure 4.25 Correlation between Connectedness Score for Total Value Added Trade and Change in Exports from 2009 to March 2011.



Source: Authors. Trade data are in million USD for the time period indicated (WTO). One outlier is excluded.

Although the correlations presented in Figures 4.24 and 4.25 are informative, and fully consistent with the interpretation of Connectedness provided in this report, they should be interpreted cautiously. Changes in export levels are determined by many factors of which Connectedness is just one. To properly explore the links between export drops, rebounds, and Connectedness, a fully specified econometric model—with a large set of control variables—would be necessary. However, such an extension is beyond the scope of this report, and is put forward as an issue that future research can take up.

5. CONCLUSION AND POLICY IMPLICATIONS

In the context of global and regional value chains as an ever more prevalent business model, it is important for APEC policymakers to be ahead of the curve in terms of creating an economic environment that allows value chains to grow, extend, and prosper. Value chains bring a variety of economic benefits to the economies that host them, and to the region as a whole: increased trade, new foreign investment, technology upgrading, diffusion of new management techniques, and, importantly, employment. PSU's Value Chain Resilience project aims to provide the region with much needed information on the policy levers that can be exercised to support private sector development, and bring these important benefits to developing and developed economies alike.

Phase One of this project concluded that APEC economies overall faced a moderate level of Value Chain Risk, but that particular action was required to deal with some of those risks where levels were higher relative to comparator regions. Phase Two, focusing on Value Chain Strength, showed that APEC economies have indeed been active in this area. They have put in place supporting environments that enable their firms to effectively manage Value Chain Risk. The conclusion to be drawn from the first two phases of this project is that although some risks are significant in the Asia-Pacific region, due often to circumstances outside governments' control, the response has been a robust one, which results in a climate in which overall Value Chain Resilience appears to be strong relative to comparator regions. Indeed, APEC's performance appears to be on a par with some developed economy groupings, and is significantly better than that of regional partners made up primarily of developing economies.

This Phase 3 has considered in detail the issue of Value Chain Connectedness. In the absence of convincing, well-established approaches, it has adopted a novel technique to measuring Connectedness, based on network analysis methods adapted from the other social sciences, as well as applied mathematics. Using newly available data on trade in value added, the report has provided—for the first time—an overview of the structure underlying value chain trade in the region, as well as its connections with other parts of the world. The report has found that APEC is, on average, a reasonably strong performer in the area of Value Chain Connectedness, comparable to the OECD, and well ahead of another regional grouping of developing economies. However, the performance gap within APEC is very large: the forum contains some of the best connected economies in the world, but also some that are relatively remote from value chain activity. A policy priority going forward will be to address this gap, and develop concerted unilateral actions that can help relatively isolated economies better integrate into the value added trading system in order to take advantage of the benefits it has to offer.

In addition to descriptive and comparative results, the report has also provided some simple analysis of some of the factors that appear to influence Value Chain Connectedness. Linking this phase of the project with the first two phases has shown that lower Value Chain Risk and higher Value Chain Strength are both associated with higher Value Chain Connectedness. The message for policymakers is that value chains need a relatively stable and secure environment in which to operate—certainty and reliability are touchstones of performance for them. However, even when an economy faces unfavorable natural conditions, it is possible for the public sector to work with the private sector to put in place risk management and response systems that make value chains stronger, and increase an economy's attractiveness. Identifying and understanding Value Chain Risk, and mobilizing resources to promote Value Chain Strength, are key objectives for economies looking to support a greater level of Connectedness.

In addition to these value chain specific factors, a number of more general policy areas have also been identified, which have clear links with Connectedness. Trade facilitation and logistics, for example, are key: stronger performance is associated with a better connected economy. Similarly, addressing behind the border issues—and most particularly, contract enforcement—should be a priority. These findings suggest that recent APEC initiatives on connectivity and Ease of Doing Business are headed in the right direction in terms of identifying areas where improvement can help promote value chain activity. Ensuring continuous improvement should be an important policy objective going forward.

In addition to promoting Connectedness, economies also need to be aware that being better connected comes with both promises and risk. The promise is that an economy can benefit more quickly and more fully from increases in economic activity abroad. The risk is that it is more subject to negative impacts from foreign recessions or other negative economic events. It is therefore important for economies to develop policies and systems to manage the risks that come with greater Connectedness. Developing and enhancing social safety nets is one area that could be deserving of attention going forward: if appropriately designed, a social safety net allows room for markets to operate as efficiently as possible, but cushions the negative impacts of some market events on workers and their families. More generally, sound macroeconomic policies—accounts at or close to balance, adequate but not excessive foreign reserves, appropriately flexible exchange rates, and reliable domestic consumer demand—can help manage the risks, and maximize the benefits, that come with greater Value Chain Connectedness.

APPENDIX 1: TECHNICAL DETAILS

This Appendix provides full technical details of the report's methodology. It is provided for additional information only, and is not crucial to an intuitive understanding of the methodology and results. It is possible to fully understand DTC's proposed methodology based on the description in Chapter 3. The presentation here is based on Bryan and Leise (2006).

Ignoring sectoral issues for ease of presentation, let VA_{ij} be value added exported from economy i to economy j. Accordingly, define $va_{ij} = \frac{VA_{ij}}{\sum_{j=1}^{N} VA_{ij}}$, in a world consisting of N economies in total. In other words, upper case indicates raw flows of value added from one economy to another, and lower case indicates trade shares (proportions of total exports of value added from each economy going to each other economy).

Under the definition put forward in Chapter 3, the Value Chain Connectedness C of economy i can be expressed as follows:

$$C_i = va_{i1}C_1 + va_{i2}C_2 + \cdots + va_{iN}C_N$$

Considering all N economies gives rise to a system of linear equations, as follows:

$$\begin{aligned} C_1 &= va_{11}C_1 + \cdots + va_{1N}C_N \\ &\vdots \\ C_N &= va_{N1}C_1 + \cdots + va_{NN}C_N \end{aligned}$$

That same system can be expressed in matrix form as:

$$\boldsymbol{C} = \boldsymbol{vaC}$$

In this case, **C** is the vector of Connectedness scores, and **va** is the weighted adjacency matrix defining the network. The solution to this matrix equation amounts to finding a right eigenvector of **va**, **C**, that corresponds to an eigenvalue of one. Matrix **va** is stochastic, in the sense that it has all entries (value added export shares) between zero and one, and the columns sum to one (total exports). By the Perron-Frobenius theorem, **C** exists, and contains all entries between zero and one. Multiplication by 100 means that Value Chain Connectedness **C** can therefore be expressed in terms of an index running from zero to 100.

In Chapter 3, it was highlighted that Connectedness of one economy can be interpreted in two ways: as a weighted average of other Connectedness scores; or as the economic value of an extra dollar of value added trade inserted into the network at a random point, and allowed to propagate. To see that this is the case, **va** needs to be given a Markovian interpretation, as a matrix of transition probabilities. In other words, each entry of **va** represents the probability that value added is exported from one economy to another. Similarly, the entries of $\mathbf{va}^2$ give the probability of exporting from one economy to another in two steps. In general, the probability of exporting from one economy to another in k steps is given by the entries of $\mathbf{va}^k$.

Under this interpretation, the eigenvector problem posed above takes on a different light: **C** is invariant under the application of the transition matrix **va**, which means that it is a stationary (steady-state) probability vector. Thus, for any starting economy i, for a given destination economy j, the following limit must hold:

$$\lim_{k\to\infty} (\boldsymbol{va}^k)_{ij} = \boldsymbol{C}_j$$

Concretely, this limit means that a random dollar of traded value added dropped into the network at a random point and allowed to propagate endlessly with arrive in economy j with probability $\mathbf{C}_j$. The economic value of that dollar to economy j is therefore the same number.

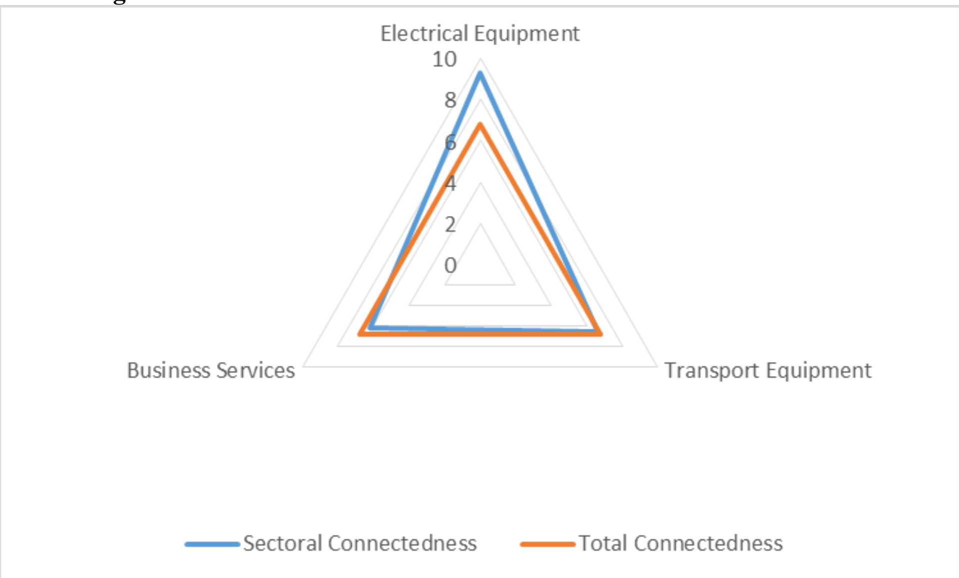
APPENDIX 2: INDIVIDUAL ECONOMY RESULTS

This Appendix provides an economy by economy analysis of results from the main report. In interpreting the numerical data presented here, it is important to keep in mind that the Connectedness measure and the TiVA data used in this report effectively focus on value chain activity as seen from the downstream point of view (i.e., that of the final consumer). Scores have a number of possible interpretations and explanations, including those explored in Chapter 4. In particular, a high Connectedness score may be evidence of strong connections with global or regional hubs, or of specialization in relatively high value added activities. A low score may indicate relatively weaker connections with global or regional hubs, or specialization in relatively low value added activities, such as the production of simple component parts, or assembly.

AUSTRALIA

Australia's Value Chain Connectedness score for total trade is 6.79. Figure A.1 shows how the score for total trade compares with scores for the three individual sectors considered in the report. As is clear from the figure, Australia's Connectedness score is higher for electrical equipment than for the other two sectors, where results are very similar to the score for total trade. This pattern of results suggests that policymakers and analysts can learn from experience in the electrical equipment sector in developing measures to increase Value Chain Connectedness for total trade going forward.

Figure A.1. Australia's Performance on Value Chain Connectedness.

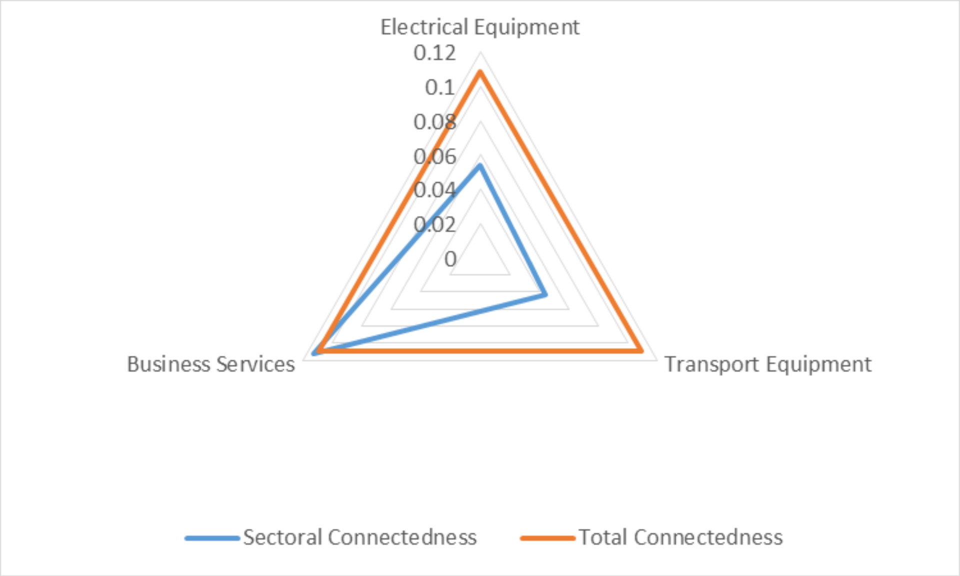


Source: Authors.

BRUNEI DARUSSALAM

Brunei Darussalam's Value Chain Connectedness score for total trade is 0.11. Figure A.2 shows how the score for total trade compares with scores for the three individual sectors considered in the report. As is clear from the figure, only the business services sector has a score that is similar to the result for total trade. Scores for electrical equipment and transport equipment are considerably smaller than the score for total trade. This pattern of results suggests that policymakers and analysts can learn from experience in the electrical equipment sector in developing measures to increase Value Chain Connectedness in other sectors going forward.

Figure A.2. Brunei Darussalam's Performance on Value Chain Connectedness.

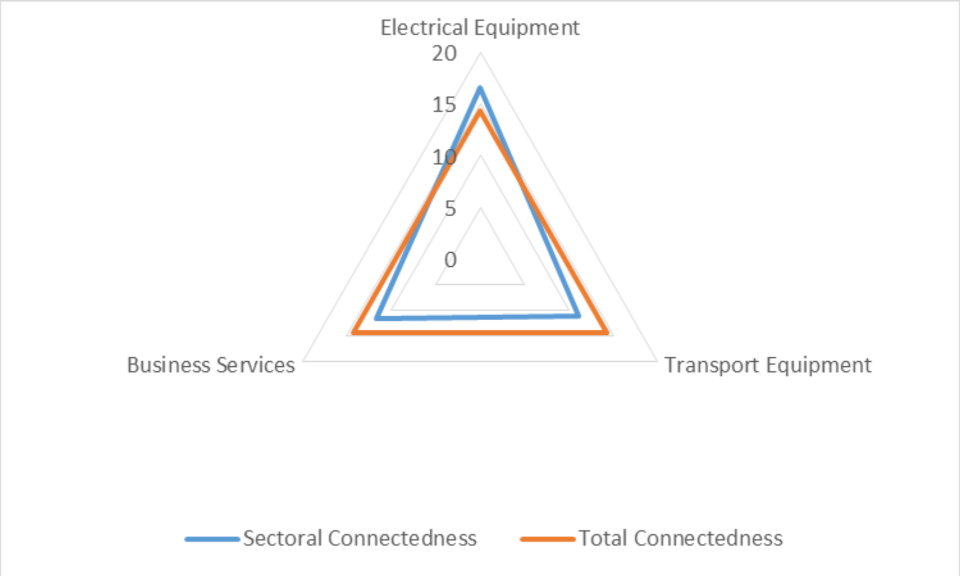


Source: Authors.

CANADA

Canada's Value Chain Connectedness score for total trade is 14.32. Figure A.3 shows how the score for total trade compares with scores for the three individual sectors considered in the report. As is clear from the figure, Canada's score for electrical equipment is higher than for the other two sectors, and for total trade. The other two sectors have scores that are noticeably lower than for total trade. This pattern of results suggests that policymakers and analysts can learn from experience in the electrical equipment sector in developing measures to increase total Value Chain Connectedness going forward.

Figure A.3. Canada's Performance on Value Chain Connectedness.

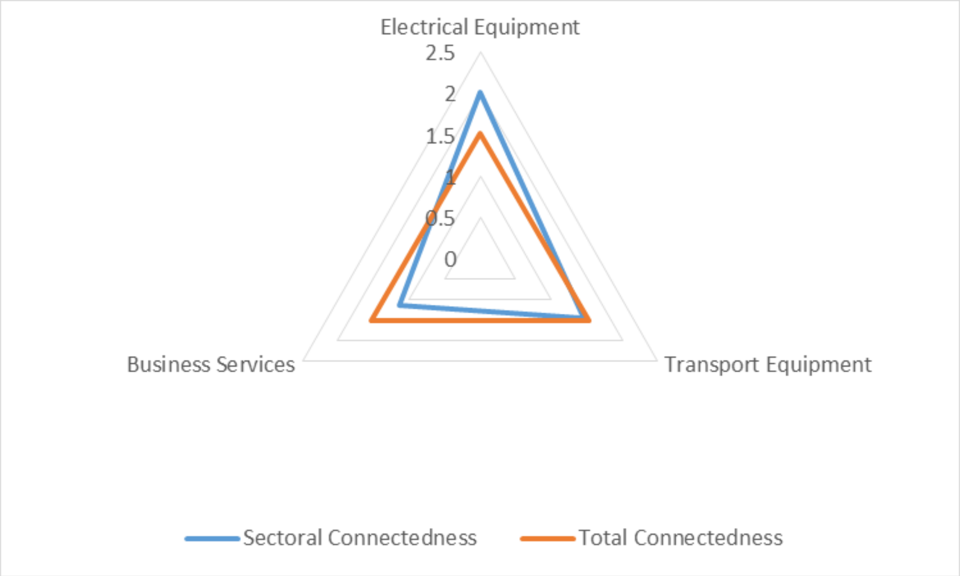


Source: Authors.

CHILE

Chile's Value Chain Connectedness score for total trade is 1.52. Figure A.4 shows how the score for total trade compares with scores for the three individual sectors considered in the report. As is clear from the figure, Chile's score for electrical equipment is higher than for the other two sectors, and for total trade. Transport equipment has a result that is very close to the economy's total trade score, but business services has a lower Connectedness score. This pattern of results suggests that policymakers and analysts can learn from experience in the electrical equipment sector in developing measures to increase total Value Chain Connectedness going forward.

Figure A.4. Chile's Performance on Value Chain Connectedness.

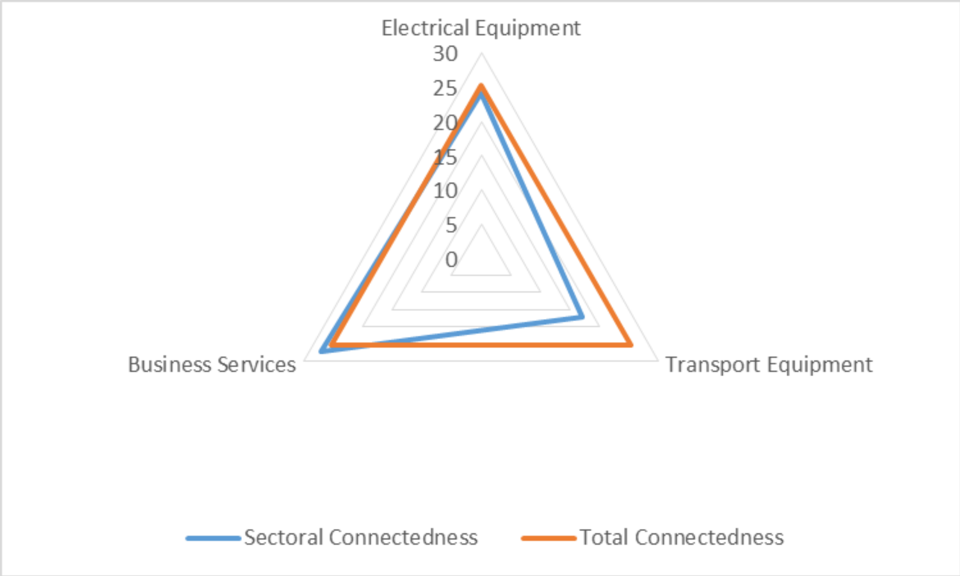


Source: Authors.

CHINA

China's Value Chain Connectedness score for total trade is 25.29. Figure A.5 shows how the score for total trade compares with scores for the three individual sectors considered in the report. As is clear from the figure, China's scores for electrical equipment and business services are very close to its score for total trade. Transport equipment, by contrast, has a lower score. This pattern of results suggests that policymakers and analysts may be able to apply experiences from other sectors of the economy to increase Value Chain Connectedness in the transport equipment sector going forward.

Figure A.5. China's Performance on Value Chain Connectedness.

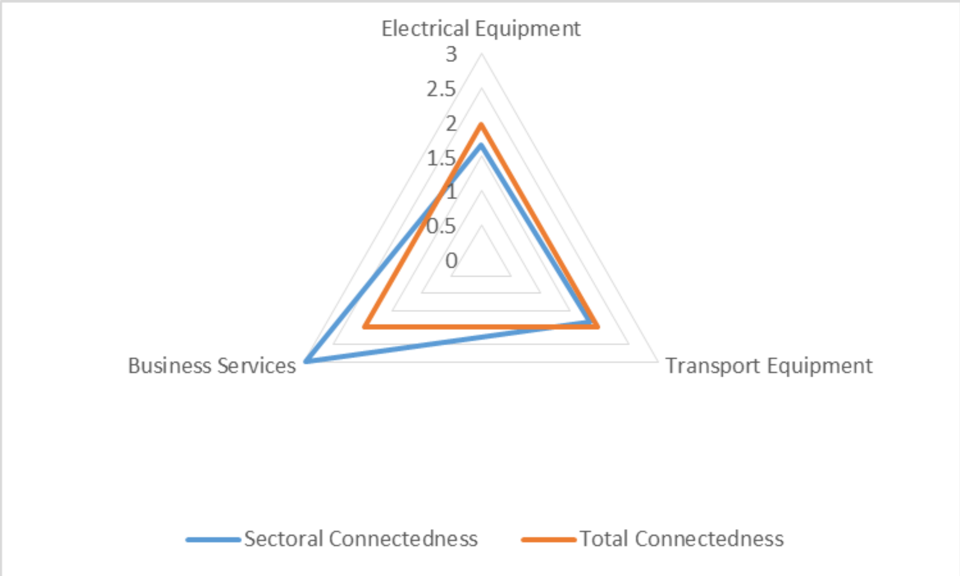


Source: Authors.

HONG KONG, CHINA

Hong Kong, China's Value Chain Connectedness score for total trade is 1.96. Figure A.6 shows how the score for total trade compares with scores for the three individual sectors considered in the report. As is clear from the figure; Hong Kong, China's scores for electrical equipment and transport equipment are very close to its score for total trade. Business services, by contrast, has a considerably higher score. This pattern of results suggests that policymakers and analysts may be able to apply experiences from the business services sector to increase Value Chain Connectedness in other sectors going forward.

Figure A.6 Hong Kong, China's Performance on Value Chain Connectedness.

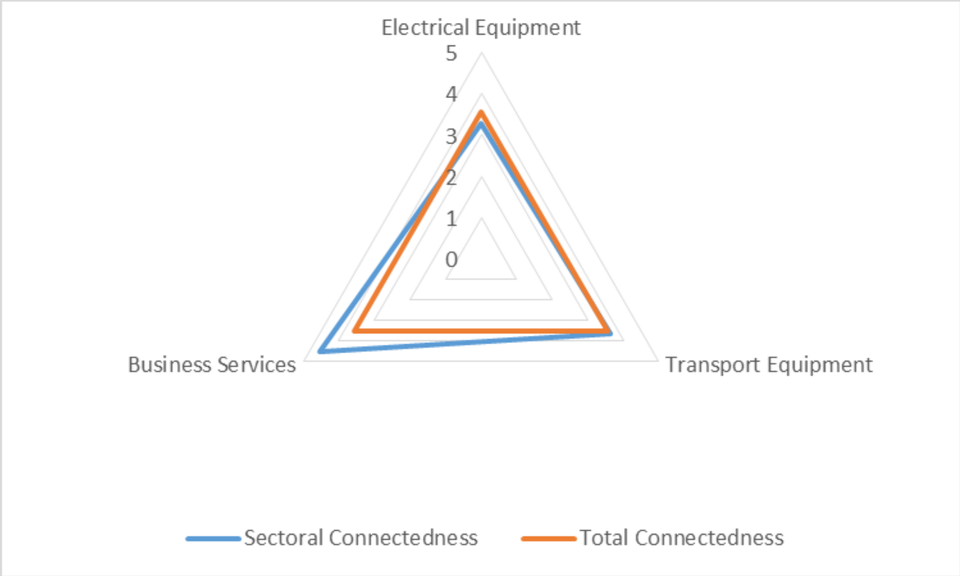


Source: Authors.

INDONESIA

Indonesia's Value Chain Connectedness score for total trade is 3.57. Figure A.7 shows how the score for total trade compares with scores for the three individual sectors considered in the report. As is clear from the figure, Indonesia's scores for electrical equipment and transport equipment are very close to its score for total trade. Business services, by contrast, has a somewhat higher score. This pattern of results suggests that policymakers and analysts may be able to apply experiences from the business services sector to increase Value Chain Connectedness in other sectors going forward.

Figure A.7 Indonesia's Performance on Value Chain Connectedness.

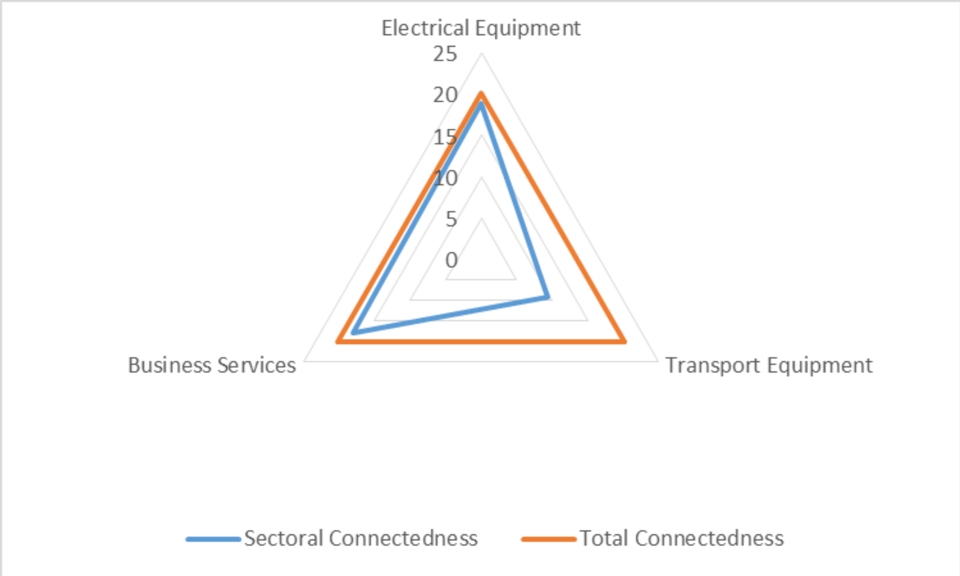


Source: Authors.

JAPAN

Japan's Value Chain Connectedness score for total trade is 20.10. Figure A.8 shows how the score for total trade compares with scores for the three individual sectors considered in the report. As is clear from the figure, Japan's scores for electrical equipment and business services are very close to its score for total trade. Transport equipment, by contrast, has a considerably lower score. This pattern of results suggests that transport equipment, along with other sectors that are potentially less connected than average, may benefit from additional policy attention going forward.

Figure A.8 Japan's Performance on Value Chain Connectedness.

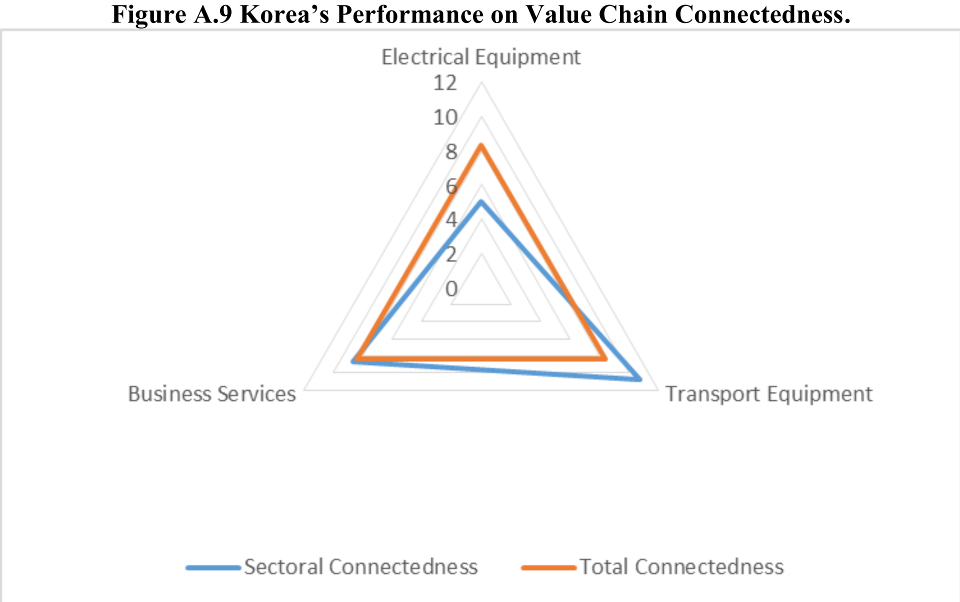


Source: Authors.

KOREA

Korea's Value Chain Connectedness score for total trade is 8.35. Figure A.9 shows how the score for total trade compares with scores for the three individual sectors considered in the report. As is clear from the figure, Korea's score for business services is very close to its score for total trade. Transport equipment, by contrast, has a noticeably higher score, and electrical equipment has a considerably higher score. This pattern of results suggests that there may be valuable insight to be gained from a better understanding of the transport equipment sector, in terms of improving the Connectedness of other sectors going forward.

Figure A.9 Korea's Performance on Value Chain Connectedness.

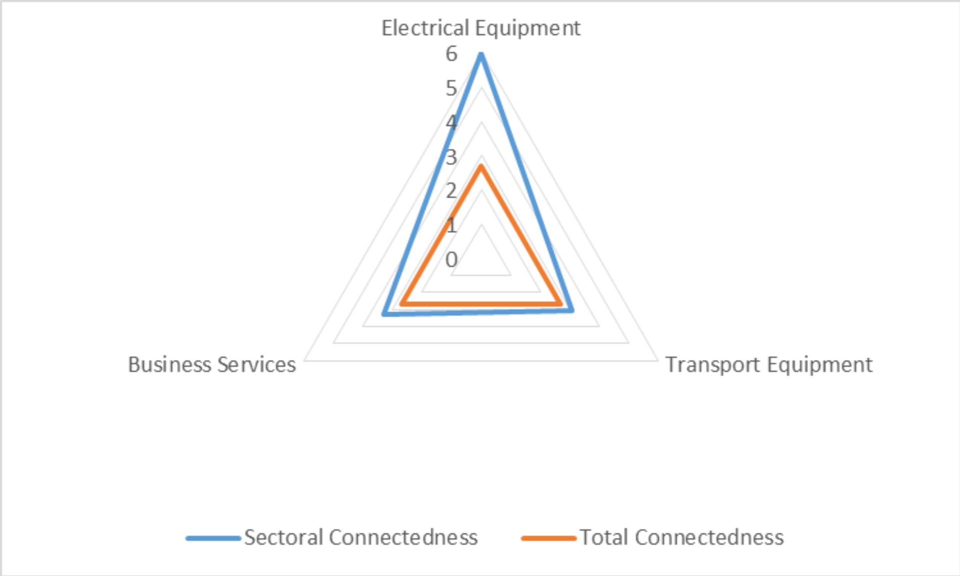


Source: Authors.

MALAYSIA

Malaysia’s Value Chain Connectedness score for total trade is 2.70. Figure A.11 shows how the score for total trade compares with scores for the three individual sectors considered in the report. As is clear from the figure, Malaysia’s scores in all three sectors are higher than its score for total trade. This pattern of results suggests that other sectors not considered individually in this report may be able to benefit from the lessons learned in the three sectors presented in the figure, in particular the electrical equipment sector.

Figure A.11 Malaysia's Performance on Value Chain Connectedness.

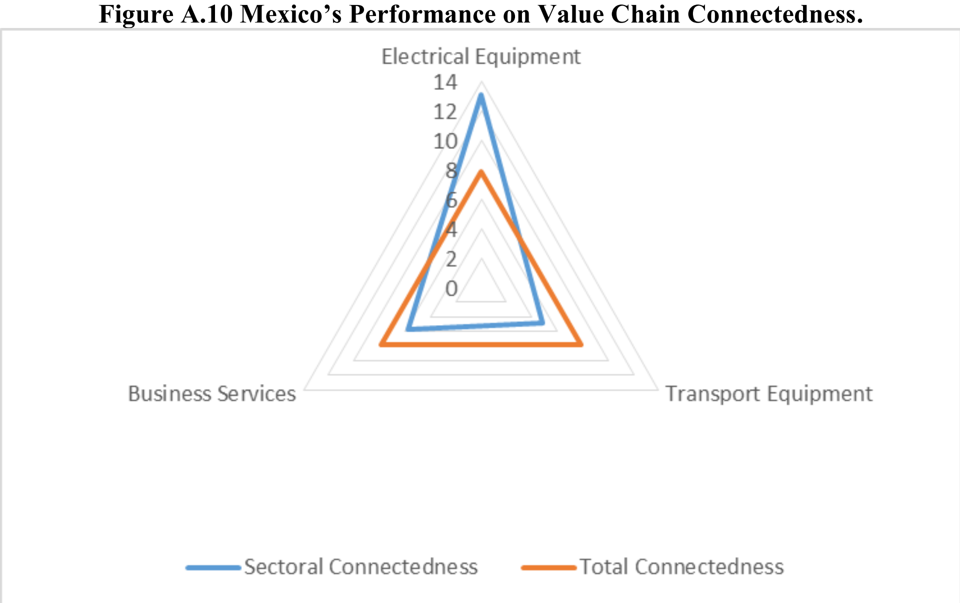


Source: Authors.

MEXICO

Mexico's Value Chain Connectedness score for total trade is 7.86. Figure A.10 shows how the score for total trade compares with scores for the three individual sectors considered in the report. As is clear from the figure, Korea's score for electrical equipment is much higher than its score for total trade, and than its scores for the other two sectors. This pattern of results suggests that there may be valuable insight to be gained from a better understanding of the electrical equipment sector, in terms of improving the Connectedness of other sectors going forward.

Figure A.10 Mexico's Performance on Value Chain Connectedness.

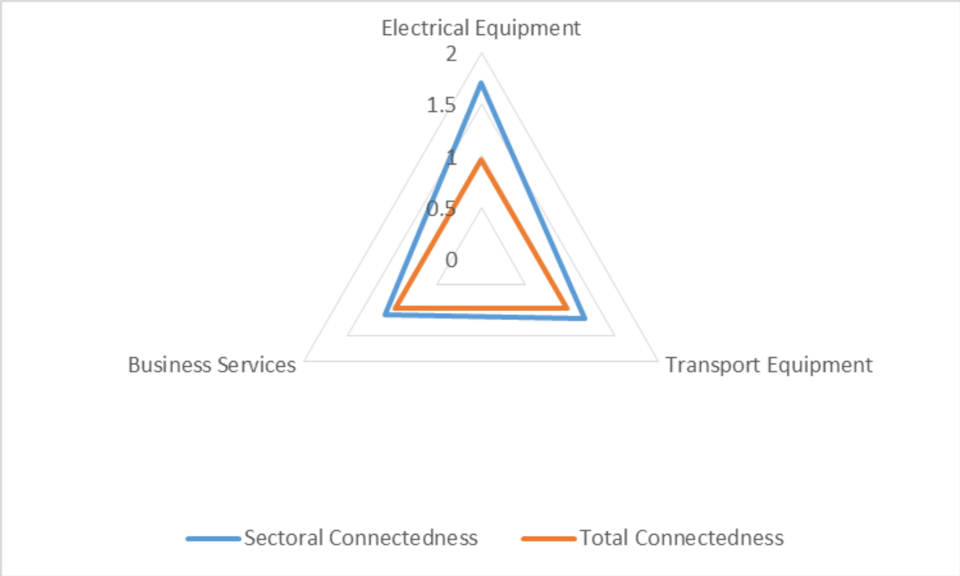


Source: Authors.

NEW ZEALAND

New Zealand's Value Chain Connectedness score for total trade is 0.97. Figure A.12 shows how the score for total trade compares with scores for the three individual sectors considered in the report. As is clear from the figure, New Zealand's scores in all three sectors are higher than its score for total trade, particularly so in the case of electrical equipment. This pattern of results suggests that other sectors not considered individually in this report may be able to benefit from the lessons learned in the three sectors presented in the figure, in particular the electrical equipment sector.

Figure A.12 New Zealand's Performance on Value Chain Connectedness.



Source: Authors.

PAPUA NEW GUINEA

Value added trade data are not available for Papua New Guinea, so Connectedness scores could not be calculated.

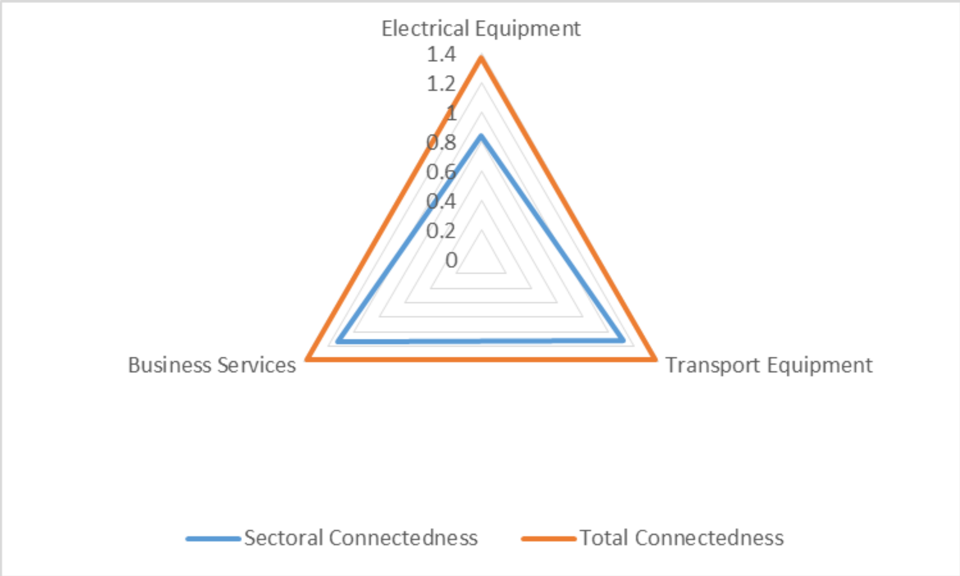
PERU

Value added trade data are not available for Peru, so Connectedness scores could not be calculated.

THE PHILIPPINES

The Philippines' Value Chain Connectedness score for total trade is 1.37. Figure A.13 shows how the score for total trade compares with scores for the three individual sectors considered in the report. As is clear from the figure, the Philippines' scores in all three sectors are lower than its score for total trade. This pattern of results suggests that the sectors considered here may be able to benefit from lessons learned in other sectors not considered individually in this report, in terms of boosting Connectedness going forward.

Figure A.13 The Philippines' Performance on Value Chain Connectedness.

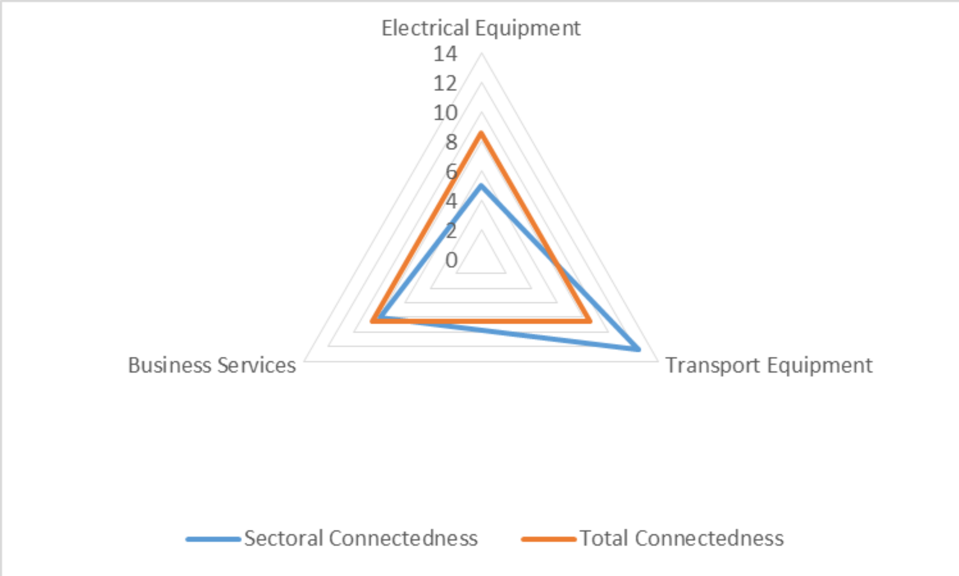


Source: Authors.

RUSSIAN FEDERATION

The Russian Federation's Value Chain Connectedness score for total trade is 8.55. Figure A.14 shows how the score for total trade compares with scores for the three individual sectors considered in the report. As is clear from the figure, the Russian Federation's score in business services is close to its score for total trade. By contrast, its score for transport equipment is higher and its score for electrical equipment is lower. This pattern of results suggests that there may be valuable lessons to be learned from the transport equipment sector in terms of measures that can increase Connectedness in other sectors going forward.

Figure A.14 The Russian Federation's Performance on Value Chain Connectedness.

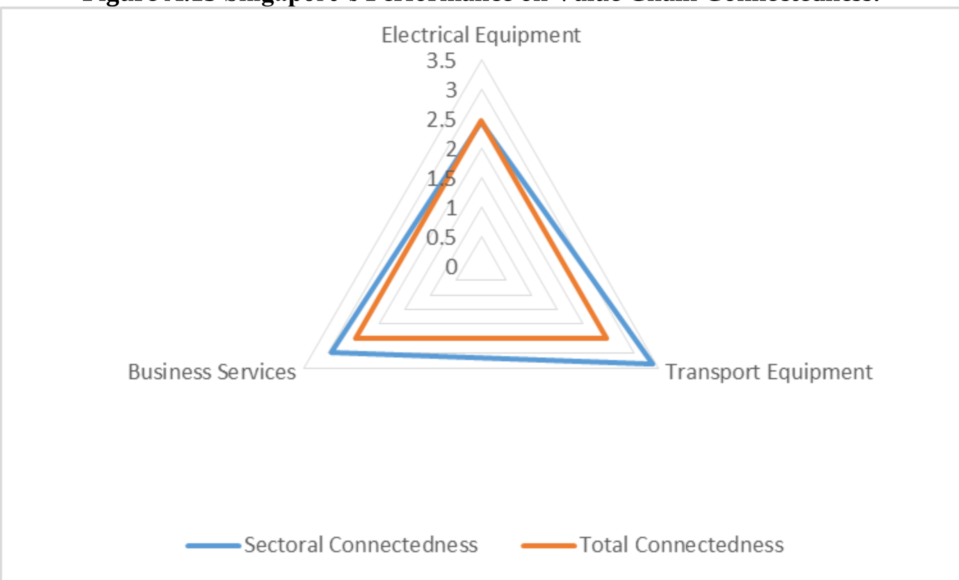


Source: Authors.

SINGAPORE

Singapore's Value Chain Connectedness score for total trade is 2.48. Figure A.15 shows how the score for total trade compares with scores for the three individual sectors considered in the report. As is clear from the figure, Singapore's score in electrical equipment is close to its score for total trade. By contrast, its scores for transport equipment and business services are higher. This pattern of results suggests that there may be valuable lessons to be learned from those two sectors in terms of ways in which Connectedness can be promoted in other sectors going forward.

Figure A.15 Singapore's Performance on Value Chain Connectedness.

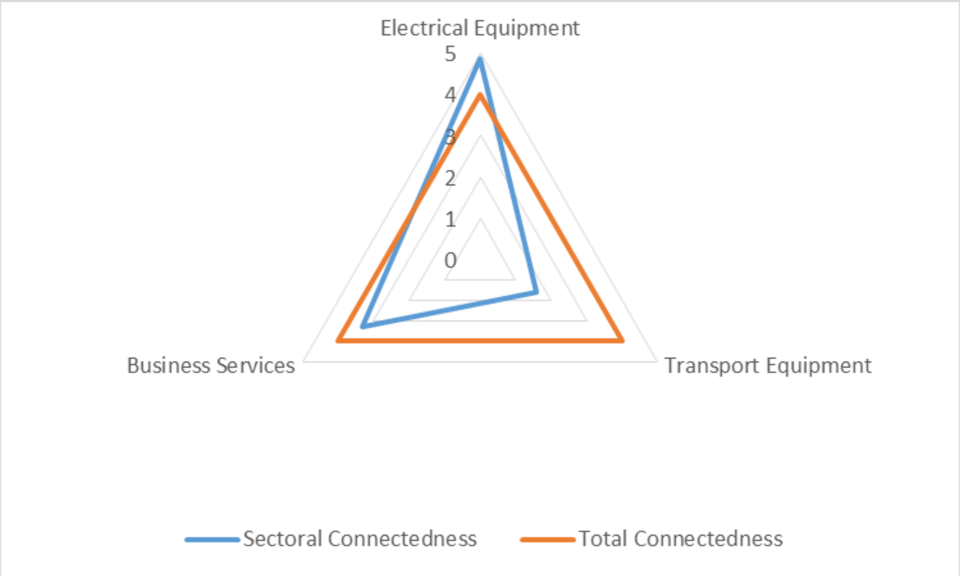


Source: Authors.

CHINESE TAIPEI

Chinese Taipei's Value Chain Connectedness score for total trade is 3.99. Figure A.16 shows how the score for total trade compares with scores for the three individual sectors considered in the report. As is clear from the figure, Chinese Taipei's score in business services is close to its score for total trade. By contrast, its score for electrical equipment is higher than its score for total trade, and its score for transport equipment is considerably lower. This pattern of results suggests that experience in sectors such as electrical equipment may provide a useful guide to ways in which other sectors can increase their Connectedness scores going forward.

Figure A.16 Chinese Taipei's Performance on Value Chain Connectedness.

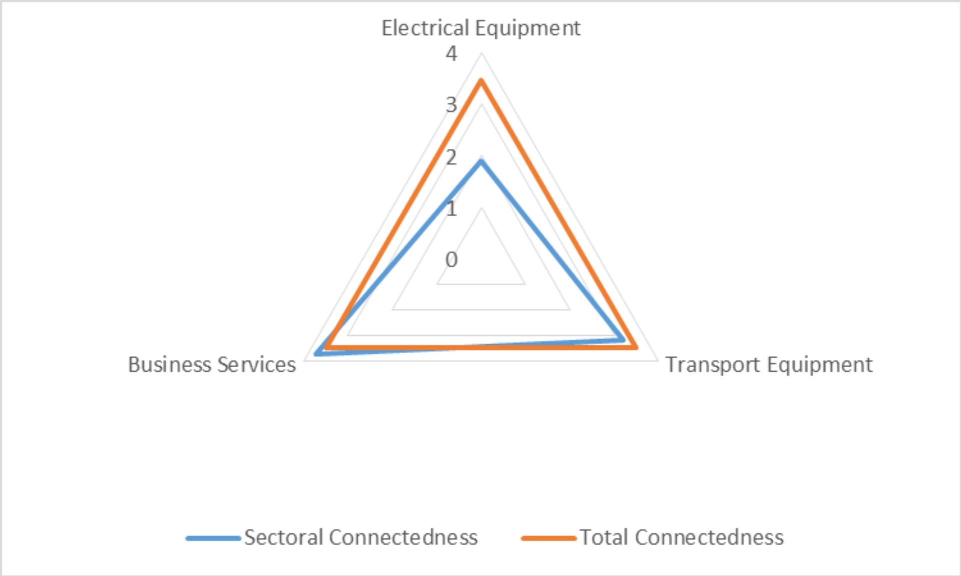


Source: Authors.

THAILAND

Thailand's Value Chain Connectedness score for total trade is 3.48. Figure A.17 shows how the score for total trade compares with scores for the three individual sectors considered in the report. As is clear from the figure, Thailand's scores in business services and transport equipment are close to its score for total trade. By contrast, its score for electrical equipment is considerably lower than its score for total trade. This pattern of results suggests that although Thailand is a significant exporter of intermediate goods in the electrical equipment sector, it has considerable scope to move up the value chain into higher value added activities, which would be reflected in a higher Connectedness score.

Figure A.17 Thailand's Performance on Value Chain Connectedness.

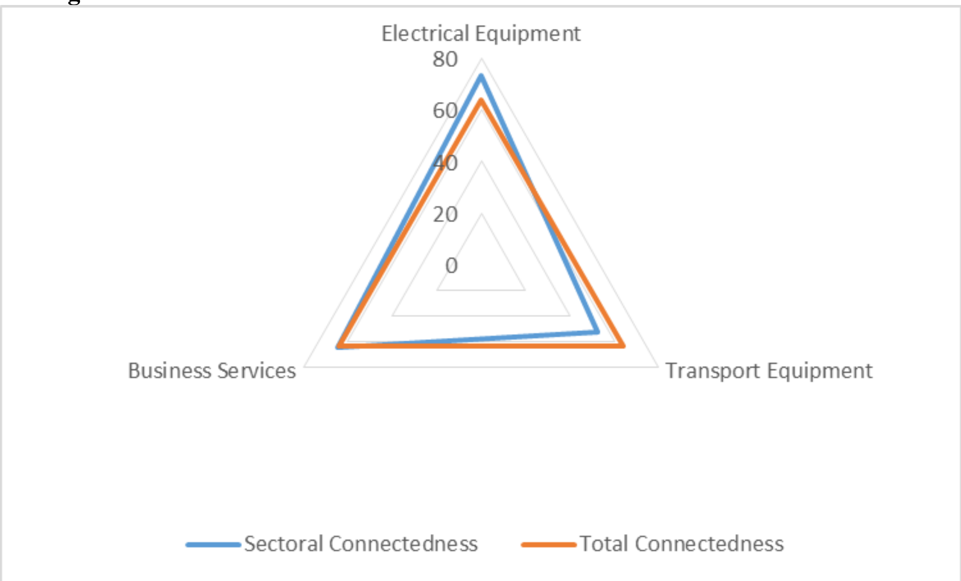


Source: Authors.

UNITED STATES

The United States' Value Chain Connectedness score for total trade is 64.11. Figure A.18 shows how the score for total trade compares with scores for the three individual sectors considered in the report. As is clear from the figure, the United States' scores in all three sectors are relatively close to its score for total trade. This pattern of results suggests that the United States is a consistently strong performer in terms of Value Chain Connectedness.

Figure A.18 The United States' Performance on Value Chain Connectedness.

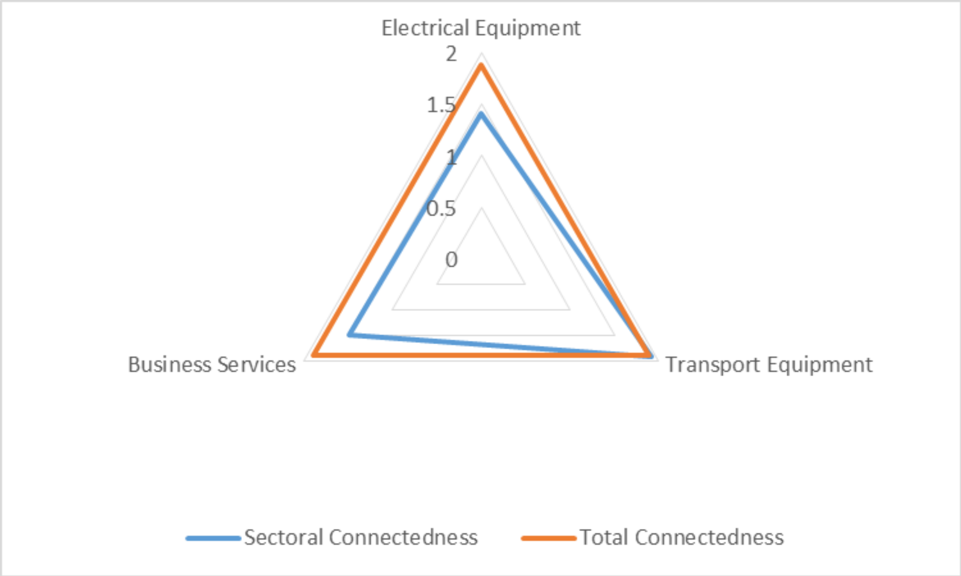


Source: Authors.

VIET NAM

Viet Nam's Value Chain Connectedness score for total trade is 1.88. Figure A.19 shows how the score for total trade compares with scores for the three individual sectors considered in the report. As is clear from the figure, Viet Nam's score for transport equipment is close to its score for total trade. Scores for the other two sectors are lower. This pattern of results suggests that there may be valuable lessons to be learned from other sectors of the economy in terms of boosting Connectedness in those sectors with lower scores than the overall score.

Figure A.19 Viet Nam's Performance on Value Chain Connectedness.



Source: Authors.

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