wiiw

JULY 2021

Working Paper 204

# Interactions Between Global Value Chains and Foreign Direct Investment:

## A Network Approach

Amat Adarov

The Vienna Institute for International Economic Studies
Wiener Institut für Internationale Wirtschaftsvergleiche

# Interactions Between Global Value Chains and Foreign Direct Investment:

## A Network Approach

AMAT ADAROV

Amat Adarov is Economist at The Vienna Institute for International Economic Studies (wiiw).

Research for this paper was financed by the Anniversary Fund of the Oesterreichische Nationalbank (Project No.18314). Support provided by Oesterreichische Nationalbank for this research is gratefully acknowledged.

# Abstract

The world economy is increasingly shaped by cross-border production and investment activity. The paper uses complex network analysis along with panel data econometric techniques to study the structure and interactions between the networks of global value chains (GVC) and foreign direct investment (FDI). The analysis reveals that both FDI and GVC networks have a distinct core-periphery structure dominated by a relatively small number of countries with the USA constituting the global hub interlinked with regional European and Asian clusters, which, in turn, are centered around regional hub countries like China and Germany. Simultaneous equation model regressions using three-stage least squares suggest that FDI centrality facilitates GVC centrality of countries. However, FDI centrality is driven to a large extent by the FDI statutory restrictions and tax offshore regulations, rather than GVC connectivity.

Keywords: global value chains; foreign direct investment; network analysis; cross-border connectivity; simultaneous equation model

JEL classification: F10, F14, F15, F21

CONTENTS

## TABLES AND FIGURES

# 1 Introduction

Participation in cross-border production sharing has fundamentally reshaped the organization of global economic activity. In light of the importance of global value chains (GVCs) for economic growth and development a growing body of empirical research has focused on investigating the participation of countries in GVCs and their sectoral specialization in production networks, the drivers of GVCs and their implications for competitiveness and economic development. The formation of GVC linkages has been studied empirically (see, for instance, in Miroudot et al, 2013; Koopman et al, 2014; Timmer et al, 2013, 2014; UNCTAD, 2013; Wang et al, 2017; World Bank et al., 2017), as well as conceptualized in a formal framework illustrating the transition mechanisms from trade in goods to trade in tasks (Grossman and Hansberg, 2008).

A vibrant body of research has focused specifically on the development and improvement of GVC integration measures. In this regard, among the seminal contributions, Hummels et al. (1998, 2001) proposed one of the earlier metrics conveying foreign value added in exports or Vertical Specialisation (VS). Daudin et al. (2011) further expanded the framework, identifying forward linkages (VS1), computed as a share of domestic value added in a countrys foreign exports. Jointly VS and VS1, therefore, pick up the total integration of a given country in GVCs. These measures were further improved in Koopman et al. (2014), proposing a methodological framework for a full decomposition of gross exports into value added components, including domestic value added absorbed abroad, domestic value added returned home after initial exports, foreign value added in exports, and pure double-counting terms. The methodology was further improved in Wang et al. (2013) and Buelens and Tirpak (2017). Los and Timmer (2018) provide a unified framework for measuring bilateral exports of value added and suggest a new measure of value added used abroad in the final stage of production (see also Johnson and Noguera, 2012 and Los et al., 2016). Among the most recent contributions, Borin and Mancini (2019) further enhance the GVC accounting methodology for bilateral trade flows at the sectoral level with an alternative breakdown of gross exports into more detailed components.

The importance of GVCs for economic growth and development has naturally spurred interest in the identification of the drivers of integration into production networks. Besides the overall macroeconomic country characteristics, size of domestic market, economic development level, industrialization level (Baldwin and Lopez Gonzalez, 2015; Hummels et al., 2001; Johnson and Noguera, 2012; Kowalski et al., 2015; Miroudot et al., 2013; OECD et al., 2014), the empirical research finds that such structural characteristics as human capital development, infrastructure and institutions, liberal trade and investment policies foster development of GVCs (Dollar and Kidder, 2017; OECD, 2013; UNCTAD, 2013; Taglioni and Winkler, 2014; Timmer et al., 2014, 2015).

It is intuitive that foreign direct investment (FDI) is closely related to cross-border production sharing, as formation of GVCs in many cases is coordinated by multinational corporations (MNEs)[1] The literature, largely focusing on trade in value added in a gravity model setup

[1] One should note, however, that it is also not imperative, as fully domestic companies are also able to integrate in value chains without being affiliated with MNEs in any way. Likewise, FDI is not always motivated by efficiency seeking motives to form GVCs, e.g. tax opmitization motives, access to markets and other motives

(Buelens and Tirpak, 2017; MartnezGalan and Fontoura, 2019) reports a generally positive association between GVCs and FDI. Adarov and Stehrer (2021) also provide empirical evidence on the heterogeneous impacts of FDI on GVCs, differentiating between backward and forward linkages, as well as inward and outward FDI.

In this paper we further contribute to the literature by employing network analysis techniques to study FDI and GVCs as networks. In contrast to the conventional methods described above, the network approach views each country as a node connected to other nodes by linkages (edges) representing in our case investment flows or value-added trade flows. Given the multilateral nature of cross-border investment flows and distributed value-added flows, this appears to be a natural complementary way to analyze FDI and GVCs. Yet, the literature that applies the network perspective is still rather scarce, particularly, as far as the economic interpretation and implications of the network structure and connectivity of these networks is concerned, as opposed to merely documenting their technical properties. Among the studies that attempted to construct global input-output networks and study their properties are Cerina et al. (2015), Cingolani et al., (2017), Criscuolo and Timmis (2018), Lejour et al. (2014) and Zhu et al., (2018). The network perspective on FDI has been taken in Alfaro and Chen (2014), Metulini et al. (2017), Wall et al. (2011) reviewing ownership linkages associated with MNEs. Damgaard and Elkjaer (2017) construct a global FDI network removing the investment attributed to special purpose entities (SPEs) and focusing on the ultimate investment relationships.

In this paper we further contribute to the literature by analyzing FDI and GVC networks jointly and empirically identifying the synergies between them. To this end we construct FDI and GVC networks as weighted directed networks and study their network properties, thereby contributing to the more general literature on the measurement of GVC participation and FDI integration, but taking a multilateral network perspective. In contrast to the conventional measures that focus strictly on the value added or investment linkages directly stemming from the country under consideration, this allows to take into account second-order effects, i.e. the connectivity of trading and investment partners, as well as better understand the structural characteristics of the entire GVC and FDI networks, e.g. the clusters and hubs. As part of this effort, we compute the measure of PageRank centrality that accounts for directed and weighted nature of value-added trade and investment linkages, as well as accounts for the second-order connectivity effects. Finally, given the likely two-way causality, we quantify the interactions between FDI and GVC connectivity in a system of simultaneous equations using three-stage least squares (3SLS), allowing for endogenous covariates.

We find that both GVC and FDI networks have a clear core-periphery structure with a relatively small number of highly influential countries comprising the strongly interconnected core. More specifically, the analysis decomonstrates that the USA is a highly central (i.e. highly connected and positioned in-between many other interconnected economies) economy in terms of both cross-border production sharing and investment linkages, effectively constituting the global hub in both the GVC and the FDI networks, while China and Germany serve as the regional Asian and European GVC-FDI hubs.[2] The Asian region is dominated by China, Japan

are also important factors of FDI confirmed empirically.

[2] As regards FDI, this holds if one omits the high connectivity of tax haven countries and rather focuses on GVC-relevant FDI.

and South Korea in terms of GVC connectivity. However, in contrast comparable European and North American hubs, they rely relatively less on FDI connectivity. The global hub status of the USA is facilitated not only by its own cross-border production and investment linkages, but also second-order connectivity through its linkages to these regional clusters. The FDI network is strongly influenced by FDI-in-transit, and the network centrality of countries in the global FDI network appears to be instrumental for identifying the conduits of such "phantom" FDI (see also Blanchard and Acalin, 2016, Damgaard et al., 2019 and Hines, 2010 for the discussion of this phenomenon). More specifically, the FDI network is dominated by the exceptionally strong linkages between the USA, Luxembourg and Ireland. Aside from these linkages apparently associated with tax optimization by MNEs, the core of the FDI network is formed by largely the same countries as that of the GVC network.

The simultanous equation model 3SLS estimation results suggest that higher centrality of a country in the FDI network is highly conducive to its connectivity in the GVC network. However, the opposite does not hold, as the impact of GVC connectivity on the centrality of a country in the FDI network is only weakly statistically significant and negative, controlling for other factors. Instead, the factors that strongly manifest themselves as drivers of FDI centrality are largely associated with the investment-related regulatory environment: as expected, tighter statutory restrictions on FDI flows have a highly negative impact, while tax offshore arrangements, on the contrary, boost FDI centrality, albeit the latter is apparently attributed to phantom FDI. Economic size, import tariffs and higher productivity are also positively associated with GVC centrality, while natural resource dependence has a negative effect.

The rest of the paper is structured as follows. Section 2 reviews the data and sample. Section 3 reviews the main features of the FDI and the GVC networks. Section 4 reports the results of the econometric analysis focusing on the relationship between connectivity in both networks. Section 5 concludes.

## 2 Data and sample

The global sample of countries that is used for the construction of GVC and FDI networks includes 60 countries over the period 2005-2015, and is determined entirely by data availability.[3] The GVC data are obtained from the OECD inter-country input-output (OECD ICIO) database associated with the OECD trade in value added database (TIVA). The FDI data are sourced from the OECD and UNCTAD databases. The details as to the construction of the GVC and FDI networks are documented in Section 3, followed by the discussion of their main features and the computation of network centrality measures used in the regression analysis in Section 4. While the FDI and GVC network data are time-varying bilateral (origin country–destination country observation per year), the computed centrality measures convey the connectivity of a country in the network in a given year and thus have country and year dimensions, i.e. a common panel data structure.

These computed centrality metrics are complemented by a range of variables obtained from public sources and used as additional explanatory variables in the econometric analysis in Sec-

[3] The availability of the data for FDI and GVC differs, and FDI data has a better coverage in terms of both country and time dimensions.

Table 1: **Sample of countries**

| ISO3 | Country name | ISO3 | Country name | ISO3 | Country name |
|---|---|---|---|---|---|
| ARG | Argentina | GRC | Greece | NLD | Netherlands |
| AUS | Australia | HKG | Hong Kong | NOR | Norway |
| AUT | Austria | HRV | Croatia | NZL | New Zealand |
| BEL | Belgium | HUN | Hungary | PER | Peru |
| BGR | Bulgaria | IDN | Indonesia | PHL | Philippines |
| BRA | Brazil | IND | India | POL | Poland |
| CAN | Canada | IRL | Ireland | PRT | Portugal |
| CHE | Switzerland | ISL | Iceland | RUS | Russia |
| CHL | Chile | ISR | Israel | SAU | Saudi Arabia |
| CHN | China | ITA | Italy | SGP | Singapore |
| COL | Colombia | JPN | Japan | SVK | Slovakia |
| CRI | Costa Rica | KAZ | Kazakhstan | SVN | Slovenia |
| CYP | Cyprus | KHM | Cambodia | SWE | Sweden |
| CZE | Czech Republic | KOR | Korea, Rep. | THA | Thailand |
| DEU | Germany | LTU | Lithuania | TUN | Tunisia |
| DNK | Denmark | LUX | Luxembourg | TUR | Turkey |
| ESP | Spain | LVA | Latvia | TWN | Taiwan |
| EST | Estonia | MAR | Morocco | USA | United States |
| FIN | Finland | MEX | Mexico | VNM | Vietnam |
| FRA | France | MLT | Malta | ZAF | South Africa |
| GBR | United Kingdom | MYS | Malaysia | | |

Table 2: **Descriptive statistics**

| | obs. | mean | std. dev. | min | max |
|---|---|---|---|---|---|
| GVC PageRank centrality, log | 556 | -4.55 | 0.89 | -5.92 | -2.13 |
| FDI PageRank centrality, log | 556 | -4.85 | 1.08 | -6.90 | -1.62 |
| Real GDP, log | 548 | 26.40 | 1.62 | 22.79 | 30.45 |
| Log (1 + Average import tariff rate/100) | 534 | 0.07 | 0.03 | 0.00 | 0.24 |
| Log (1 + Effective average corporate tax rate/100) | 454 | 0.21 | 0.05 | 0.08 | 0.31 |
| FDI Regulatory Restrictiveness index | 285 | 0.08 | 0.09 | 0.00 | 0.45 |
| Natural resource rents, share of GDP | 548 | 0.03 | 0.07 | 0.00 | 0.55 |
| REER, log difference | 446 | 0.00 | 0.05 | -0.25 | 0.19 |
| Political Stability and Absence of Violence index | 556 | 0.46 | 0.79 | -2.06 | 1.60 |
| Real labor productivity, log | 548 | 10.68 | 0.98 | 7.04 | 12.06 |
| Total factor productivity growth | 538 | 0.13 | 2.85 | -18.64 | 16.64 |

tion 4. In particular, the data for effective average corporate tax rates are obtained from the Oxford University Centre for Business Taxation (CBT) database and the ZEW Taxation Knowledge Database[4]. Real GDP (PPP-adjusted constant 2011 international dollars), average most-favored nation (MFN) import tariff rate, real effective exchange rate (REER) and total natural resources rents (% of GDP) data are sourced from the World Bank's World Development Indicators. Real labor productivity (real GDP per employment) and total factor productivity growth data are from the World Bank's Aggregate Productivity database. Institutional development indicators—Political Stability and Absence of Violence, Control of Corruption, Regulatory Quality and Government Effectiveness indices are sourced from the World Bank's Worldwide Governance Indicators. These are continuous indices that are comparable both across countries and over time, with higher values indicating better institutional development outcomes, and therefore are particularly well-suited for econometric analysis. The FDI Regulatory Restrictiveness index is sourced from the OECD FDI Regulatory Restrictiveness database. The index measures statutory restrictions on FDI across multiple sectors and focuses on four main dimensions, including foreign equity limitations, discriminatory screening or approval mechanisms, restrictions on the employment of foreigners and other operational restrictions. By construction, the aggregate index is the average of the scores across multiple sectors and dimensions and varies from 0 (open economy) to 1 (closed economy).

The descriptive statistics are reported in Table 2. The number of observations per each variable differs significantly across countries and years, and therefore the effective sample size for the baseline specification involving all variables in a two-equation model also reduces to 218 observations, largely owing to the limited data coverage in the FDI Regulatory Restrictiveness database.

# 3 GVC and FDI networks and their key properties

Complex network analysis is a natural way to analyze economic systems in which individual entities—in our case, countries—can be viewed as nodes (also known as vertices) interacting via linkages (edges) representing bilateral economic relationships, and the topology of the network, and possibly economic properties of nodes and linkages have implications for the network and the connectivity of its elements. In the context of this paper, countries constitute nodes linked by cross-border trade (in intermediates) and FDI flows. Apparently, for both GVC and FDI networks the weight of each linkage (FDI or trade value) and its direction matter, and therefore we construct directed and weighted networks, while each country-node is also characterized by inherent properties, e.g. real GDP, institutional quality and other characteristics.

Figure 1 shows a stylized representation of a weighted directed network for a better understanding of the key concept concepts and metrics, as well as the difference from the conventional approach that does not take into account multilateral connectivity. The figure shows nodes denoted by letters A–H connected by weighted directed linkages (the weights are indicated by numbers). As can be seen, the nodes differ significantly in terms of their relative connectivity to other nodes and their overall importance to the system, e.g. nodes H and G have only one

[4] The database uses the effective tax rates computed using the Devereux / Griffith methodology.

inflow linkage each, while nodes D and E are highly interconnected with five linkages each. In the language of the network theory, nodes H and G have a total degree (or degree centrality) of 1, while nodes D and E have the degree of 5. Distinguishing the direction of the linkage, the in-degree count of node D—the number of incoming linkages—is 3, and its out-degree is 2. It is common to scale the degree measure by the total number of possible linkages that can be formed by a given node (in the given network each node can form a maximum of 7 linkages). Table 3 reports the basic centrality measures, including scaled degree. Another important metric, weighted degree, summarizes the total value of linkages incoming (weighted in-degree) to the node and outgoing (weighted out-degree) from the given node.

**Figure 1: Stylized weighted directed network**

Note: The figure shows a stylized weighted directed network with nodes indicated by letters A–H and numbers indicating the weight of a directed link. Source: Own elaboration.

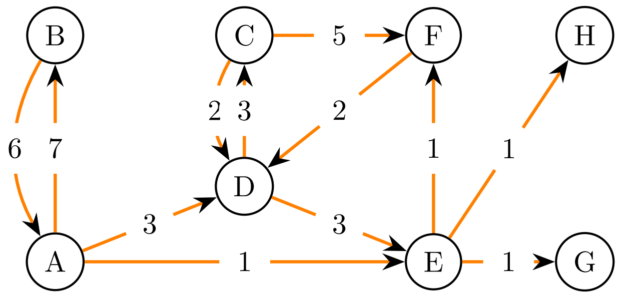



**Table 3: Selected centrality measures for the stylized network**

| Node | PageRank | Degree | In-degree | Out-degree | Weighted degree | Weighted in-degree | Weighted out-degree |
|---|---|---|---|---|---|---|---|
| A | 0.12 | 0.57 | 0.14 | 0.43 | 17 | 6 | 11 |
| B | 0.10 | 0.29 | 0.14 | 0.14 | 13 | 7 | 6 |
| C | 0.13 | 0.43 | 0.14 | 0.29 | 10 | 3 | 7 |
| D | 0.22 | 0.71 | 0.43 | 0.29 | 13 | 7 | 6 |
| E | 0.14 | 0.71 | 0.29 | 0.43 | 7 | 4 | 3 |
| F | 0.15 | 0.43 | 0.29 | 0.14 | 8 | 6 | 2 |
| G | 0.07 | 0.14 | 0.14 | 0.00 | 1 | 1 | 0 |
| H | 0.07 | 0.14 | 0.14 | 0.00 | 1 | 1 | 0 |

To illustrate the difference between a conventional approach and a network perspective, it is useful to compare nodes B and D. Both have the same weighted degree of 13 and also the weighted in-degree and the weighted out-degree are the same—7 and 6, respectively (the weighed degree in this regard is analogous to the total value of flows, e.g. gross trade value or total FDI inflow, scaled or unscaled by GDP). However, clearly, node D is much more important to the network as it bridges 4 other nodes, as opposed to node B, which is only linked to node A. The importance of node D is even higher if one takes into account that it is linked to another highly connected node E. In turn, both nodes D and E, have the same number of linkages (five), although their direction and weight differ significantly.

Certain network-based measures of connectivity can take into account such second-order connectivity effects due to the adjacent nodes ("neighbors"), along with the weight and the direction of the nodes' own linkages, to arrive at a proper measure of a node's "centrality" in the network. In the spectrum of different centrality measures that have been devised to date, however, only a few are able to incorporate the notions of direction and weight of linkages. In this paper, among other measures, we therefore use PageRank centrality, originally developed in Brin and Page (1998) and Page et al. (1999), which allows to summarize the centrality of a node in the network taking into account the weight and the direction of linkages, as opposed to simple eigenvector centrality measures.[5] Furthermore, unlike alternative measures of centrality, e.g. Katz centrality, PageRank centrality can be computed for weighted directed networks that include cycles, i.e. paths that start and end at the same node, as opposed to acyclic networks (in the context of GVC relationships, double counting of value added, i.e. cycles in the value-added linkages, is a known issue). In brief, PageRank centrality is an eigenvector-based algorithm that measures the fraction of time spent visiting a given node in a random walk summarized over all linkages in the network. In other words, PageRank can be viewed as the probability that a shock originating in a randomly chosen node anywhere in the network and traveling through it from one node to another via the linkages will arrive at a given node (averaged over all possible shock source nodes in the network). A weighted directed network assumes directed linkages via which the shock travels and a proportionally higher probability of chooses the linkage with a higher weight in the cases when several outgoing linkages extend from the currently visited node. Thus, by construction PageRank centrality varies in the 0–1 range with greater values reflecting higher probability of being visited by a shock, i.e. greater multilateral connectivity.

Originally, PageRank was used to quantify the relative importance of web pages in the Internet (hyperlinked network), but has gained popularity in other disciplines given its desired properties that allow to account for more complex network relationships. As can be seen in Table 3, PageRank indeed identifies node D as the most “central” node in the stylized network, unlike simpler measures.

Therefore, we proceed by constructing the GVC and FDI networks for each year in the sample and computing PageRank and other centrality measures for all countries. The construction of the GVC network from the inter-country input-output yearly tables is straightforward as essentially the inter-country value-added trade partition of a typical ICIO database (OECD ICIO or WIOD) is de facto an adjacency matrix at the country-sector level, fully symmetric and consistent internally (the same structure of the database is followed for all years). The stylized representation of the structure of a typical inter-country input-output table for a given year is shown in Figure 2 for a world economy comprising J countries and S sectors. Each cell in the table represents the value of output flows from countries and their sectors indicated in the leftmost column to countries and sectors importing the intermediate inputs as indicated in the top rows (there is also the partition with the final use, however, in the analysis we are interested only in the GVC relationships, i.e. the supply and use of intermediate inputs). As our analysis focuses on aggregate country-level relationships, the data in the intermediate supply-use tables are aggregated by each country across its S sectors, amounting to the adjacency matrix of size J $\times$ J.

Based on these data we construct the GVC network for each year in the sample period (2005–2015). Figure 3 shows the complete GVC network for the year 2015, listing the countries

[5] Python NetworkX package was used to process the networks and compute weighted directed PageRank centrality.

**Figure 2: The structure of an inter-country input-output database**

Note: The figure shows a stylized inter-country input-ouput database for J countries and S sectors. Source: own elaboration.

| | | | Use of inputs and value added by countries and sectors | | | | | | | | | Final use (households, government, GFCF) | | | Total use |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Country 1 | | | ... | | | Country J | | | Country 1 | ... | Country J | |
| | | | Sector 1 | ... | Sector S | ... | | | Sector 1 | ... | Sector S | | | | |
| Intermediate inputs supplied by countries and sectors | Country 1 | Sector 1 | | | | | | | | | | | | | |
| | | ... | | | | | | | | | | | | | |
| | | Sector S | | | | | | | | | | | | | |
| | ... | ... | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | Country J | Sector 1 | | | | | | | | | | | | | |
| | | ... | | | | | | | | | | | | | |
| | | Sector S | | | | | | | | | | | | | |
| Total value added | | | | | | | | | | | | | | | |
| Gross output | | | | | | | | | | | | | | | |

in a circular layout in the alphabetic order by ISO3 code.[6] The size of each country-node is proportional to its weighted degree—the total sum of a country's incoming and outgoing intermediate trade flow values. The thickness and the color intensity of linkages are proportional to their weight (trade value).

Overall, the GVC network has a clear core-periphery structure with a relatively small of number of countries forming a highly interlinked cluster, while most countries are also connected, but much more sparsely and via linkages with smaller trade values. As one can see, the top countries by the total value of GVC linkages are China (2.5 trillion USD), USA (2.36 trillion USD) and Germany (1.85 trillion USD), followed by Japan, South Korea, France and the UK. The strongest linkages extend between China and the USA (exports from CHN to USA amount to 260 billion USD and from USA to CHN – 134 billion USD) and between Canada to the USA (exports from CAN to USA are 199 billion USD; exports from USA to CAN are 134 billion USD). Jointly with the exports from South Korea to China (157 billion USD), they constitute the top 5 most sizable value-added trade linkages in the GVC network in 2015 (in general, the GVC linkages are rather stable over time, especially in terms of relative connectivity of countries). Other high-intensity linkages are between the USA, Germany, Mexico, Japan, South Korea, UK, France, albeit their values are smaller.

The core-periphery structure is more clearly visible when focusing only on the strongest linkages and nodes in the network—depicted in Figure 4 with the "ForceAtlas" layout algorithm that tends to position more tightly interconnected countries in proximity to each other. Within the general core-periphery structure of the GVC network one may also notice an implicit regional hierarchy with the USA serving as the global hub interlinked with regional European and Asian clusters (as well as dominating the American value-added trade), which, in turn, are centered around regional hub countries, most prominently, China and Germany. The backbone of the regional cluster centered around China is formed also by Japan and South Korea, jointly interlinking most other Asian economies. In Europe, the particularly strong regional cluster is centered around the well-documented German-Central European "manufacturing core".

Next, in a similar fashion we construct the inter-country FDI networks for each year in the sample period. To this end we use net FDI inflow data on immediate investor basis and

[6] The rest-of-the-world aggregate is not shown in the figures, but is nevertheless used in the computation of centrality measures.

**Figure 3: GVC network, 2015**

Note: The figure shows the GVC network for the year 2015. The size of each node is proportional to its weighted degree (the total value of value-added exports and imports). The thickness and the color intensity of linkages are proportional to their weight. The countries are listed clockwise by ISO3. Only linkages with the value added above 500 mn USD are shown for clarity. Source: own calculations based on the OECD ICIO data.

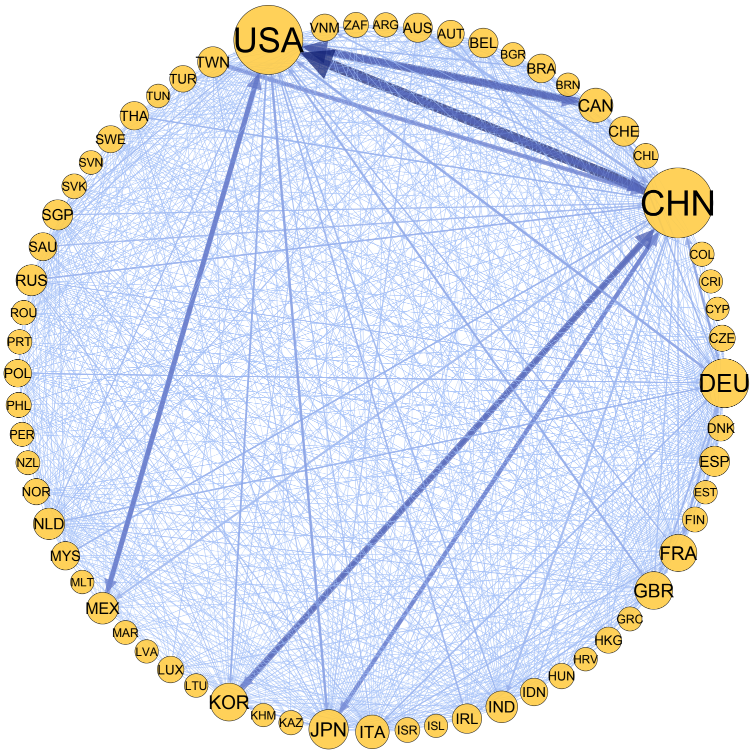
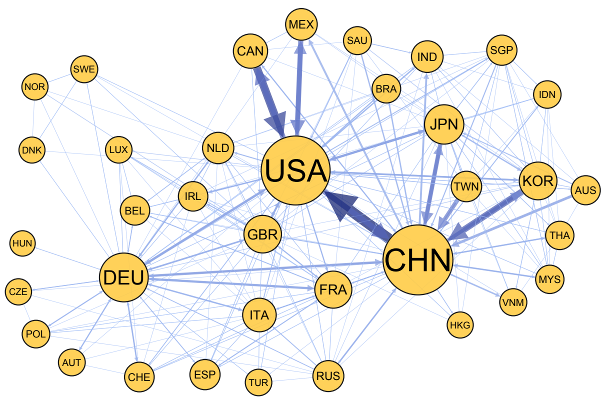



**Figure 4: GVC network–core, 2015**

Note: The figure shows the subset of the GVC network with the largest nodes and linkages. The size of each node is proportional to its weighted degree (the total value of value-added exports and imports). The thickness and the color intensity of linkages are proportional to their weight. Only countries with the weighted degree above 100 billion USD and the linkages with the weight above 5 billion USD are shown for clarity. Source: own calculations based on the OECD ICIO data.




including special purpose entities, as we are interested in the analysis of FDI relationships in general, inter alia, including its features associated with FDI in-transit and the role of tax havens in shaping global investment flows.[7]

Figure 5 shows the global FDI network for the year 2015. As the number of countries available for the FDI network is higher in comparison with the GVC network discussed above, we use the "Radial Axis" layout grouping countries by their degree (the number of linkages) and showing only stronger linkages for clarity—FDI flow values above 100 million USD. Similarly to the GVC network, for illustrative purposes the size of each node is proportional to its weighted degree, and the thickness and the color intensity of linkages are proportional to their weight. In addition, the core of the FDI network is rendered in Figure 6 using the "ForceAtlas" algorithm.

As can be inferred from both graphs, the connectivity of countries in the global FDI network is also highly asymmetric. While Italy and Turkey have a high number of linkages, the USA is nevertheless strongly dominant in terms of the number of linkages (degree centrality) and their intensity, thereby amounting to a very high total value of incoming and outgoing FDI linkages, i.e. its weighted degree, which secures its most central position in the FDI network as measured by multilateral connectivity measures, e.g. PageRank centrality. Especially strong FDI flows are associated with tax offshore jurisdictions, e.g. Luxembourg, the UK, Ireland. In particular, the highest investment flow value in 2015 is registered for FDI from Ireland to Luxembourg (about 219 billion USD), closely followed by investment flows between the USA and Luxembourg (197 billion USD from USA to LUX and 173 billion USD from LUX to USA). Notably, when not considering the countries central in the FDI network on account of their tax optimization regulations, e.g. Luxembourg and Ireland, the core of the FDI network is formed largely by the same countries as that of the GVC network, although the role of Asian economies in the case of the FDI network, while still important, is relatively smaller in comparison with other the USA and the hub countries of Europe.

As noted above, the main metric that we use in the econometric analysis is PageRank centrality, which is capable of summarizing the connectivity of nodes-countries in weighted directed networks with cyclical loops taking into account the connectivity of neighboring nodes.[8] Figure 7 juxtaposes GVC PageRank against FDI PageRank centrality measures for the panel data, as well as for the average over the period 2005–2015 with country labels. For clarity both variables are plotted on a log-log scale and isolated country-nodes (those with zero and near-zero centrality values) are not included—however, it should be noted that log-transformation visually reduces the de facto wide gap in connectivity between highly central countries, e.g. the USA, Germany, China and Luxembourg, and the periphery. Overall, as can be seen, there is a strong positive correlation between the connectivity of countries in both networks. The countries that are most integrated in both GVC and FDI networks are the USA, Germany, France, Italy and the UK. Notably, Asian systemically important economies—China, Japan and South Korea—while being highly central in the GVC network, as noted before, have a high, but relatively lower

[7] For research questions focusing explicitly on the role of ownership structure it is advised to focus on FDI by ultimate investing country, and for the analysis emphasizing the real economic impacts of FDI—on FDI data net of special purpose entities and controlling for tax offshore countries, see also Adarov and Stehrer (2021).

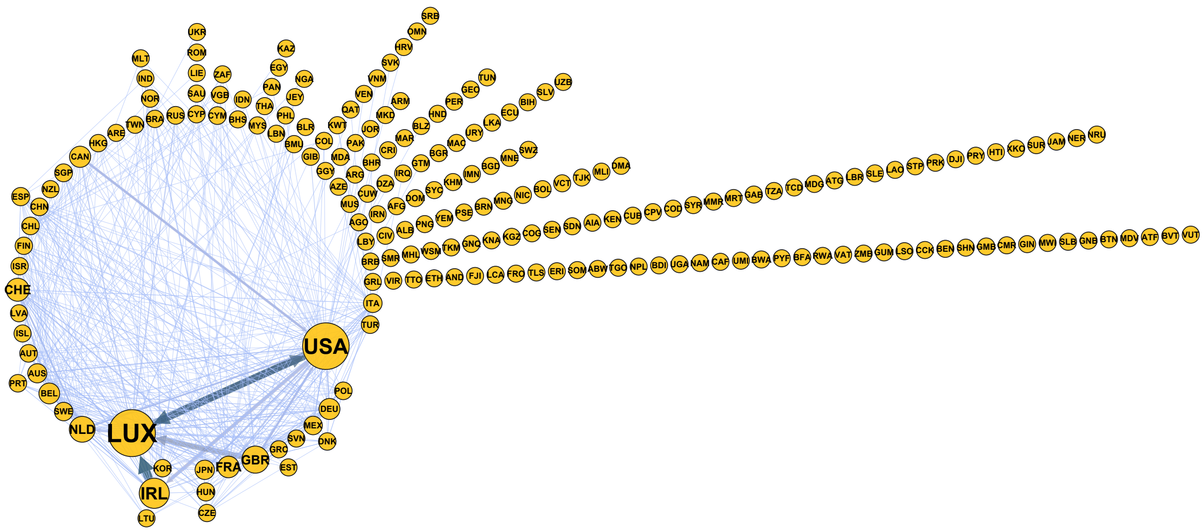
[8] The computation of both FDI and GVC centrality measures is based on the internally consistent sets of countries for each network—balanced panel data—which makes the computed metrics comparable across time, although the sets of countries covered in the OECD ICIO and the combined UNCTAD/OECD FDI databases differs (the FDI dataset covers more countries, while in the ICIO dataset a range of countries are aggregated into the rest-of-the-world group, which is also taken into account in the computation of centrality measures).

connectivity in the FDI network relative to peers, in this respect deviating from the general trend association between FDI and GVC centrality, implied by the fitted linear regression line. The figure also illustrates the extent to which the relationship is biased by the phantom FDI associated with tax offshore jurisdictions: while FDI PageRank centrality of these countries is very high, in fact, among the highest in the sample, their GVC PageRank centrality is much lower relative to the expected level.

Summarizing the diagnostics across both FDI and GVC networks, the US is highly central in terms of both cross-border production sharing and investment, being the global hub in the joint GVC-FDI network, while Germany and, to a lesser extent, Italy, France and the UK, constitute the regional European GVC-FDI hub. The Asian region is dominated by China, Japan and South Korea in terms of GVC connectivity. However, in contrast to European and North American hubs, they rely much less on FDI connectivity. The global hub status of the USA is facilitated not only by its own cross-border production and investment linkages, but also by its strong connectivity to the regional hubs and clusters, i.e. via second-order effects.

**Figure 5: FDI network, 2015**

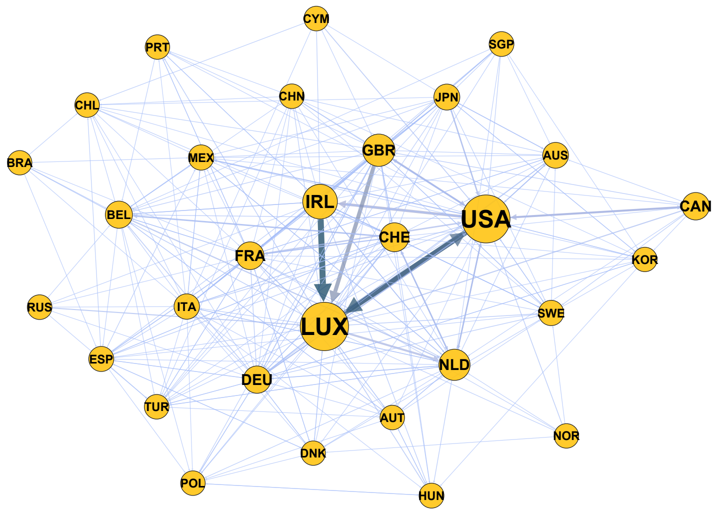
Note: The figure shows the FDI network for the year 2015. The size of each node is proportional to its weighted degree (the total value of a country's FDI inflows and outflows). The thickness and the color intensity of the linkages are proportional to their weight (value of FDI flow). Only linkages above 100 million USD are shown. Countries are ordered clockwise by their degree (number of linkages) with the highest degree in clock position 3 (ITA)—the set GRL–VUT has the lowest degree value. Source: own calculations based on the based on the OECD and UNCTAD data.




Another important feature of FDI and GVC centrality measures is the relative stability of a country's position in both networks over the sample period. Figure 8 shows the evolution of selected highly interconnected countries in the GVC–FDI centrality space over the period 2005-2015. As one can see, while countries drift gradually over time (mostly in the FDI centrality dimension rather than in terms of their GVC centrality), their position relative to other countries in the sample remains nevertheless rather stable over the entire period. This poses additional technical challenges for econometric analysis discussed next, as in this case the identification

**Figure 6: FDI network–core, 2015**

Note: The figure shows the subset of the FDI network with the largest nodes and linkages. The size of each node is proportional to its weighted degree (the total value of FDI inflows and outflows). The thickness and the color intensity of the linkages are proportional to their weight (value of FDI flow). Only linkages above 100 million USD and only the nodes with the weighted degree above 10 billion USD are shown. Source: own calculations based on the OECD and UNCTAD data.




of the mutual impacts and drivers of connectivity has to rely on between-panel (rather than within-panel) variation, and the use of country fixed effects (or within-transformation) would lead to a loss of essential relevant information.

**Figure 7: Scatterplot of GVC vs FDI PageRank centrality**

Note: The figure shows the scatterplot of FDI and GVC PageRank centrality (in logs) for the 2005–2015 average (left panel) and all observations in the sample period (right panel). Tax haven countries are marked in red.

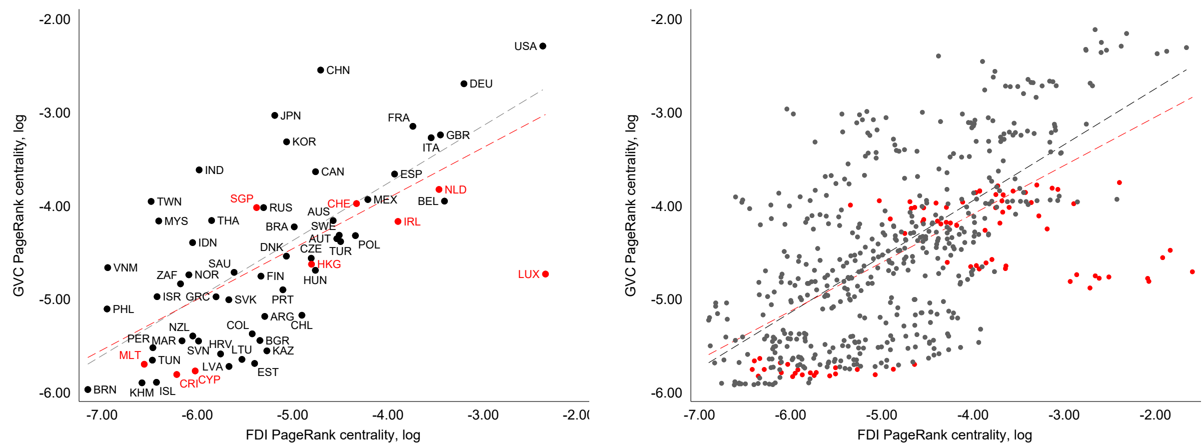
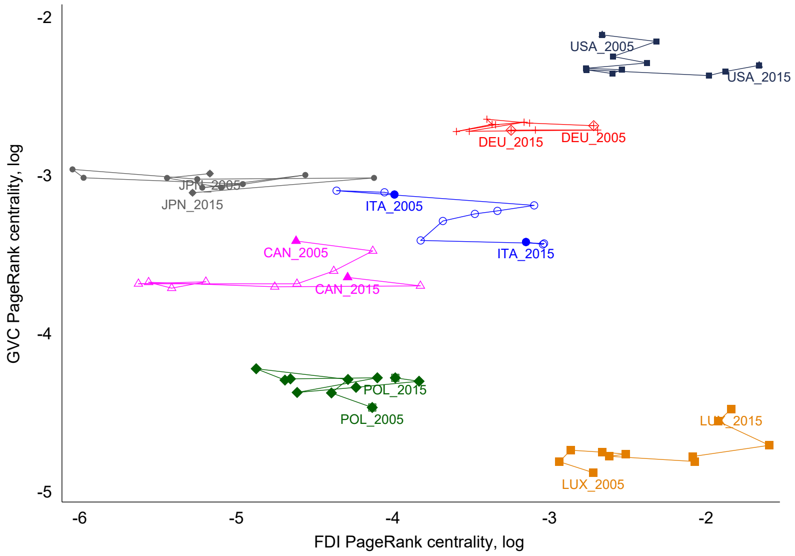


**Figure 8: Evolution of selected countries in the GVC–FDI centrality space**

Note: The figure shows the evolution of selected countries in the space spanned by FDI and GVC PageRank centrality measures over the period 2005–2015. Each connected marker denotes a year for a given country with the first and the last year of observation labeled.




# 4 Econometric analysis

This section examines the relationship between the connectivity in the GVC and FDI networks more formally, using econometric techniques that allow to control for other relevant factors that may impact a country's integration in both networks. As causality between FDI and GVC is likely to be reciprocal, we estimate the equations explaining FDI network centrality and GVC network centrality jointly in a simultaneous equation model formulated as follows:

$$\begin{cases} FDI_{c,t} = \alpha \times GVC_{c,t} + \mathbf{\Psi^N} \times \mathbf{Y}_{c,t}^{FDI} + \mathbf{\Psi^X} \times \mathbf{X}_{c,t}^{FDI} + \tau_t^{FDI} + \epsilon_{c,t}^{FDI} \\ GVC_{c,t} = \beta \times FDI_{c,t} + \mathbf{\Theta^N} \times \mathbf{Y}_{c,t}^{GVC} + \mathbf{\Theta^X} \times \mathbf{X}_{c,t}^{GVC} + \tau_t^{GVC} + \epsilon_{c,t}^{GVC} \end{cases}$$

where $FDI_{c,t}$ and $GVC_{c,t}$ are FDI and GVC connectivity measures (PageRank centrality of country $c$ in year $t$), respectively, in logs;[9] $\alpha$ and $\beta$ are the coefficients that capture the mutual impacts between the GVC and the FDI connectivity variables. $\mathbf{Y}_{c,t}^{FDI}$ and $\mathbf{Y}_{c,t}^{GVC}$ are the vectors of endogenous explanatory variables with the associated coefficient vectors $\mathbf{\Psi^N}$ and $\mathbf{\Theta^N}$. In the baseline analysis, real GDP (log) is included as the endogenous variable in both equations of the system.[10] The larger size of an economy is expected to be conducive to FDI inflows (vertical and horizontal), as well as lead to a greater variety and value of economic activities contributing to cross-border production sharing.

[9] The logarithmic transformation helps reshape these data towards the normal distribution (otherwise, as noted, the statistical distributions of both measures are highly skewed). This also allows to interpret the estimates as (semi-) elasticities.

[10] In other specifications for robustness we also check real GDP per capita, which however results in inferior diagnostic test results, as well as poses collinearity issues with some regressors of interest, e.g. institutional quality or productivity.

The vectors of exogenous variables for the GVC and FDI equations include other variables that are deemed to be relevant in the literature. In this respect, one should note that the centrality measures employed in the model have not been hitherto used as dependent variables in the literature; however, it is plausible that they may be driven by similar structural and policy variables as more conventional measures of GVC participation or inward FDI as a share of GDP. Therefore, the choice of control variables is motivated by the empirical studies on the drivers of GVC and FDI. While some variables, being relevant to FDI and GVC alike, enter both equations, others are equation-specific and reflect the drivers specific to FDI or GVC centrality, which also addresses the exclusion restrictions requirements of the 3SLS estimation framework (the models are validated via diagnostic checks and instrument validity tests, e.g. Hansen-Sargan test).

More specifically, the vector of exogenous variables for the GVC centrality equation—$\mathbf{X}_{c,t}^{GVC}$—includes average MFN import tariff rate entering the model as log(1+import tariff rate/100), natural resource rents as a share of GDP, real effective exchange rate (log-difference) and Political Stability and Absence of Violence index, which is used as a measure of institutional development (for robustness, other World Bank's Worldwide Governance Indicators indices, e.g. Control of Corruption and Government Effectiveness, were also used in alternative specifications; however, the institutional development indices are generally highly correlated, while the Political Stability index yields better results in terms of the model fit and the stability estimated coefficients across specifications). In additional specifications the model is augmented by real labor productivity level and TFP growth rate. To avoid collinearity issues this is done sequentially and excluding the institutional development variable.

The vector of exogenous variables for the FDI centrality equation, $\mathbf{X}_{c,t}^{FDI}$, includes effective average corporate tax rate that enters the model as log(1+tax rate/100), FDI Regulatory Restrictiveness index, Political Stability and Absence of Violence index and the Tax haven dummy variable, which takes the value of unity if the country is a classified as a tax haven country in Hines (2010). In this regard, the specification, besides efficiency-seeking and market access motives of FDI, accounts for MNEs' incentives to take advantage of a low-tax environment and a high level of investor confidentiality[11], as well as regulatory obstacles to free flow of capital. Similarly to the GVC equation, in additional specifications we also control for real labor productivity and TFP growth. Both model equations include year fixed effects $\tau_t^{GVC}$ and $\tau_t^{FDI}$ to account for correlated common shocks, e.g. the effects of the global economic crisis. $\epsilon_{c,t}^{FDI}$ and $\epsilon_{c,t}^{GVC}$ are the error terms of the FDI and the GVC equation, respectively.

As discussed in the previous section, the dynamics of both GVC and FDI centrality measures are rather stable over time and the heterogeneity mainly comes from the between-panel variation. Moreover, many other covariates of interest, e.g. FDI Regulatory Restrictiveness and institutional variables, do not vary much over time for a given country. Therefore, the introduction of country fixed effects that would absorb the meaningful (between-panel) variation in the data is problematic and is avoided in the baseline specification, and in this respect when interpreting the estimation results one should recognize the possible caveats associated with the

[11] See also the discussion on tax optimization and profit-shifting motives by MNEs related to the phantom FDI phenomenon in Blanchard and Acalin (2016) and Damgaard et al. (2019).

unobserved country heterogeneity (the estimation results that employ country fixed effects are however also reported for comparison).

The model is estimated via 3SLS (Zellner and Theil, 1962)—three-stage least squares method to solve simultaneous equation models.[12] In the first stage, the estimator obtains 2SLS estimates of each equation (instrumented values are estimated for all endogenous variables, regressing them on all exogenous variables in the system, as in the first step of a typical 2SLS estimator). In the second stage, the 2SLS estimates of the first stage are used to determine cross-equation correlations and obtain a consistent estimate for the covariance matrix of the equation disturbances. In the third stage, generalized least squares technique is used to estimate the model parameters using the covariance matrix obtained in the second stage and the instrumented values for the endogenous variables.

The 3SLS framework is preferred for the estimation of our two-equation jointly determined model as it uses an instrumental-variable approach to arrive at consistent estimates and accounts for the correlation in the error terms across the system via generalized least squares, while allowing for additional exogenous and endogenous variables in the system. As the 3SLS estimator takes into account the information from both equations in the simultaneous equation model, it is thus not only consistent, but also asymptotically more efficient than 2SLS, which is agnostic about the contemporaneous covariance structure between the error terms in the model equations.

Table 4 reports the estimation results listing the baseline model (Column 1) and additional specifications estimated for robustness. The top partition of the table shows the results for the GVC PageRank centrality equation and the bottom partition—for the FDI PageRank centrality equation. Overall, the model shows a rather good fit for both equations. The validity of the instruments is confirmed using the Hansen-Sargan overidentification test (the statistic is reported for each specification along with the associated p-value)[13]—only models 4 and 6 fail to satisfy the criteria, however, these specifications are only listed as a sensitivity check. More specifically, models 2 and 3 are augmented by real labor productivity level and TFP growth, instead of the institutional development variable used in the baseline specification. In model 4, real GDP is implemented as an exogenous variable, in contrast to the baseline and other specifications, where it is treated as an endogenous variable (and is therefore instrumented along with other endogenous variables in the 3SLS framework). Specification 5 adds country fixed effects to both equations, in addition to year fixed effects that are used in all models. In specification 6, GVC and FDI weighted degree centrality variables, rather than PageRank centrality variables, are used as the measure of countries' connectivity, as an additional sensitivity check.

Focusing first on the GVC centrality equation of the system, the results suggest that, notably, FDI PageRank centrality is highly conducive to GVC centrality—the estimates are highly statistically significant and the magnitude of the estimated coefficient suggests that a 1-percent increase in the FDI network centrality is associated with about 0.17-percent increase in the GVC network centrality. The estimates are also robust across specifications. The only exception is the specification with country fixed effects (column 5); however, as mentioned above,

[12] To this end we use Stata's *reg3* command.
[13] The overid package developed for Stata by Baum et al., 2020 is used for this test.

this specification is problematic as the dependent variables and several explanatory variables of interest do not vary much over time for any given country and thus country fixed effects absorb variation in the data rendering all estimates insignificant.

**Table 4: Simultaneous equations model 3SLS estimation results**

Note: The table shows simultaneous equations model 3SLS estimation results listing the GVC equation (top partition) and the FDI equation (bottom partition) for each specification (columns 1–6). All models are estimated with year fixed effects. All specifications, except specification 4, include real GDP as an endogenous variable (in addition to FDI and GVC PageRank centrality variables). Specification 4 (Exog.) incorporates real GDP as an exogenous variable. Specification 5 (Endog. FE) includes country fixed effects. Specification 6 (W-degree) uses FDI and GVC weighted degree centrality instead of PageRank centrality (as the dependent variable and regressors in both system equations). Robust standard errors are included in parentheses. *, ** and *** indicate statistical significance at the 1, 5 and 10% levels, respectively.

| | 1<br>Endog. | 2<br>Endog. | 3<br>Endog. | 4<br>Exog. | 5<br>Endog. FE | 6<br>W-degree |
|---|---|---|---|---|---|---|
| *[GVC equation] Dependent variable: GVC PageRank centrality, log* | | | | | | |
| FDI PageRank centrality, log | 0.174*** | 0.144*** | 0.181*** | 0.169*** | 0.392 | 0.163*** |
| | (0.028) | (0.031) | (0.027) | (0.027) | (0.436) | (0.030) |
| Real GDP, log | 0.417*** | 0.406*** | 0.414*** | 0.474*** | 1.613 | 0.048 |
| | (0.021) | (0.019) | (0.019) | (0.014) | (3.569) | (0.036) |
| Import tariff rate, log | 3.042*** | 3.685*** | 2.786*** | 3.230*** | -1.959 | 1.894 |
| | (0.861) | (0.909) | (0.829) | (0.800) | (5.947) | (1.295) |
| Natural resource rents, share of GDP | -4.104*** | -3.664*** | -4.187*** | -4.055*** | 2.247 | -3.449*** |
| | (0.445) | (0.488) | (0.434) | (0.418) | (5.135) | (0.671) |
| REER growth | 0.063 | -0.012 | 0.071 | 0.167 | 0.085 | -0.396 |
| | (0.369) | (0.374) | (0.366) | (0.350) | (0.289) | (0.481) |
| Political Stability index | 0.057* | | | 0.092*** | -0.114 | 0.044 |
| | (0.033) | | | (0.030) | (0.550) | (0.053) |
| Real labor productivity, log | | 0.135*** | | | | |
| | | (0.043) | | | | |
| Total factor productivity growth | | | 0.025*** | | | |
| | | | (0.009) | | | |
| Constant | -14.880*** | -16.232*** | -14.745*** | -16.475*** | | -4.549*** |
| | (0.654) | (0.776) | (0.579) | (0.496) | | (0.813) |
| Observations | 218 | 218 | 218 | 218 | 218 | 218 |
| R-squared | 0.924 | 0.920 | 0.925 | 0.933 | 0.967 | 0.585 |
| *[FDI equation] Dependent variable: FDI PageRank centrality, log* | | | | | | |
| GVC PageRank centrality, log | -0.890* | -0.989* | -0.881* | -0.891* | 3.798 | -1.052 |
| | (0.492) | (0.528) | (0.483) | (0.480) | (3.788) | (0.889) |
| Real GDP, log | 0.699 | 0.842** | 0.650* | 0.857*** | 0.049 | 0.496 |
| | (0.493) | (0.353) | (0.348) | (0.281) | (2.998) | (0.505) |
| Average corporate tax rate, log | 4.833 | 1.905 | 5.875 | 2.402 | -0.838 | 13.082 |
| | (7.737) | (4.505) | (5.510) | (1.776) | (3.714) | (9.191) |
| FDI Regulatory Restrictiveness index | -5.616*** | -5.683*** | -5.497*** | -5.673*** | 1.624 | -2.660 |
| | (1.333) | (1.318) | (1.250) | (1.259) | (3.220) | (2.821) |
| Tax haven | 1.638*** | 1.581*** | 1.697*** | 1.603*** | -0.802 | 2.968*** |
| | (0.274) | (0.256) | (0.264) | (0.246) | (4.110) | (0.350) |
| Political Stability index | 0.169 | | | 0.235* | -0.507 | 0.346 |
| | (0.206) | | | (0.134) | (0.748) | (0.281) |
| Real labor productivity, log | | 0.248 | | | | |
| | | (0.184) | | | | |
| Total factor productivity growth | | | 0.072* | | | |
| | | | (0.043) | | | |
| Constant | -28.000** | -34.359*** | -26.826*** | -31.838*** | | -7.605 |
| | (13.501) | (11.672) | (10.171) | (9.464) | | (12.575) |
| Observations | 218 | 218 | 218 | 218 | 218 | 218 |
| R-squared | 0.307 | 0.306 | 0.300 | 0.338 | 0.862 | 0.465 |
| Hansen-Sargan test statistic | 2.888 | 2.878 | 3.123 | 22.695 | 0.046 | 22.529 |
| Hansen-Sargan test p-value | 0.236 | 0.237 | 0.210 | 0.000 | 0.830 | 0.000 |

Besides FDI connectivity, the economic size of a country, measured by real GDP, also fosters GVC connectivity, consistent with the idea that larger economies can engage in a greater number of economic activities (tasks within value chains), as well as do this at a larger scale relative to smaller economies, which is conducive to cross-border production sharing resulting in higher multilateral connectivity in the GVC network. At the same time, higher natural resource intensity is associated lower GVC centrality, ceteris paribus. While natural resources are certainly critical for most value chains, heavy specialization of countries in resource extraction activities, i.e. in the very upstream segments of value chains, reflects negatively on their economic diversification prospects (see also the literature on the "natural resource curse", e.g. Van der Ploeg, 2011). Institutional development, as measured by the Political Stability index, is associated with better GVC connectivity outcomes, although the estimate is statistically significant only at the 10-percent level in the baseline estimation.[14] Contrary to expectations, the estimates suggest that import tariffs are positively associated with GVC centrality, which may reflect the fact that countries with higher MFN tariffs are largely developing countries, which may use tariff protection as a policy tool to shield domestic industries from foreign competition and thereby boost their competitiveness.[15] Finally, productivity improvements are also associated with higher GVC centrality, which is expected given that productivity is an essential element of competitiveness.

The estimation results for the FDI equation (the bottom partition of Table 4), suggest that GVC centrality is negatively associated with the FDI centrality, although the effect is only marginally statistically significant at the 10-percent level. While this does not seem intuitive at a first glance, interpreting this result jointly with the estimates for the GVC equation, it may indicate that, while FDI is important for boosting GVC connectivity, countries that are already well-integrated in GVC networks do not require further FDI inflows, and, vice-versa, countries with a yet-unrealized potential for deeper GVC integration encourage greater FDI by MNEs as a means to establish economic presence in the host economies. As a related matter, investment-friendly regulatory environment is paramount for attracting FDI, which is also confirmed by our estimates: FDI Regulatory Restrictiveness index enters negatively and is highly statistically significant, implying that such statutory restrictions as foreign equity limitations, screening mechanisms and other restrictions on FDI flows are indeed strongly detrimental to a country's FDI connectivity. Finally, tax offshore countries, captured by the Tax haven dummy variable, are strongly associated with higher FDI flow connectivity, consistent with the literature on phantom FDI and FDI in-transit and providing further empirical support this time using a network approach.[16]

[14] Among other institutional development variables examined, the Government Effectiveness index is also found to be conducive to GVC centrality with the estimate of 0.098***, i.e. statistically significant at the 1-percent level; the Control of Corruption index, by contrast, is not statistically significant.

[15] However, higher import tariffs also imply higher costs of imported intermediates, which may, on the contrary, impact negatively domestic producers relying heavily on imported inputs.

[16] In additional specifications a range of other variables have also been tested, e.g. alternative institutional development variables, import tariff rate to test possible "tariff-jumping" hypothesis; yet those turned out to be insignificant. Furthermore, the results remain unchained for a specification with the higher number of observations if FDI Regulatory Restrictiveness index, for which the data is particularly limiting, is dropped. Additional results are available from the author on request.

## 5 Conclusion

Cross-border production sharing and FDI are critically important for economic development and growth. In this paper we contribute to the literature by examining FDI and GVC patterns through the prism of a complex network analysis. This appears to be an especially useful way to look at the increasingly globalized world economy in which countries are closely intertwined via trade and financial flows, international migration, information and technology diffusion. From this perspective, countries can be viewed as nodes-conduits in the continued global flow of economic value in different forms from one country to another, and in this respect multi-dimensional connectivity of countries is particularly important when analyzing such phenomena as the strategic position of countries in global production chains, exposures to economic shocks and associated cross-border economic contagion risks.

We specifically focus on the GVC and FDI networks, revealing the connectivity of countries therein and exploring the relationship between them in a simultaneously determined system of equations. The analysis shows that both networks are highly asymmetric with a clear core-periphery structure as a relatively small number of systemic economies closely interconnected via trade and investment ties dominate the global economy, while also bridging other more sparsely connected countries. There is also evidence of regional clustering in both networks centered around regional hubs, e.g. China and Germany. Furthermore, we illustrate and empirically confirm that the FDI and GVC networks are interrelated with higher centrality in the global FDI network being highly conducive to the centrality in the GVC network. The only exception from this pattern is the group of countries commonly classified as tax havens, which are characterized by a very high centrality in the FDI network associated with high levels of simultaneous FDI inflows and outflows.

In light of these results, from the policy perspective our study brings up several themes worthy of further elaboration. The analysis once again highlights the strong and persistent economic asymmetries at the international level, which are closely related to the issues of global inequality and the distribution of the gains from globalization. A relatively small group of countries are much better strategically positioned in both FDI and GVC networks to reap greater benefits from cross-border production activities, while many countries on the periphery fail to integrate successfully. As also shown in the analysis, FDI is conducive to GVC integration, which reiterates the importance of policy efforts aiming at fostering FDI and, more generally, better investment climate. A distinct, but related issue, is associated with the asymmetries in the FDI network related to phantom FDI. This topic remains high on the policy agenda. Only recently major advances have been made in the coordination of the global effort to overhaul international tax laws in order to reduce the incentives by MNEs to seek tax havens and rather pay a "fair share" in the countries of their de-facto operation—the "Global Tax Deal" agreement between 130 countries was reached in July 2021 (see OECD, 2021).

On the flip-side, the core-periphery structure and the inter-relatedness of the FDI and the GVC networks also bring up the question of vulnerabilities that may arise due to the central role that a small number of hub countries play in both networks. The Great Recession has highlighted the high global risks stemming from economic disruptions in systemic economies. More recently, the COVID-19 pandemic and related disruptions of economic activities around the world, have also emphasized the vulnerabilities arising from economic connectivity, prompting further research and additional policy efforts to engineer feasible responses to foster greater resilience to common exposures and economic shock contagion in the global economic architecture.

# References


Adarov, A. and Stehrer, R. (2021) "Implications of foreign direct investment, capital formation and its structure for global value chains." The World Economy, June 1, 2021, forthcoming.

Alfaro, L., Chen, M., 2014, The Global Network of Multidimensional Firms, Journal of International Economics, Volume 94, Issue 2, Pages 263-276.

Baldwin, Richard and Lopez-Gonzalez, Javier (2015) "Supply-chain Trade: A Portrait of Global Patterns and Several Testable Hypotheses," The World Economy, 38, issue 11, p. 1682-1721.

Baum, C.F., Schaffer, M.E., Stillman, S., Wiggins, V., Windmeijer, F. (2020) Overid: Stata module to calculate tests of overidentifying restrictions.

Blanchard, Olivier and Julien Acalin (2016), What Does Measured FDI Actually Measure? PIIE Policy Brief 16-17, Peterson Institute for International Economics.

Borin, Alessandro and Mancini, Michele (2019). "Measuring What Matters in Global Value Chains and Value-Added Trade," Policy Research Working Paper Series 8804, The World Bank.

Brin, S., Page, L. (1998). "The anatomy of a large-scale hypertextual web search engine." In Seventh international world-wide web conference (WWW 1998).

Buelens, Christian and Tirpak, Marcel (2017), "Reading the Footprints: How Foreign Investors Shape Countries Participation in Global Value Chains," Comparative Economic Studies, 59, issue 4, p. 561-584.

Cerina F, Zhu Z, Chessa A, Riccaboni M (2015) "World Input-Output Network." PLoS ONE 10(7): e0134025.

Cingolani, Isabella; Panzarasa, Pietro; Tajoli, Lucia. (2017). "Countries positions in the international global value networks: Centrality and economic performance." Applied Network Science. 2. 10.1007/s41109-017-0041-4.

Criscuolo C. and Timmis J. (2018) "The Changing Structure of Global Value Chains: Are Central Hubs Key for Productivity?" International Productivity Monitor, Centre for the Study of Living Standards, vol. 34, pages 64-80, Spring.

Damgaard Jannick and Thomas Elkjaer (2017). "The Global FDI Network: Searching for Ultimate Investors," IMF Working Papers 2017/258,

Daudin, G., C. Rifflart, and D. Schweisguth (2011). "Who produces for whom in the world economy?" Canadian Journal of Economics 44(4), 1403-1437.

Dollar, D. and M. Kidder (2017), Institutional quality and participation in global value chains, in: Measuring and analysing the impact of GVCs on economic development, Global Value Chain Development Report, 2017.

Grossman, G. M., and Rossi-Hansberg, E. (2008). "Trading Tasks: A Simple Theory of Offshoring." The American Economic Review, 1978-1997.

Hines Jr, James R.. (2010). Treasure Islands. Journal of Economic Perspectives. 24. 103-26. 10.1257 / jep.24.4.103.

Hummels, David, Jun Ishii, and Kei-Mu Yi. (2001) "The Nature and Growth of Vertical Specialization in World Trade." Journal of International Economics 2001, 54:75-96.

Johnson, Robert C. and Guillermo Noguera (2012). Accounting for Intermediates: Production Sharing and Trade in Value Added. Journal of International Economics, 86(2), 224- 36.

Koopman, Robert, Zhi Wang and Shang-Jin Wei (2014). Tracing Value-Added and Double Counting in Gross Ex-ports. American Economic Review, 104(2), 459-94.

Kowalski, P., Ugarte, C., Ragoussis, A., and Lopez Gonzalez, J. (2015). "Participation of developing countries in global value chains: implications for trade and trade-related policies.' (OECD Trade Policy Papers, No. 179.

Lejour A, Rojas-Romagosa H, Veenendaal P (2014). "Identifying hubs and spokes in global supply chains using redirected trade in value added. Working Paper Series 1670, European Central Bank

Los, Bart, Marcel P. Timmer and Gaaitzen J. de Vries (2016). Tracing Value-Added and Double Counting in Gross Exports: Comment. American Economic Review, 106(7), 1958-66.

Los Bart and Marcel P. Timmer (2018), "Measuring Bilateral Exports of Value Added: A Unified Framework", Chapter in "The Challenges of Globalization in the Measurement of National Accounts", ed. Nadim Ahmad, Brent Moulton, J. David Richardson, and Peter van de Ven. University of Chicago Press: NBER Book Series Studies in Income and Wealth.

MartnezGaln, E, Fontoura, MP. Global value chains and inward foreign direct investment in the 2000s. World Econ. 2019; 42: 175196.

Metulini, Rodolfo; Riccaboni, Massimo; Sgrignoli, Paolo; Zhu, Zhen. (2017). “The indirect effects of foreign direct investment on trade: A network perspective”. The World Economy, 40(6).

Miroudot, S., Spinelli, F., and Rouzet, D. (2013). “Trade policy implications of global value chains: Case studies”. OECD Trade Policy Paper, No. 161

OECD (2013). Interconnected Economies: Benefiting from Global Value Chains, OECD Publishing, Paris.

OECD, WTO and the World Bank (2014). Global value chains: Challenges opportunities and implications for policy. 2014.

OECD (2021). Statement on a Two-Pillar Solution to Address the Tax Challenges Arising From the Digitalisation of the Economy. July 1 2021.

Page, L., Brin, S., Motwani, R., Winograd, T. (1999). “The PageRank citation ranking: Bringing order to the web.” Technical report 1999-66, Stanford InfoLab.

Taglioni, Daria; Winkler, Deborah (2014). Making Global Value Chains Work for Development. Economic premise; no. 143. World Bank, Washington, DC.

Timmer M.P., B. Los, R. Stehrer and G.J. de Vries (2013) ”Fragmentation, Incomes and Jobs: An Analysis of Euro-pean Competitiveness” Economic Policy, 28, 613-661.

Timmer M.P., A.A. Erumban, B. Los, R. Stehrer and G.J. de Vries (2014) ”Slicing Up Global Value Chains” Journal of Economic Perspectives, 28(2), 99-118.

Timmer, M. P., Dietzenbacher, E., Los, B., Stehrer, R. and de Vries, G. J. (2015), ”An Illustrated User Guide to the World InputOutput Database: the Case of Global Automotive Production”, Review of International Economics., 23: 575605.

UNCTAD (2013) “Global Value Chains and Development: Investment and Value Added Trade in the Global Economy,” 2013.

Van der Ploeg, Frederick. “Natural Resources: Curse or Blessing?” Journal of Economic Literature, vol. 49, no. 2, 2011, pp. 366420.

Wall, R.S., van der Knapp G.A. (2011). “Sectoral Differentation and Network Structure within Contemporary Worldwide Corporate Networks,” 2011, Economic Geography 87 (3), 267-308.

Wang Z, Wei S-J, Zhu K (2013) “Quantifying international production sharing at the bilateral and sector levels.” NBER Working Paper No. 19677

World Bank et al. (2017) “Global Value Chain Development Report 2017. Measuring and analysing the impact of GVCs on economic development.”

Zellner, A., and H. Theil (1962). “Three stage least squares: Simultaneous estimate of simultaneous equations.” Econometrica 29: 54-78.

Zhu, Z., Morrison, G., Puliga, M., Chessa, A., and Riccaboni, M. (2018). “The similarity of global value chains: A network-based measure.” Network Science, 6(4), 607-632.

IMPRESSUM

Herausgeber, Verleger, Eigentümer und Hersteller:
Verein „Wiener Institut für Internationale Wirtschaftsvergleiche“ (wiiw),
Wien 6, Rahlgasse 3

ZVR-Zahl: 329995655

Postanschrift: A 1060 Wien, Rahlgasse 3, Tel: [+431] 533 66 10, Telefax: [+431] 533 66 10 50
Internet Homepage: www.wiiw.ac.at



Offenlegung nach § 25 Mediengesetz: Medieninhaber (Verleger): Verein "Wiener Institut für Internationale Wirtschaftsvergleiche", A 1060 Wien, Rahlgasse 3. Vereinszweck: Analyse der wirtschaftlichen Entwicklung der zentral- und osteuropäischen Länder sowie anderer Transformationswirtschaften sowohl mittels empirischer als auch theoretischer Studien und ihre Veröffentlichung; Erbringung von Beratungsleistungen für Regierungs- und Verwaltungsstellen, Firmen und Institutionen.

wiiw

wiiw.ac.at

https://wiiw.ac.at/p-5876.html