Slowbalisation or a "New" type of GVC participation? The role of digital services

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Abstract

This paper investigates the role of digital services in the dynamics observed in global value chains (GVCs) from 1995 to 2018. Despite the context of a deceleration in globalisation, we observe how countries' exports are increasingly incorporating foreign digital services, suggesting that a new channel, digitally driven, for globalization and GVC participation is emerging. Using trade in value added data and Social Network Analysis (SNA) methodology, we map the network of these digital services flows linked to GVCs and analyse its characteristics and evolution for the period 1995–2018. Moreover, we identify the leading economies in those networks from the point of view of both source and destination countries. New actors such as China, India and Israel arise, sharing with the USA, Germany, and the UK the leadership as global providers of intermediate digital sectors. Small European economies and Singapore show the highest dependence on foreign digital sectors to be incorporated in their exports.

Keywords Digital services · Global value chains · International trade · Social Networks Analysis

JEL Classification F01 · F14 · L16

1 Introduction

It is well known that, from the fall of the Berlin Wall to the global financial crisis of 2007–2008, advances in information and communication technologies (ICT) and the progressive liberalisation of trade flows between countries stimulated the implementation of international fragmentation strategies for production and the expansion of Global Value Chains (GVCs) (Amador & Cabral, 2016). During this period,

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production processes were segmented into multiple independent stages, and each stage was located where it could be executed at the lowest cost. In this new form of organising production, advanced economies tend to specialise in stages located at the beginning and the end of the value chain, where most of the value is added and where greater technological knowledge and skills are required. Manufacturing and assembly stages, which require lower levels of skill and involve more routinised tasks, tend to be offshored to emerging and developing economies (Baldwin et al., 2014). This international production sharing practice has strongly boosted cross-border trade flows and marks the beginning of a new phase in globalisation, in which trade integration has been more rapid than ever. For that reason, this period of fast-growing interdependence between economies is called 'hyperglobalisation' (Subramanian & Kessler, 2013) or New Globalisation (Baldwin, 2016), in contrast to the era of globalisation that characterised the post-World War II phase. This expansion of GVCs has had a very positive impact on production costs, productive efficiency and competitiveness of economies (Amiti & Konings, 2007; Antràs, 2020; Goldberg et al., 2010), especially in developing economies. These economies have managed to become part of world markets, reaching high rates of economic growth (OECD, 2013; Taglioni & Winkler, 2016; World Bank, 2020).

However, the Great Recession paved the way for a period of stagnation in GVCs. The literature recognises this new phase, also known as deglobalisation or slowbalisation[1] (Antràs, 2021; Javorcik, 2020; Titievskaia et al., 2020; Van Bergeijk, 2019). Essentially, just as hyperglobalisation was associated with the emergence and consolidation of GVCs, slowbalisation is related to a slowdown in GVC activity (Antràs, 2021; Crozet et al., 2015; IRC Trade Task Force, 2016; Kataryniuk et al., 2021).

There are several complex reasons for this slowdown in GVC activity (Antràs, 2021; Cigna et al., 2022; Kataryniuk et al., 2021): (i) the reduction of cost advantages in developing countries that have been more actively involved in GVCs (such as China); (ii) the lesser prominence of these cost advantages in the current context of increasing automation and robotisation caused by Industry 4.0 (Stapleton, 2019); (iii) the increasing protectionist trends of some advanced countries such as the USA in response to the loss of their industrial base and employment as a consequence of relocations to low-cost countries (Gopalakrishnan et al., 2022). The COVID-19 pandemic has further accentuated this slowdown trend in two ways (Brenton et al., 2022; Javorcik, 2020). In the early moments of the pandemic, the high specialisation of China in some components of high-tech manufacturing resulted in the interruption of their supply (Baldwin & Tomiura, 2020; Ramani et al., 2022). Those components are crucial for the automotive, electronics and telecommunications industries. Later, when the recovery was progressing in Europe and the USA, it was difficult for providers to respond to the intense increase in world demand for some of the productions most linked to GVCs. Because of a shortage of containers, a drastic increase in freight charges between summer 2020 and fall 2021 has also negatively impacted

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[1] The term 'slowbalisation' was coined by Dutch trend-watcher Adjiedj Bakas in 2015 and popularised by *The* Economist (2019). Since then, its use has spread worldwide to signify the diminishing of globalisation as we know it.

GVCs (Attinasi et al., 2021). These difficulties have revealed the risk of dependence on a few providers located in foreign countries and have reinforced the arguments in favour of strategic autonomy, especially in the productions linked to new technologies (Montanino et al., 2022; Van den Abeele, 2021). This would undoubtedly affect the configuration of GVCs.

Recently, two new interconnected elements, servicification and digitalisation, are emerging and impacting the reconfiguration of GVCs (Zhan, 2021). The former can be defined as the increasing content of services in manufacturing firms or industries (Lodefalk, 2013), whereas the latter is the adoption or increase in the use of digital or computer technology by a firm, industry, or country (OECD, 2017). Regarding servicification, previous literature has shown the rise in the share of foreign services embodied in manufacturing exports, which has been found to have a competitiveness-enhancing effect (Blázquez et al., 2020; Díaz-Mora et al., 2018; National Board of Trade, 2016). This happens because certain types of services (transportation, quality control, communication services, etc.) are essential for firms involved in GVCs (Elms & Low, 2013) and because these firms incorporate services to add value and differentiate their production and thus improve their competitiveness (Giovannetti et al., 2010; Mirodout & Cadestin, 2017). As Cernat (2021) points out, "to continue being competitive, companies can no longer be just a manufacturing company or a service company".

Concerning digitalisation, as Baldwin (2016) points out, digital technologies are making it easier for people located in one country to offer services that previously required face-to-face interaction with people in another country, enabling digital services to be traded internationally. Hence, this geographic separation of labour and labour services via digital technologies opens the door to a new channel of globalisation (Baldwin, 2019). This new channel of globalisation and of interdependence between countries would take place through growing international flows of intermediate digital services. Since a widely accepted indicator of GVC participation is the share of foreign value added embodied in gross exports, which is labelled as backward GVC participation (Amador & Cabral, 2016; Cigna et al., 2022; Koopman et al., 2014; OECD, 2022), we propose to use the share of foreign digital services to capture a particular, digitally driven type of backward participation in GVCs. An increase of this share would indicate that a new channel for GVC participation is emerging. Also van der Marel (2020a) suggests that globalisation is not in decline, but it is undergoing a remarkable shift by becoming more immaterial, non-physical and digital. This new type of globalisation is illustrated by the fast growth of these non-physical flows in recent years, although their global share is still relatively small. In this way, servicification and digitalisation are converging, and the term of digital servicification has emerged to describe the increase in the use of digital services by manufacturing firms or industries.[2]

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[2] This term has begun to be used recently in business literature to describe the provision of digital services embedded in physical products and the shift from a product-centric to a service-centric business model (Tronvoll et al., 2020; Vendrell-Herrero et al., 2018), and is a topic with a wide scope for future research (Gebauer et al., 2021).

This topic has hardly been explored. As far as we know, ADB (2021) is the only previous study that analyses the growing role of digital sectors in international trade and participation in GVCs. ADB's analysis is performed for 43 economies (27 EU countries and 16 other major countries) using value added trade data from two different sources: the World Input–Output Database (WIOD) for the period 2000–2014 and the Multi-Regional Input–Output (MRIO) tables for the period 2017–2019. It shows that digital sectors have been expanding their GVC participation since the beginning of the new century and are doing so at a faster rate than non-digital sectors, mainly in the post-Great Recession period. The prominent role of digital sectors as suppliers of value added to other sectors in foreign countries evidences the increasing efforts of non-digital firms to incorporate digital technologies into their products and processes. The levels and growth rates have been very different by regions. Digital sectors in the EU have the highest level and growth of GVC participation, followed by those in advanced Asian economies. These trends could be particularly beneficial for developing countries, since, as noted in Rodrik (2018), services such as IT services are highly tradable and, like manufacturing, are technologically dynamic, offering possibilities for (unconditional) convergence in productivity with advanced countries. Thus, their increasing use in GVCs could partially offset the disadvantage in terms of productivity and employment growth that developing countries (with the exception of some Asian countries) are experiencing as manufacturing becomes increasingly technology- and skill-intensive and no longer absorbs capabilities from low-skilled employment.

To shed light on this issue, this paper analyses the entity and evolution of the incorporation (direct and indirect) of foreign inputs from digital services into the production of goods and services for export. Moreover, we study the way cross-border flows of these intermediate digital services are altering the dimension and configuration of GVCs, new intercountry relationships and even new country actors in this new channel of globalisation. For this analysis, we use data from the recently updated OECD Inter-Country Input–Output Database (ICIO 2021 edition) for the period 1995–2018 and Social Network Analysis techniques. To the best of our knowledge, this is the first paper that addresses this topic using these techniques, which are particularly suitable for capturing the structure and the dynamics of complex intercountry relationships. Here, it is important to include a wider sample of countries to better map the global network of digital services linked to GVCs and its change over time. The 2021 edition of the TiVA database offers information for 66 economies including all OECD, EU and G20 countries, and a selection of East and Southeast Asian economies and South American countries (see Supplementary Table A.1 in the Statistical Appendix); that is, it includes a larger number of countries, particularly, more developing economies, and for a longer period (23 years, from 1995 to 2018) than ADB (2021). The inclusion of a larger number of economies in the analysis is particularly important as most of the studies related to participation in GVCs where innovation and technology diffusion play an important role are focused on large emerging economies, such as China and India, while others in Africa, Asia and Latin America are rarely included in the analyses (Lema et al., 2021).
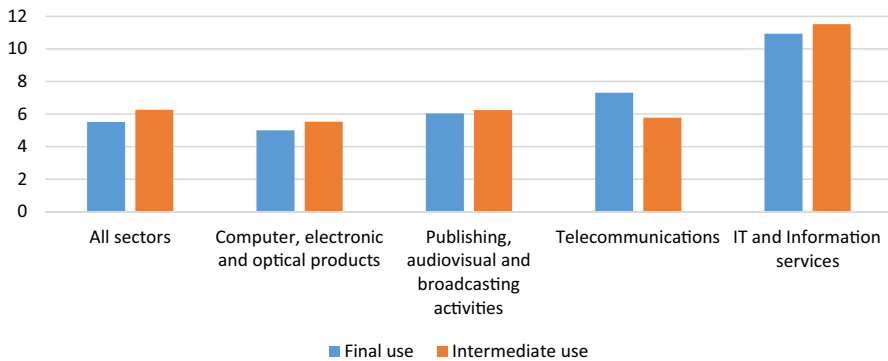
Fig. 1 Evolution of world gross exports according to intermediate or final uses. (Annual cumulative rate in % between 1995 and 2018). Source: Authors' calculation based on OECD-WTO TiVA Database 2021 edition

The article is structured as follows. After this introduction, Sect. 2 offers several indicators for inferring whether a new type of globalisation and GVC participation related to digital services is coming. Section 3 presents the analysis of the characteristics of the network of digital services inputs flows between countries and the leading countries from the perspectives of both user and supplier. Final considerations are reported in Sect. 4 see Supplementary Table A.2 in the Statistical Appendix.

2 A new type of globalisation and GVC participation?

Before analysing whether a new type of globalisation and GVC participation related to digital services is emerging, we need to define which sectors are digital services. Digital sectors are defined as goods and services with the main function of generating, processing, or storing digitised data (ADB, 2021). According to this definition, four ISIC Rev. 4 industries from the most recent update of the TiVA database are identified as digital: one manufacturing industry, manufacture of computer, electronic and optical equipment (Division 26), and three services industries, publishing, audio-visual and broadcasting activities (Divisions 58–60), telecommunications (Division 61), and IT services and information services (Divisions 62–63)[3].

Among these four digital industries, the world gross exports of IT services and information services have been the most dynamic, showing an annual cumulative rate of around 12 percent between 1995 and 2018 (Fig. 1). This rate is quite similar for final and intermediate gross exports. This growth implies that the value of gross exports of these specific digital services has multiplied by 11 in this period, whereas

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[3] This definition of digital sectors is similar to those described in previous works such as van der Marel (2020b) and ADB (2021). According to the International Standard Industrial Classification of All Economic Activities (ISIC), Rev. 4, Division 62 includes computer programming, computer consultancy and other information technology and computer service activities, and Division 63 includes data processing, hosting and related activities, web portals and other information service activities.
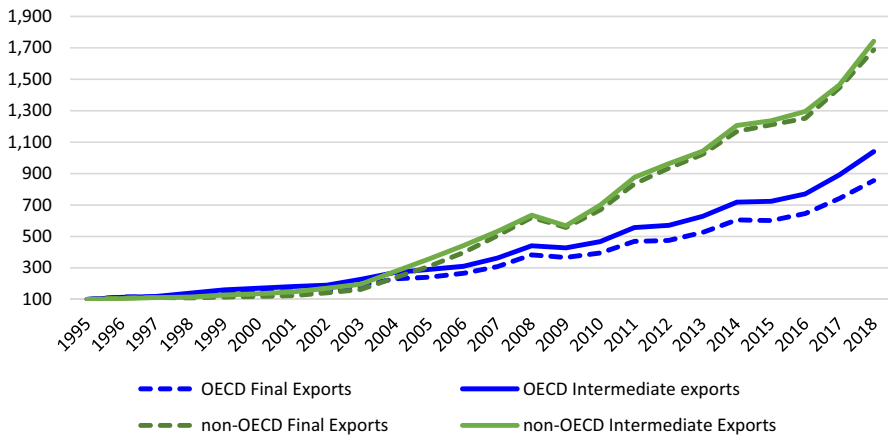
Fig. 2 Evolution of OECD and non-OECD gross exports of IT and Information services according to intermediate or final uses (Index numbers, 1995 = 100). Source: Authors' calculation based on OECD-WTO TiVA Database 2021 edition

total exports and other digital industries have multiplied by around four. From now on, we focus our analysis on IT and information services as their fast growth would illustrate the existence of a new type of globalisation linked to digital services.

The solid dynamism of IT and Information services in world exports is repeated in both OECD countries and non-OECD countries (Fig. 2).[4] The value of non-OECD intermediate exports of IT and information services multiplied by 17 between 1995 and 2018. This growth rate is clearly higher than that of OECD countries, where the value multiplied by 10. Although exports of IT and information services from OECD countries are still higher than those from non-OECD countries, the higher growth rate of the latter has shortened the gap between them since 1995. Whereas in 1995 the intermediate exports of IT and information services from OECD countries were triple those from non-OECD countries, in 2018 the former was only 60% higher than the latter. The strongest growth of intermediate exports is common in both groups of countries, although it is very slight for non-OECD countries and much sharper for OECD countries.

The strong growth of intermediate gross exports of IT and information services (IT services henceforth) is reflected in their increasing participation in GVCs. We measure this participation using data from OECD Inter-Country Input–Output (ICIO) tables on foreign value added content of gross exports as a share of those gross exports. As explained in the introduction, this indicator estimates the contribution to the total value of exports originating from foreign suppliers, which is considered a measure of backward linkages in analyses of GVCs. This foreign value added share can be broken down according to the value added source industry. We follow

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[4] Here and in the following figures, OECD and non-OECD export data are calculated as the sum of exports of the different OECD and non-OECD countries, respectively.
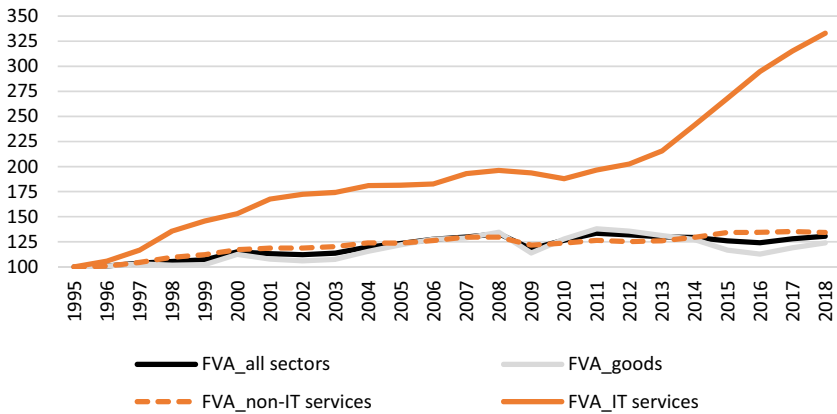
Fig. 3 Evolution of world's backward GVC participation, by value added source industry (Index numbers, 1995 = 100). Note: Backward GVC participation is measured as the share of foreign value added (FVA) embodied in gross exports. FVA is broken down according to the value added source industry. Source: Authors' calculation based on OECD-WTO TiVA Database 2021 edition

the guide to the OECD trade in value added indicators, 2021 edition, to calculate these different shares which would capture different channels of countries' backward participation in GVCs (OECD, 2022).

The evolution of the share of foreign value added embodied in world gross exports broken down by value added source industry is shown in Fig. 3. We observe that the share of foreign value added from IT services more than tripled between 1995 and 2018. However, the rise of the share of total foreign value added was much less pronounced in the same period, barely 31 percent.[5] The increase of the share of foreign value added from non-IT services was very close (34 percent). A weaker rise is observed for the share of foreign value added from goods industries (24 percent). These different evolutions imply that backward GVC participation of countries is increasingly based on the importing of intermediate IT services for their exports. That is, backward GVC participation is becoming more digitally dependent.

The different evolution of the content of foreign IT services takes place in both subperiods: before and after the Great Recession. Between 1995 and 2007, the share of the foreign value added content of world gross exports increased by around 30 percent, with a similar rise if foreign value added came from goods or from non-IT services, and a rise that doubled if the foreign value added came from IT services. After the Great Recession, mainly since 2012, the content of foreign IT services showed a sharp rise that contrasts with the stagnation of the share of total foreign value added embodied in word gross exports, which has been interpreted as a

[5] According to previous literature, there is strong evidence that foreign services are increasingly embodied as intermediate inputs in GVCs (Mirodout and Cadestin, 2017; National Board of Trade, 2016). Moreover, when different types of services are broken down, foreign business services (which comprise digital services such as computer and related activities and other business activities) show a higher rise in their share in gross manufacturing exports (Díaz-Mora et al., 2018).
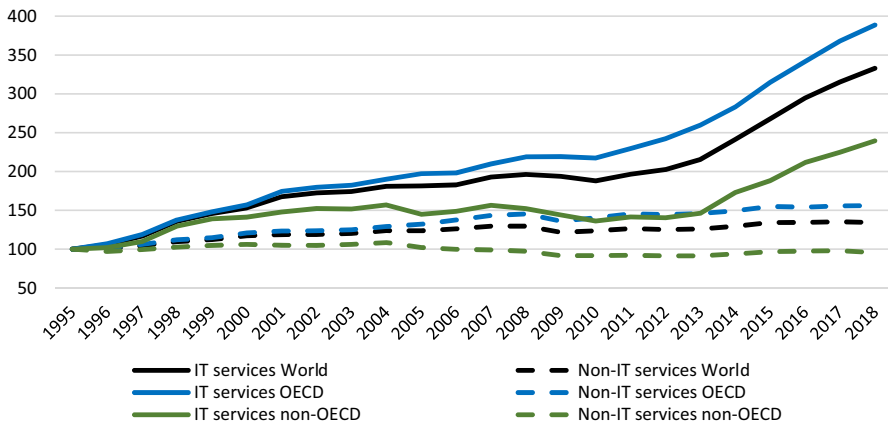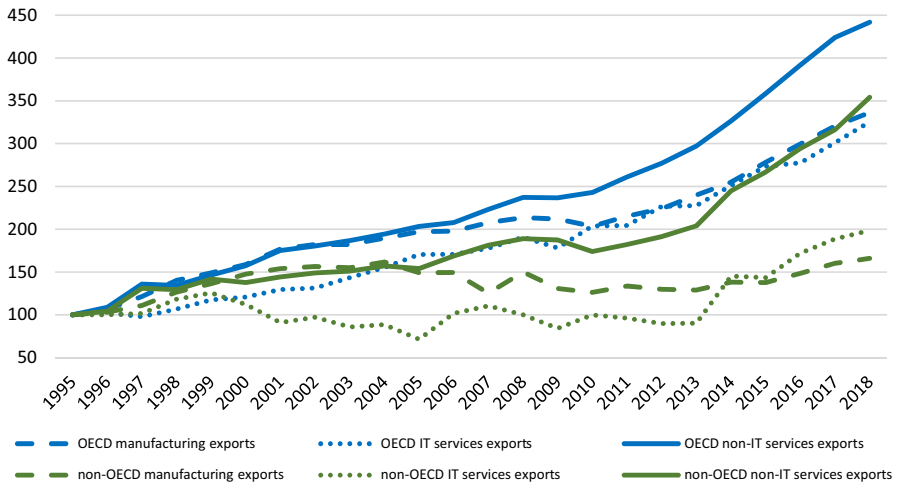
Fig. 4 Evolution of the share of foreign IT services and non-IT services value added embodied in gross exports, by exporting area (Index numbers, 1995 = 100). Source: Authors' calculation based on OECD-WTO TiVA Database 2021 edition

slowdown of globalisation. Hence, the emergence of a new channel, via IT services, for GVC participation is particularly evident after the financial crisis.

This expansion of foreign IT services content in the 1995–2018 period is common for both OECD and non-OECD countries, although has been greater for the first one (Fig. 4). Hence, we find evidence of a new type of globalisation and GVC participation related to digital services for both country groups. Although both share an increasing trend, the content of foreign IT services is higher in OECD countries' exports than in non-OECD countries' exports in 2018. In Fig. 4 we also observed how the strong increase of the content of foreign IT services does not occur in non-IT services. That is, the different evolutions of the share of embodied foreign IT and non-IT services are repeated for both country groups.

We go one step further and analyse whether the IT services content is expanding in both manufacturing and services exports. In the latter, we distinguish between IT services and other services (excluding IT services) exports. We find that all three sectors are increasing their dependence on foreign digital services and in all cases the increase is stronger in OECD than in non-OECD countries (Fig. 5). World manufacturing exports have almost tripled their share of embodied IT services, providing evidence of digital servicification, which is even stronger in OECD countries. IT services exports have multiplied their dependency on foreign inputs from the same industry by 2.7, a growth rate again higher for OECD countries. The highest growth rates are found for the share of IT services embodied in other services exports, and this happens for both OECD and non-OECD countries. We highlight that, after the Great Recession, the dependence on foreign IT services by non-OECDE services exports has increased the same than that by OECD countries. These figures show that both manufacturing and services are contributing to this new type of GVC participation linked to IT services. Again, IT services shares in exports are relatively small, particularly in non-OECD countries: in 2018, around 0.6 percent in both manufacturing and other than IT services in OECD exports and below that

Fig. 5 Evolution of the share of foreign IT services value added embodied in gross exports, by exporting sector and area (Index numbers, 1995 = 100). Source: Authors' calculation based on OECD-WTO TiVA Database 2021 edition

figure in non-OECD countries, with the share for services exports always higher. These shares are notably higher in IT services exports: almost 4 percent in OECD countries and around 2.3 percent in non-OECD countries. That is, as van der Marel (2020b) found, services are generally more digital-intense than goods, with IT services the most dependent on foreign intra-industry inputs.

3 Mapping the digital intermediate services network

3.1 Structural properties of the network

To further analyse this increased role of IT services in GVCs, we will study the evolution of the global network in which these embodied IT services are participating in recent decades, from 1995 to 2018. The analysis will be approached both from a structural point of view and by identifying the economies that have played a leading role in these dynamics.

To do this, we will apply Social Network Analysis (SNA) methodology based on mathematical graph theory. SNA is a widely used methodology for analysing the relationships, both direct and indirect, that occur in the trading network. It emphasises the relationships between countries in the network and the structure of the system itself rather than the attributes of the countries in the network (De Benedictis and Tajoli, 2011). This methodology is complementary to other empirical approaches such as gravity models (Anderson & van Wincoop, 2003), which analyse the impact on bilateral trade transactions of countries' attributes, and although they consider network dependencies by way of multilateral resilience, they are not able to

reflect the complexity and heterogeneity of the network (De Benedectis and Tajoli, 2011; De Benedictis & Taglioni, 2011; Dueñas & Fagiolo, 2013; Ward et al., 2013).

In the SNA, what is analysed is how countries are inserted into the complex network of global trade relations, which involve individuals and companies located in different parts of the world (Arribas et al., 2009). It is not enough to consider economies in isolation or to consider only their bilateral relations (Smith & Gorgoni, 2019). These bilateral relationships, although very relevant in the interaction of countries, explain only a small fraction of the interactions that take place in the network, as the evolution of one country can influence others with which that country does not even have a direct relationship (Abeysinghe & Forbes, 2005). The nature of the relationships between countries, the patterns of connections that link countries around the world, the dynamics of the network, its evolution and the formation of specially connected groups depend on structural factors of the network in addition to dyadic relationships. It is this analysis of the global trading system as a complex interdependent network that has allowed us to make the recent methodological advances in the study of networks (Kali & Reyes, 2007) that we will apply in this study to the digital intermediate services trading network. An overview of the literature can be found in Garlaschelli and Loffredo (2005), Kali and Reyes (2007), Bhattacharya et al. (2008), Fagiolo et al. (2010) and De Benedictis and Tajoli (2011). More recent applications are Maeng et al. (2012), De Benedictis et al. (2014), Amador and Cabral (2017), Abbate et al. (2018), Cepeda-López et al. (2019), Blázquez et al. (2020) and Herman (2022). We start from an inflow/outflow matrix for flows of embodied IT services for each source–destination country pair. To build the network, the nodes are the 66 countries included in the TiVA 2021 database, and the edges represent those bilateral flows of embodied IT services. Specifically, the latter is a bilateral indicator that quantifies the IT services value added that comes from a country source to be incorporated in gross exports of a destination country, expressed as share of those gross exports. In this sense, this indicator captures the flows from both backward (flows from the source country or inflows) and forward linkage perspective (flows to the destination country or outflows).[6]

We adopt a number of precautions in the analysis. We compare the networks at different moments; therefore, we eliminate trend effects and obtain adimensional weights that are automatically deflated, allowing for consistent comparisons across different years and country types (Squartini et al., 2011). Additionally, to consider only relevant flows between countries of IT services value added embodied in

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[6] These two perspectives do not correspond exactly to the widely used measures of backward and forward GVC participation suggested by Koopman et al. (2014). These authors propose an index of a country's GVC participation as a sum of two shares: the share of foreign value added that the country embodied in its gross exports over those gross exports (backward GVC participation) and the share of domestic value added that the country incorporated into third countries exports (forward GVC participation) over the country gross exports. Those are two different indicators. As explained above, to construct the inflow/outflow network, we also adopt a backward and forward perspective depending on whether we look at the origin or the destination country, but the indicator is the same: value added from a source country to be incorporated into gross exports of a destination country as a share of those gross exports. That is, our indicator would correspond with the common backward GVC participation indicator, which here is constructed bilaterally and analysed from both a source and a destination country perspective.
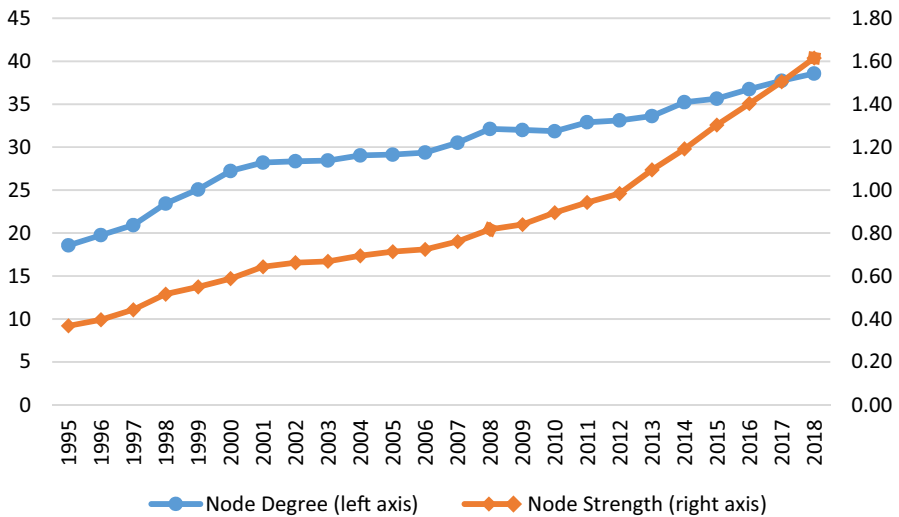
Fig. 6 Evolution of node degree and node strength statistics (1995–2008). Source: Authors' calculation based on OECD-WTO TiVA Database 2021 edition

exports, a threshold is set. Specifically, we include only links larger than 0.005%, that is, flows of digital services value added to be incorporated in the destination country exports as a percentage of these exports larger than 0.005%. By imposing this threshold, we cover around 95 percent of the total IT services value added exchanged between the countries included in the sample over the period analysed.[7]

We analyse the dynamics of the network and its main characteristics by exploring its topological measures and paths (Wasserman & Faust, 1995, Newman, 2010 and Jackson, 2010). We start by studying the structural properties of the whole network and its evolution: the number of partners and the interaction intensity of countries (its density); the volume of embodied digital services value added exchanged; the shape of the network; the heterogeneity of the role of its members; and whether or not and to what extent there exist relatively dense subnetworks and thus cohesive subgroups within the whole network.

We start the analysis by studying the evolution of aggregate statistics of the binary network. From this perspective, we consider only the existence or non-existence of IT services flows between countries. The first aspect to be noted is that the network is becoming progressively more extensive over time, as the number of flows (arcs) within the network has risen steadily: it has more than doubled. That is also reflected in the increase of the density, which has passed from 14.5% of possible relationships realized in 1995 to 29.2% in 2018. Accordingly,

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[7] Alternative threshold percentages (slightly lower or higher) were tested, and the main features of the networks remained qualitatively unchanged for similar values. For an extensive discussion on the imposition of thresholds in network analysis, see Kali and Reyes (2007). Other papers that have recently set different thresholds in their empirical work are De Bennedictis et al. (2014) and Amador and Cabral (2017).

Table 1 Evolution of IT services network topological measures

Binary network	1995	2005	2018
Arcs (#)	622	976	1,292
Density	0.145	0.221	0.292
Average node degree (average number of arcs)	18.48	29.134	38.567
Indegree/Outdegree (Average)	*9.24*	*14.567*	*19.284*
Degree centralization	0.84	0.80	0.85
Indegree centralization	*0.27*	*0.30*	*0.36*
Outdegree centralization	*0.87*	*0.79*	*0.72*
Diameter (average path length)	6 (2.172)	5 (1.851)	4 (1.765)
Closeness centrality (Average)	0.332	0.517	0.522
Betweenness centrality (Average)	0.008	0.007	0.009
Clustering coefficient	0.515	0.579	0.603
Weighted network	1995	2005	2018
Average node strength	0.374	0.714	1.615
Instrength/Outstrength (Average)	0.187	0.357	0.807
Random walk betweenness centrality	0.151	0.134	0.153
Weighted clustering coefficient	0.007	0.010	0.016
Modularity	0.218	0.206	0.193

Source: Authors' calculation based on OECD-WTO TiVA Database 2021 edition

the average number of partners that each country has (*average node degree*) increased substantially, from 18.5 to 38.6 (see Fig. 6). When the weighted network is considered, we observe that the average intensity of these flows (*average node strength*) has increased even more strongly than the number of connections, from 0.37 to 1.61 (see Fig. 6). Therefore, not only has the average number of flows of digital services value added embodied in countries' exports more than doubled, but the intensity of those flows (as a percentage of exports) has, on average, almost multiplied by five in the period of analysis.

As shown in Fig. 6, and in line with the results of Sect. 2, two clearly differentiated periods can be distinguished in the evolution of network connectivity and intensity. The first period covers the period between 1995 and the years prior to the financial crisis, when both node degree and node strength grow vigorously until the early years of the century and then slow down until the mid-2000s. Subsequently, first strength and then degree embark on an uninterrupted upward path until 2018, even more vigorously than in the previous period, with an acceleration in 2012. Based on these results, we initially focused our network analysis on four years of the period: 1995, 2005, 2012 and 2018. However, we noted that the differences found between the 2012 and 2018 results were very small, which would suggest that any change in the network as a result of the effects of the crisis had already been incorporated in 2012. We have therefore restricted the analysis on network characteristics to the years 1995, 2005 and 2018, as these three stages represent the most significant changes in the network during the period of study. Those significant structural changes detected in the network are summarised in Table 1 and Fig. 7.

Together with an even evolution over time of the connectivity and the intensity of relationships within the network, we detected that the correlation between countries' degrees and strengths is very high, although decreasing over time: 0.89 in 1995; 0.88 in 2005; and 0.73 in 2018. Therefore, in general, the most connected countries are also the ones which trade more intensely within the network. Similarly, the correlation between the countries' *indegrees* and *instrengths* is very high in the three years of analysis: 0.79, 0.79 and 0.76, respectively. Therefore, countries that have a more diversified supplier base are also the ones that incorporate a higher proportion of foreign digital intermediate services into their exports.

We also observe in Table 1 that the network has increasingly become more integrated since the distances within the network have shortened. The diameter of the network (i.e., the longest of the all geodesics in the network, meaning the longest of the shortest paths between two countries) and the average path length (i.e., the number of steps on average it takes to get from one country to another) have decreased, and the *average closeness centrality* (i.e., the inverse of the sum of distances from each node to all other nodes) has increased significantly, meaning that a greater number of links seems to imply more direct links. Also, the *average clustering coefficient* is showing a higher integration of the network, showing a higher percentage of countries' neighbours that are also connected between them in 2018 than in 1995 (60.3% in comparison with 51.5%). Finally, the *average betweenness* of countries (i.e., the degree to which a country lies on the shortest path between two other countries, becoming an intermediary (Fisher & Vega-Redondo, 2006; Newman, 2005)) has slightly increased over the years. Therefore, there are a growing number of countries with a prominent role in the network as intermediaries. When we consider the equivalent weighted measures of the latter two indicators, the overall trends are confirmed.

Additionally, we have found that countries which are more connected within the network are also closer and have a more prominent role as intermediaries. The correlation between these scores has remained stable or even increased over time, especially in the case of closeness.

From a structural point of view, one of the main features of this network is that, although we observe that the whole network has a centre-periphery structure in terms of connectivity, with a *degree centralisation index* (i.e., the extent to which a network is centred on one or several important nodes) higher than 0.8 in the four years, the results are markedly different when we distinguish the two directions of the network: the *outdegree centralisation* is much greater than the *indegree centralisation* (see Table 1 and Fig. 7). That means that the supplying leaders provide those intermediate IT services to most of the other countries, while the rest of the economies provide them to few markets or are mere destination countries. The lower *indegree centralisation* would indicate that the number of providers from whom destination countries incorporate intermediate digital services are relatively more similar among countries.

Notwithstanding this overall result, we note that, unlike for the *out-centralisation*, an increasing *in-centralisation* of the network over time is observed. There are two main reasons for these opposite paths. Firstly, although some countries —important suppliers themselves—have significantly diversified their suppliers' basis, buying

foreign digital intermediate services from an increasing number of countries, there are still many countries with a very small number of providers (some of them have fewer than 10 providers). In parallel, small countries had many providers in 1995, and several of them have continued to increase their number of suppliers over time. Therefore, the variability in the number of providers of countries has increased over the period. Secondly, over time, many economies have increased their destinations' basis, thus widening the centre of the supply network. In spite of this, the variability between the connections of source countries has remained very high.

When the weighted network is considered, we observe similar trends. While in 1995 and 2005, the variability of countries' *outstrengths* was much higher than the variability of their *instrengths*, in 2018, the variability of both flows was similar. The reason is that, in 1995 and 2005, the main supplying countries recorded percentages much higher than the rest of the economies, while in 2008 these differences shrank.

These results contrast with those obtained in Blázquez et al. (2020) for foreign services value added embodied in countries' manufacturing exports (as a share of those manufacturing exports) and those obtained in Blázquez et al. (2021) for business services embodied in manufacturing, where much lower centralisation indices were obtained, describing the network a regular shape, and where the differences between both directions of the networks were not so marked.

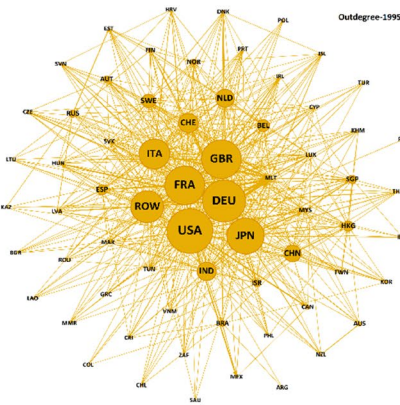### 3.2 Partnerships *In* and *Out*

Moving our analysis towards the **specific countries' characteristics**, the study of source countries' *outdegree*s and *outstrengths* scores will allow us to identify the economies which contribute more to the percentage of added value of intermediate digital service embodied in their customers' exports. Conversely, the study of origin countries' *indegrees* and *instrengths* scores will permit us to identify the most dependent economies of those digital services within the network. Additionally, we calculated the *hub* and *authorities* scores to identify the most relevant providers (*hubs*), meaning those who supply to the main demanding countries (*authorities*), and the major users (*authorities*), meaning those who are pointed to by the main suppliers (*hubs*) (Kleinberg, 1999).
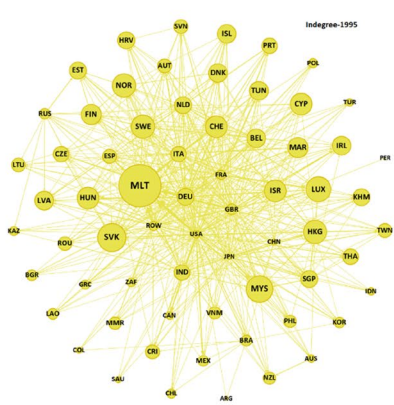
3.2.1 Source countries

We observe in Fig. 7 and Table 2 that, in **1995**, the countries with the highest outdegrees were the USA, Germany, the UK, France, Japan and Italy, with more than 40 customers. They were also the economies with the highest outstrengths. Therefore, those countries were the big providers within the network, the ones with the widest customers base and the largest contributors in terms
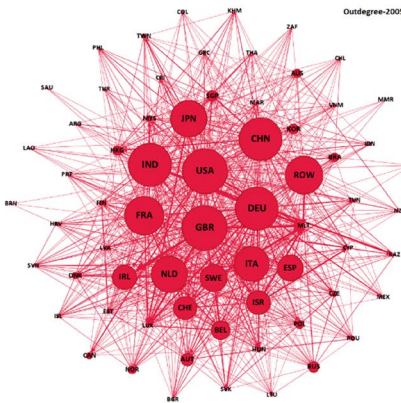
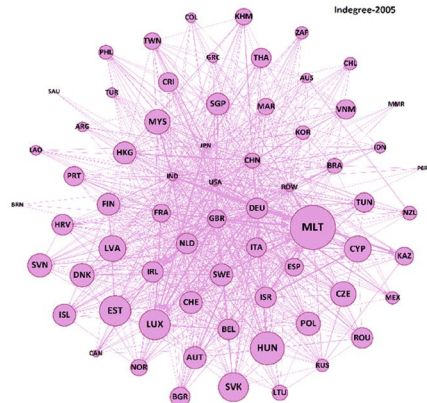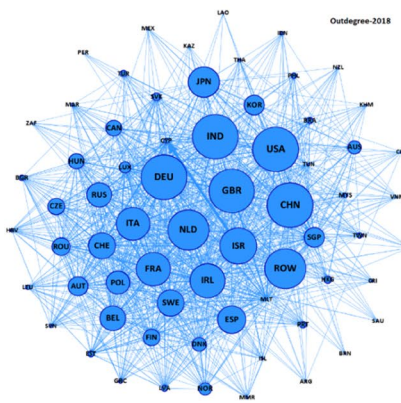**Table 2** Top countries by *indegree*, *outdegree*, outstrenght and instrenght scores, 1995, 2005 and 2018

	outdegree-1995		outdegree-2005		outdegree-2018		indegree-1995		indegree-2005		indegree-2018	
1	USA	65	GBR	66	DEU	66	MLT	27	MLT	34	MLT	43
2	DEU	61	USA	66	CHN	66	SVK	18	HUN	26	CYP	42
3	GBR	56	DEU	63	IND	66	MYS	17	EST	24	LUX	40
4	FRA	56	CHN	63	USA	66	LUX	16	LUX	24	FIN	33
5	JPN	52	IND	63	GBR	65	SWE	15	SVK	23	SGP	32
6	ITA	43	FRA	57	NLD	59	HKG	15	LVA	21	HUN	30
7	CHE	27	NLD	53	ISR	53	NOR	15	CYP	21	DNK	30
8	IND	26	JPN	53	IRL	50	CHE	14	MYS	20	POL	30
9	NLD	25	ITA	51	FRA	49	ISR	14	CZE	20	EST	29
10	CHN	23	SWE	39	ITA	48	HUN	14	POL	19	IRL	29
11	SWE	18	ESP	37	JPN	44	CYP	14	DNK	19	NLD	29
12	BEL	16	IRL	35	ESP	40	FIN	13	SVN	19	ROU	29
13	HKG	13	ISR	34	SWE	38	MAR	13	SWE	18	DEU	28
14	ESP	13	CHE	33	CHE	38	BEL	12	CHE	18	SWE	28
15	SGP	10	BEL	26	BEL	36	DNK	12	AUT	18	AUT	28
16	RUS	9	AUT	17	RUS	35	TUN	12	SGP	18	BEL	26
17	ISR	8	SGP	14	POL	33	ISL	12	HKG	18	SVN	26
18	NOR	7	RUS	14	SGP	28	IRL	12	FIN	18	LVA	26
19	AUT	7	KOR	13	KOR	28	LVA	12	ISL	18	CZE	25
20	BRA	7	HKG	12	AUT	27	DEU	11	DEU	17	CHE	25

	outstrength-1995		outstrength-2005		outstrength-2018		instrength-1995		instrenght-2005		indestrength-2018	
1	USA	2.142	GBR	3.231	USA	7.029	MLT	1.860	MLT	2.430	MLT	7.312
2	DEU	1.930	DEU	2.740	DEU	5.611	MYS	0.529	LUX	1.405	CYP	6.281
3	FRA	1.240	USA	2.486	IND	4.840	LUX	0.443	IRL	0.936	LUX	4.503
4	GBR	1.175	IND	2.393	ISR	4.173	CHE	0.378	HUN	0.767	SGP	2.479
5	JPN	1.042	CHN	1.338	GBR	3.875	HUN	0.347	CHE	0.739	IRL	1.688
6	ITA	0.791	JPN	1.319	CHN	3.825	SVK	0.347	CYP	0.717	FIN	1.401
7	IND	0.348	FRA	1.270	FRA	2.096	HKG	0.314	MYS	0.654	EST	1.233
8	CHE	0.310	ITA	1.168	NLD	1.854	IRL	0.307	BEL	0.547	HUN	1.230
9	CHN	0.309	NLD	0.981	IRL	1.841	BEL	0.299	KAZ	0.531	CHE	1.151
10	ESP	0.306	SWE	0.905	RUS	1.569	ISR	0.290	FIN	0.527	SWE	1.105
11	SWE	0.249	ISR	0.808	SWE	1.377	LVA	0.288	NLD	0.519	DNK	1.094
12	NLD	0.235	ESP	0.602	ITA	1.315	TUN	0.263	HKG	0.517	AUT	1.050
13	BEL	0.190	BEL	0.433	ESP	1.277	MAR	0.232	DNK	0.495	ROU	1.039
14	RUS	0.180	IRL	0.415	POL	1.048	NLD	0.229	EST	0.487	POL	0.999
15	SGP	0.158	CHE	0.389	AUT	0.973	EST	0.228	ISR	0.480	BEL	0.991
16	ISR	0.150	AUT	0.284	CHE	0.965	PRT	0.224	CZE	0.441	LVA	0.984
17	AUT	0.138	RUS	0.248	BEL	0.881	SWE	0.223	SWE	0.429	NLD	0.967
18	HKG	0.131	SGP	0.181	JPN	0.810	CZE	0.206	SVK	0.424	SVK	0.933
19	FIN	0.091	NOR	0.172	ROU	0.499	SGP	0.206	SVN	0.405	DEU	0.911
20	AUS	0.071	BRA	0.161	EST	0.483	FIN	0.201	POL	0.396	CZE	0.872

Source: Authors' calculation based on OECD-WTO TiVA Database 2021 edition

of percentage of added value of digital services embodied in users' exports. In **2005**, the most remarkable novelty was the entry of China and India in the top five in both the ranking of countries with the largest number of customers and the ranking of countries with the largest shares. Another noteworthy move was Ireland's entry into the middle part of the ranking, moving up from zero in 1995 to 37 clients in 2005. It is also important to note that all countries significantly increased their number of providers since 1995 as we saw in Sect. 2. Finally, in **2018**, the USA, China, Germany, India, and the UK remained in the top positions as the best-connected suppliers, all of them with more than 60 clients, and were also the main contributors in terms of share. In this last period of analysis, also notable is the ascendancy of Israel and Ireland, which ranked in the top 10 in outdegrees, with Israel climbing to fourth in the outstrength ranking. Finally, the strong entries of Poland and, to a lesser degree, Romania and Estonia are also noteworthy. On the other hand, we observe that France, Japan and Sweden

lost customers in this period. However, while France and Sweden still managed to increase their shares slightly, Japan reduced its share.

Regarding the role of countries as hubs (i.e., those which supply to the main demanding countries (Kleinberg, 1999)), we observe perfect correlation between the outdegrees and the hub scores in the three years (see Table A.3 in the Statistical Appendix). Additionally, when we correlate the outstrengths and the weighted hubs score, we also observe a very high correlation for 1995 and 2005 (0.97 and 0.98, respectively), and a high but smaller correlation in 2018 (0.78). Therefore, those countries are not only connected and intense suppliers, but they also provide digital service to the most important destination countries (authorities).

In this analysis, it is also interesting to identify the countries that have increased their contribution the most over time. Table A.4 in the Statistical Appendix gives this multiplication factor for the period between 1995 and 2018.

We can see that Korea and Greece are the countries with the highest multiplication factors, greater than 30. Israel also shows a very high factor (27.9). Prominent contributors in 2018 like India and China, some Eastern European countries like the Czech Republic and Slovakia, and Denmark have multiplied their contributions of intermediate digital services to their customers' exports by more than 10. The rest of the Nordic countries, Russia, the Netherlands, Austria, Slovenia, Canada, and Taiwan have multiplied their contributions by five. We observe that while some countries increased their contribution mainly in the decade between 1995 and 2005, like Korea, Israel, India, China, Denmark, the Netherlands and Sweden, other economies contributed to a greater extent in the period between 2005 and 2018. Such is the case of Slovakia, Russia, Finland and Turkey. The rest of the countries maintained a steady increase in their contribution throughout the period of analysis. Therefore, as van der Marel (2020a) pointed out, the growth of these contributions has not been exclusive to advanced countries but has also been driven by upper middle-income countries with digital advantages and a large manufacturing base or an employment population that is relatively young.

3.2.2 Destination countries

Regarding the most dependent countries, Table 2 shows that, in **1995**, the economies with a greater number of suppliers (indegrees) and a higher share of foreign IT services value added embodied in their gross exports (instrengths) were small countries with different levels of development (Malta, Slovakia, Malaysia, Luxembourg, Sweden, Hong-Kong, Norway, Switzerland, Israel, Hungary and Cyprus), with more than 15 providers. In **2005**, all these main buyers had increased their number of providers, but the most significant developments in both rankings involved the rise of other Eastern European countries such as Estonia, Latvia, the Czech Republic, Poland and Slovenia, and also Cyprus. The rise of Ireland, Kazakhstan, Finland and Denmark are other noteworthy movements in the instrengths ranking, meaning that these countries, although still with a very modest import base, are increasing their dependence on imports of foreign IT services. The small size of some of

these economies or their intense participation in global value chains make all of them notably dependent on intermediate digital services. Finally, in **2018**, the main changes were the continued rise of Cyprus, Finland, Poland and Latvia, but also the progress of other countries like Singapore, Austria and Romania. It is also important to note that, during this period, not only these main providers but also some of the main suppliers steadily widened their buying basis. This is the case of Ireland, the Netherlands and Germany. It is remarkable that those countries had both a wide basis of providers and customers in 2018, although their number of clients was still much higher than their number of providers.

Concerning the authorities' scores (i.e., users who are pointed to by many hub suppliers) as shown for hubs, we also observe a correlation between the indegrees and the authorities' scores that are higher than 0.9 all three years. And the same result is found when we correlate the instrengths and the weighted authorities scores. Hence, the more dependent countries, both in terms of connections and intensity, buy their intermediate digital services mainly from the hubs of the network. Hence, the more dependent countries buy their intermediate digital services mainly from the hubs of the network (see Supplementary Table A.3 in the Statistical Appendix).

3.2.3 Contributions and Dependencies: A Sectorial Approach

Now that we know how the structure of the network of intermediate digital services has evolved over time and which countries are the main players within it, it is of interest to identify which sectors are the most decisive in shaping its structure and the relevance of the economies within the network. And this, once again, must be done from the point of view of both the countries of origin and the countries-sectors of destination.

Figure 8 and Supplementary Table A.5 in the Statistical Appendix show the main contributing countries and the main dependent countries-sectors in 2018. We can see that the IT-services themselves and the rest of the services are driving the network. Specifically, the countries that incorporate a higher share of foreign intermediate IT services (more than 5%) in their exports of IT services (Divisions 62–63) are Cyprus, Luxembourg, Singapore, Austria, Switzerland, Malta, Poland, Malaysia, Slovakia, Vietnam and Germany. Another highly dependent sector are Divisions 58–60: publishing, audio-visual, and broadcasting activities. Some of the most dependent countries (with shares higher than 2%) are again the group of the four smallest countries (Cyprus, Luxembourg, Singapore, and Malta) and Slovakia and Poland, but there are also Sweden, Greece, Kazakhstan, Denmark and Hungary. Telecommunications (Division 61) is also an important destination. In this sector, the most dependent countries (share higher than 2%) are the group of the four smallest countries and Vietnam, Malaysia, Kazakhstan, Estonia, Poland, Denmark and New Zealand. Financial and insurance activities (Division 64), public administration, education, health and other personal services (Divisions 84–98) are other highly dependent industries. In Division 64, apart from the smallest countries, there are also Latvia, Hungary, Finland, Poland, Ireland and Romania, and in Division 84–98, the most dependent are the four smallest countries. In addition to these services sectors, an important dependent manufacturing division is, as might be expected, 26:

computer, electronic and optical products. For this industry, the most dependent destination countries are (with shares greater than 1.4%) Croatia, Finland, Luxembourg, Estonia, Hungary, the Netherlands, Bulgaria, Singapore and Romania.

It is interesting to note that, in comparison with 1995 (see Supplementary Table A.5 in the Statistical Appendix), the most dependent sectors of IT services are the same, and in some sectors, the most dependent economies are almost the same. However, there are some exceptions. For example, for sector 26, there were more dependent countries in 1995 than in 2018 among the top 150 countries-sectors, and the main players were completely different, while in sector 61, there were fewer dependent countries among the top 150 in 1995 than in 2018, but the most dependent countries also changed drastically.

Moving now to the source countries of digital intermediate services to be incorporated into the respective export sectors, on the right side of Fig. 8, we can observe that the economies that contribute the most with their supply of intermediate IT services to total exports in sector 62 of the other countries (with percentage higher than 5%) are Israel, the USA, China, Germany, the UK, Ireland, France, Russia, Spain, Switzerland and the Netherlands. The same countries (except Switzerland) are the main suppliers for Divisions 58–60 (with shares higher than 2%). The same countries (except Switzerland and Spain) for industry 61 and also (except Switzerland, Spain Russia and the Netherlands) for Division 64 (with shares higher than 2.7%). For Division 84, only four of those countries, Germany, Israel, the UK and China, are among the top 150 suppliers (with percentages higher than 3%). Finally, the main suppliers for Division 26 are the USA, Germany, the UK and India (with shares higher than 4%).

From the point of view of the source countries, when we compare with 1995 (see Supplementary Table A.5 in the Statistical Appendix), we observe how in most contributing sectors, the main countries remain and others have entered (like China in most sectors and India in some of them, for example, 26). We can also observe the decreasing role of some countries like Japan in all the aforementioned divisions.

3.3 Country grouping

Once we have analysed the main structural changes in the network over the period of analysis and identified its main actors, it is also interesting to study whether particularly connected sub-networks have been established over time. One possibility is to divide the network into modules (also called groups, clusters or communities). These communities are groups of countries densely connected to each other but with sparse connections with countries in the rest of the communities. To do this, we will apply the ***modularity*** measure. Modularity is the fraction of the edges that are within the given groups minus the expected fraction if edges were distributed at random. The value of the modularity for weighted and directed graphs lies in the range of $[-1,1]$. It is positive if the number of edges within groups exceeds the number expected based on chance (Blondel et al., 2008; Lambiotte et al., 2008).

As we can observe in Table 1 and Fig. 9, the scores are positive and, hence, some different groups can be detected in all three years. **In 1995**, four different
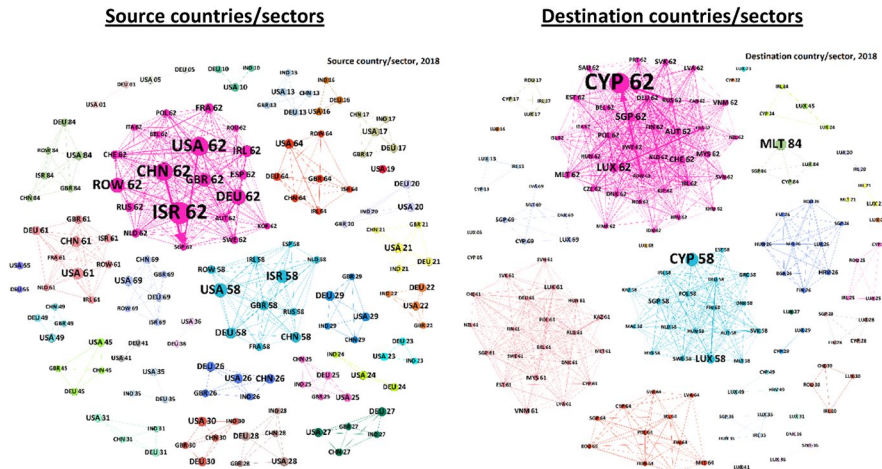
Fig. 8 Figure 8 150 main contributing countries and dependent countries/sectors, 2018. Note: The size of the nodes (countries) and the thickness of the edges are related to the flows of digital services embodied in exports as percentage of those exports (*outstrengths and instrengths*). Source: Authors' calculation based on OECD-WTO TiVA Database 2021 edition and using the program package *Gephi*

communities can be identified: **two European communities,** one led by Germany and the other led by the UK-France axis; one **American community**, led by the USA**;** and one **Asian-Pacific group**, with Japan as the big player. In the European community led by Germany, there were Switzerland and Austria, southern countries like Italy, Spain, Portugal and Greece, Eastern European countries like Hungary, Romania, Slovakia, the Czech Republic, Croatia, Poland, Bulgaria and Malta, Baltic countries like Latvia and Slovenia, and there was also Myanmar, particularly connected with Italy. In the other European cluster, together with France and the UK, there were the BENELUX countries, the Nordic countries, Ireland (very much dependent on the UK), some Baltic countries like Lithuania and Estonia, Russia, some Mediterranean countries in the orbit of France, like Tunisia and Morocco, South Africa, which depended heavily on the UK, and Kazakhstan, with important links with Russia. The American community includes the three NAFTA countries, South American countries like Brazil, Costa Rica, Chile, Colombia, Peru and Argentina, and also Israel, Cyprus and Turkey, very connected among them and with the USA. Finally, in an Asian-Pacific group, there was Japan together with China and India, and with several other Asian countries like Hong Kong, Malaysia, Singapore, Taiwan, Thailand, Korea, the Philippines, Vietnam, Indonesia and Cambodia, other countries in the South Pacific like Australia and New Zealand, and Saudi Arabia, who was a client exclusively of the USA, Japan, and India.

In **2005**, a big move was detected; thus, only three communities were identified: a large **European community**, a huge **American-Asian-Pacific cluster** and a small **group led by India**. Most of the European economies are included in the

first European community, except for Nordic and Baltic countries, Greece, Malta, Cyprus and Russia. Again, Tunisia and Morocco, Lao, South Africa and Myanmar belonged to this community. Now, Turkey belongs to the European community, as its main providers are now Germany, France, the UK and Italy. There was also Brunei because of its links with the Netherlands and the UK. The second cluster shows the other important movement happened in this decade: the approach of America and Asia, which goes hand in hand with the USA and China. The group consists of the USA, China, Japan, and then the same other countries that formed those two groups except for Indonesia and Saudi Arabia. Those two countries, together with the European countries not included in the first community, Israel and Kazakhstan, composed the third group, led by India. The reasons for the emergence of this network are that some of those countries like Finland, Norway, Denmark, Malta, Cyprus, Israel, Kazakhstan, Indonesia and Saudi Arabia developed a strong dependent relationship with India in the decade between 1995 and 2005, and, at the same time, some of those countries are very much connected to each other, like Sweden with the rest of the Nordic and some of the Baltic countries, Russia with Kazakhstan and Latvia and Greece and Israel with Cyprus and Malta.

Finally, in **2018**, four different communities were detected: one **large European community**, one **tiny European subgroup**, an even larger **American-Asian-Pacific cluster** and a small group around the **Russia-Israel axis**. In the first European group, we observe a very interesting transition. Some European countries remained together in the same community as in 2005: Germany, the UK, Italy, Spain, Portugal, Austria and most of the Eastern European countries, like the Czech Republic, Slovakia, Hungary, Poland, Croatia and Slovenia. Tunisia also remained in this group. These countries are joined now with the Nordic countries, Malta, and Estonia. Now, however, there is a second group that consists only of four European countries: France, Belgium, Switzerland, and Luxembourg, based on the dependence of Luxembourg on France, Belgium and Switzerland. The other big movement between 2005 and 2018 was the incorporation into the large American-Asian community of India and countries with strong links with her, like Indonesia and Saudi Arabia, other European countries like the Netherlands, Ireland, Iceland, Latvia and Lithuania, and other non-European economies which used to belong to the European communities, like Morocco, Lao, South Africa, Myanmar, Turkey and Brunei. Finally, the fourth group is formed by European countries like Romania, Bulgaria, Greece and Cyprus, and by Russia, Kazakhstan and Israel. In this group, the heaviest dependent relationship is between Cyprus, Israel and Russia. Some of the rest of countries have close connections among themselves and others also with Russia.

Therefore, in recent decades, we have witnessed the formation of two major axes, one mainly European and the other mainly Asian-Pacific-American, with smaller groups emerging through the creation of particularly close alliances between them. However, we have also observed that these alliances are dynamic and vary considerably over time, so they cannot be considered fully consolidated or not subject to unpredictable swings.

Modularity-1995   **Modularity-2005**
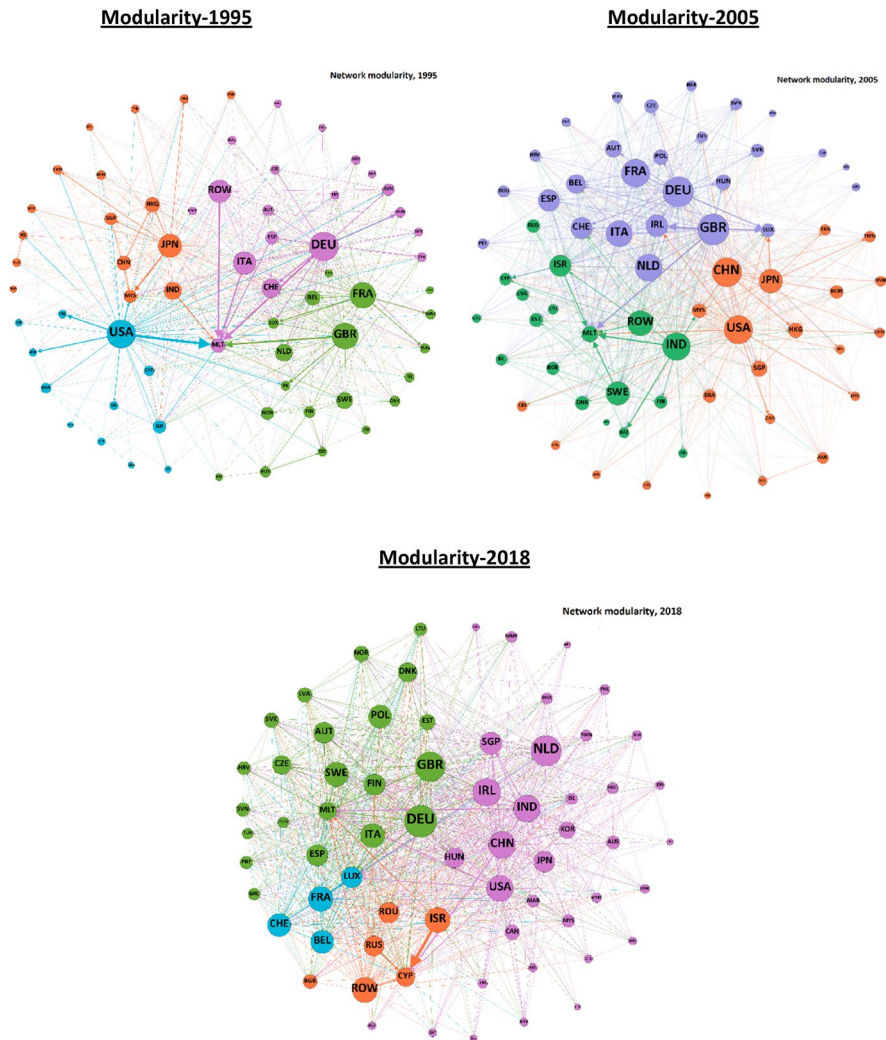
Modularity-2018

Fig. 9 Network Modularity. Note: The size of the nodes (countries) is related to their total number of links (*all node degrees*). The links between countries reflect the flows of digital services embodied in exports as percentage of those exports. Source: Authors' calculation based on OECD-WTO TiVA Database 2021 edition and using the program package Gephi

4 Conclusions

In this paper, we contribute to the literature on the recent evolution of GVC trade and on the debate about a deglobalisation or slowbalisation trend associated with a slowdown in GVC activity. We show that, as some authors have pointed out, a certain slowdown in GVC activity has been occurring since the Great Recession. This is illustrated by the stagnation of the share of total foreign valued added embodied

in world gross exports, which is a widely accepted indicator of GVC backward participation. This stagnation, even decline, is taking place only for the share of foreign value added from goods industries. However, the foreign IT services content of exports has shown a sharp rise, mainly since 2012, which suggests that GVC backward participation is becoming more digitally dependent. Hence, our paper adds empirical evidence on the manner in which globalisation is changing and how a new channel of GVC participation is gaining prominence hand in hand with digitalisation. This new digital channel of GVC participation is not exclusive to the most advanced countries.

Using Social Network Analysis techniques, we map the network of these increasing cross-border digital services flows linked to GVCs and analyse its structure and the dynamics of complex intercountry relationships from the point of view of both source and destination countries. Our analysis shows that there is a growing group of relevant IT services providers, while the network of destination countries is more diversified, although it is becoming more centralised as more and more countries are widening their export dependence on IT services and diversifying their providers. The more dependent countries are small economies but also countries deeply involved in GVCs, such as Eastern European countries. In parallel, the centre of the suppliers' network is also widening, and new countries such as China, India, Israel and Ireland have increased their role as global providers of intermediate IT services over time, sharing the leadership positions with the USA, Germany, the UK, France and the Netherlands. At the other extreme, other developed countries, such as Japan, are becoming less important in this supplier network. These dynamics have gradually drawn a map with an increasingly reduced number of large blocs of countries that are particularly connected to each other in different great trade clusters. Each of the blocs includes countries of very different levels of development and size, which means that the digital network is expanding and giving prominence to advanced economies but also to middle-income economies.

Hence, our analysis shows how cross-border flows of intermediate IT services are altering the dimension and configuration of GVCs by emerging new intercountry relationships and even new country actors in this new digital channel of countries' backward participation in GVCs. In this scenario of globalisation, the digital sectors and the economies specialised in those digital sectors are increasing their relevance in the world economy, altering the way in which economies compete with each other.

Finally, to increase this new channel of countries' GVC participation via intermediate digital services, it is important to identify policy actions that could facilitate it. We highlight three of them. One is to devote efforts to improve and extend countries' digital infrastructures such as information, communication and technology (ICT) infrastructure, cloud computing infrastructure and data infrastructure. Another would be the improvement of digital skills of countries' workforce. Because digital infrastructures and digital skills are often underdeveloped in less advanced countries, those policy actions are key for those countries. Moreover, they have to be nationwide to ensure that most territories and workers within the countries have the opportunity to become involved in the digital channel of GVC participation. Additionally, policy makers must detect specific barriers to international trade of digital

inputs and try to remove them, particularly in developing countries, which generally have more restrictive policies regarding digital trade, according to Ferracane et al. (2018). This is particularly important for small and medium firms since trade barriers impact them disproportionately compared with large firms. In turn, these policy measures would help to make the network of IT suppliers less centred, with more countries actively contributing to its expansion and intensification, thus benefiting from GVC participation through digitalisation.

Data availability The raw/processed data required to reproduce the above findings are available to download from https://www.oecd.org/sti/ind/measuring-trade-in-value-added.htm.

Declarations

Conflict of interest On behalf of all authors, the corresponding authors states that there is no confict of interest.

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