Participation and positioning of Greek sectors in Global Value Chains and evolution of their trade patterns

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Abstract

The aim of this working paper is to map Greece's participation in Global Value Chains (GVCs) at the country and sector level. We utilise and extend established empirical methodologies on the quantification of participation in GVCs to develop a novel dataset of relevant indicators at the country and sector level. To this end, we estimate standard input-output based measures of GVC participation by applying a production-based decomposition of value-added flows and offer a comprehensive mapping of the different dimensions of GVC integration at the country and sector levels. Furthermore, we apply key elements of network analysis to construct the GVC network from the bilateral GVC value-added flows, and asses the position and relative importance of Greece's sectors within them in terms of connectivity and centrality. We use this to map the participation of Greece in GVCs in terms of both forward and backward production linkages and identify its most GVC-intense sectors.

Keywords: Global Value Chains (GVCs); Input-Output Analysis; network analysis; GVC participation;

JEL Codes: F14: Empirical Studies of Trade

L16: Industrial Organization and Macroeconomics: Industrial Structure and Structural Change; Industrial Price Indices

O14: Industrialization; Manufacturing and Service Industries; Choice of Technology

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1. Introduction

The global economy has undergone significant transformations in recent decades, characterized by the proliferation of intricate networks of production, distribution, and consumption that span multiple countries and sectors. National and organizational boundaries no longer bound firms' production activities; instead, outsourcing and offshoring can disperse their activities to different locations based on efficiency and cost-minimization criteria networks (Ambos et al., 2021; Antràs, 2020), creating complex production networks (Xiao et al., 2017). These networks, characterized by the spatial and temporal disintegration of production have been known as Global Value Chains (GVCs), shaping international trade patterns, industrial dynamics and -ultimately- economic growth and development (World Bank, 2020).

The emergence of GVCs gives rise to a finer international division of labour and activities across countries and sectors, resulting in significant opportunities for greater specialization gains. Therefore, each country is challenged to identify and better understand its structural weaknesses and perceived comparative advantages and leverage them to design strategies to secure maximum gains from GVC participation (World Bank, 2020). Given the importance of this new production paradigm, assessing the extent of the integration of a country within GVCs has become key to drawing comparisons with other similar economies, identifying strategic opportunities and shaping its industrial policy. Issues such as the positioning and participation patterns in GVCs have been extensively considered for the comparative assessment of national economic performance (Gereffi, 1999).

In this context, this study sets to provide a comprehensive mapping of Greece's involvement in GVCs at the sector level, both in terms of its participation and of its positioning along the value chain curve using elements from both input-output (Leontief, 1936; Miller & Blair, 2009) and network analysis (Wasserman & Faust, 1994). To this end, we utilize the latest set of OECD's inter-country input-output tables (ICIOTs), covering 45 NACE rev.2 sectors for 76 countries from 1995 to 2020 (OECD, 2023). We apply the production-based decomposition of (Wang et al., 2022) to obtain the bilateral value-added flows that concern the GVC components of international trade. From this, we estimate measures of GVC participation for all 45 NACE rev.2 Greek sectors, and measures of their positioning along the value in terms of their relative *upstreamness* and *downstreamness* (Antràs & Chor, 2018). Furthermore, we apply key elements of network analysis to construct the *GVC network* (Amador & Cabral, 2017; Cingolani et al., 2017) from the bilateral GVC value-added flows, and asses the position and relative importance of Greece's sectors within them in terms of connectivity and centrality.

This approach is highly complementary, as standard input-output GVC metrics capture the intensity of involvement in GVCs, while network metrics are more nuanced in capturing the positioning within GVCs (Amador et al., 2015; Tsekeris, 2017). This complementarity enables the study of Greece's integration in GVCs from multiple points of view and maps its evolution over a long time period containing multiple structural shifts and shocks in the world economy (from the dot-com bubble of the 2000's to the 2008 crisis and the covid-19 pandemic). The resulting trends and patterns are useful in many facets of public debate around Greece's industrial policy.

The remainder of the paper is structured as follows: Section 2 presents the theoretical background of the paper, which is structured around two main theoretical pillars: i) GVC participation measurement, ii) specific channels of GVC participation gains. Section 3 presents the methodology of the paper, discussing the development of different variables. In Section 4, we present and discuss the and results, and finally, Section 5 summarizes the main findings and concludes the paper.

2. Theoretical background

At this point, it is well understood that modern goods and services are no longer "*made in*" a certain part of the world but are the end product of a vast and disaggregated production networks that spans many economic sectors and countries; recent sources report that it now roughly accounts for about one half of all trade activities (Antràs, 2020; Antràs & Chor, 2022). Accordingly, the production activities of firms and countries are embedded in these networks, known as Global Value Chains (GVCs), where each stage has its own requirements in production inputs and adds its own value (Antràs & Chor, 2022). The unequal appropriation of value-added (VA) across all the different globally engaged actors reflects specialization patterns of higher or lower VA components of the GVC, affecting the quality and technology content of its exports.

In this context, it is important to account for the specific implications that relate to the measurement of GVC participation and positioning, as traditional gross export-based measures become unreliable for the complex production transactions at the sector and country level (Borin & Mancini, 2023; Johnson & Noguera, 2012; Koopman et al., 2014). In response to this problem, detailed inter-country input-output tables (ICIOTs), and corresponding factor-based decomposition methods were developed to measure the VA content of international trade. The estimation of such metrics broadly relies on identifying the proportion of VA that is embodied in the exported goods and services that are then used as intermediate inputs for production abroad. From the early work of (Hummels et al., 2001) where gross exports were divided between domestically produced items and imported inputs

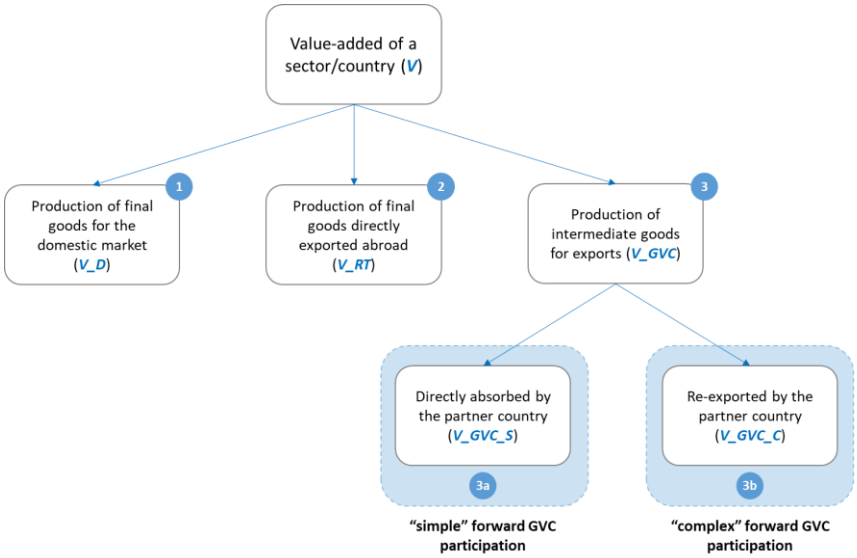
embedded in exports, to Johnson and Noguera (2012) value-added-export (VAX) ratio. More recent studies (Koopman et al., 2014; Borin and Mancini, 2023) formalized measures of aggregate GVC trade and specific types of GVC participation: i) backward participation in GVCs, which covers the VA originating from upstream suppliers abroad, and ii) forward participation, which contains the VA sent to downstream partners abroad. Further elaborating on this duality of GVC participation types, (Wang et al., 2022) developed a framework that further split backward and forward participation in two distinct sub-types: simple participation, that refers to production sharing involving exports/imports of intermediates that cross borders only once, and complex activities, which include exports/imports of intermediates across multiple borders and production stages.

The advancements highlighted above paved the way for empirical studies to understand and measure GVC participation at the country and sector level. At the same time, another empirical research stream stemming from the study of networks took an interest in the underlying production structure of GVCs, as they essentially describe the value added of all activities that are directly and indirectly involved in the production of final products. Indeed, the bidirectional flows of intermediate products and their VA content that are the focus of the I-O based GVC studies constitute a production network between all involved sectors and countries across time. The appeal of using network analysis in the study of such relations comes from their ability to consider the whole structure of interactions and to explore the entire pattern of connections, instead of focusing on the isolated characteristics of each individual element (Amador and Cabral, 2015).

Therefore, the fundamental elements of network analysis can be applied to study its structure and unveil trade patterns that other empirical metrics may miss; it offers a powerful analytical tool to study collective interactions among heterogeneous agents in complex systems with limited resources, acting at all (global, regional and national) geographical scales and participating in diverse organizational structures (Boccaletti et al., 2014; Varela et al., 2015). Over the last decade, numerous studies have employed network analysis to visualise, map, and conceptualize GVC activities [among others, (Amador et al., 2018; Cerina et al., 2015; Criscuolo & Timmis, 2018; Ferrantino & Taglioni, 2014; Ferrarini, 2013; Tsekeris, 2017; Xiao et al., 2017; Zhou et al., 2016)]. We embed our approach in this broader framework and focus on multiple types of GVC networks, as described in the following section.

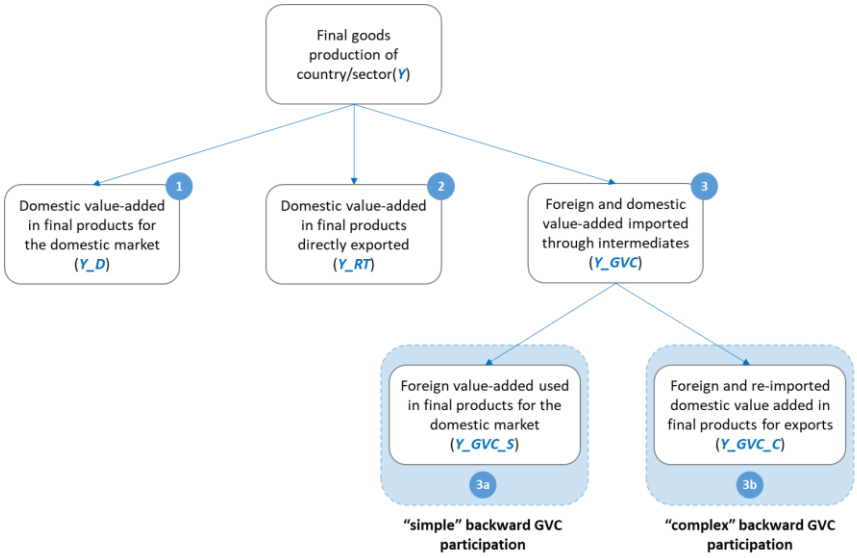
3. Methodology

The methodological procedure of this paper utilizes the latest edition (2023) of OECD's inter-country input-output tables[10] (ICIOTs), covering 45 NACE rev.2 sectors for 76 countries from 1995 to 2020. At the first stage, we estimate the intermediate and final trade flows from the ICIOTs. Then, we apply the production-based decomposition of (Wang et al., 2022) to obtain the bilateral value-added flow matrices. Ath this point, these are used to obtain both the GVC components of international trade for forward (panel a) and backward (panel b) participation (briefly illustrated in Figure 1)[1] and to construct the directed and weighted GVC networks (overall GVC networks, simple GVC trade networks, and complex GVC trade networks, based on the number of times the value-added crosses national borders).



(a)

[1] For more information on the decomposition framework and the analytical procedures, see Wang et al. (2022)



(b)

Figure 3.1. Disaggregation of value-added (a) and final goods (b) production of a country-sector in terms of its forward (a) and backward (b) simple and complex participation in GVCs.

Source: Authors' elaboration on Wang et al. (2022).

The flowchart with the main methodological stages is shown in Figure 3.2 below. Drawing on this framework, we estimate measures of GVC participation for all 45 NACE rev.2 Greek sectors. This enables the study of Greece's integration in GVCs from multiple points of view and maps its evolution over a period containing multiple structural shifts and shocks in the world economy (from the dot-com bubble of the early 2000's to the 2008 crisis and lastly, the COVID-19 pandemic). The key insights, patterns and trends that emerge from the analysis are of significant value for evidence-based policymaking and can help refine the country's national industrial strategy in the future.

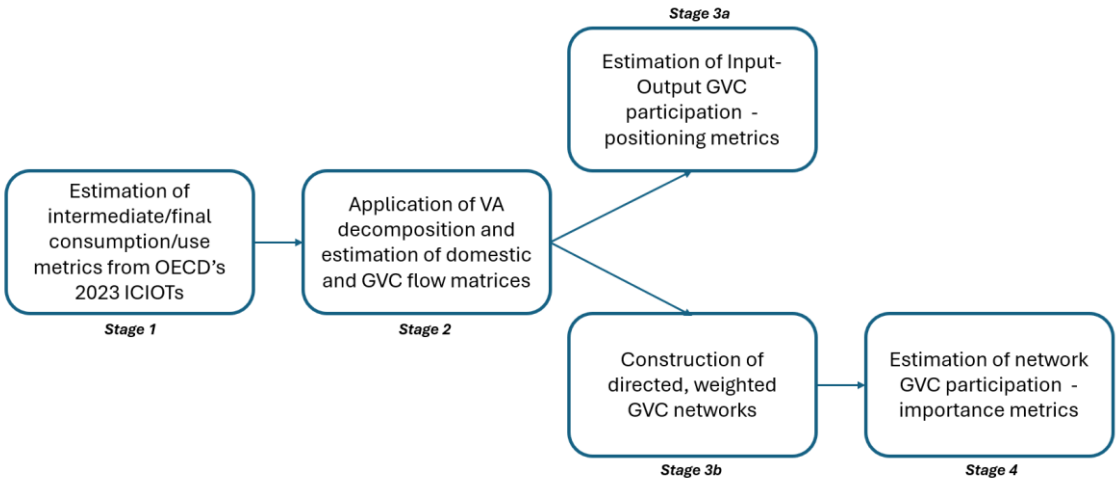


Figure 3.2. flowchart of the main methodological stages.

4. Results and discussion

4.1 Results from input-output analysis

The first set of results concerns the mapping of Greece's aggregate participation in GVCs in comparison with the rest of the EU-27 in Figure 1. It is evident the country's participation pattern across the examined period mirrors that of the EU, for both forward (panel a) and backward (panel b) participation, but at a lower magnitude. Three distinct patterns emerge: i) a trend of GVC deepening from 1995 to 2008, a period that is widely acknowledged as the "era of GVCs" (World Bank, 2020) , ii) a steep decline in participation in 2009-2010, caused by the financial crisis and its corresponding shocks in the global supply network, and iii) a resurgence in GVC activities in a new steady state from approximately 2012 onwards.

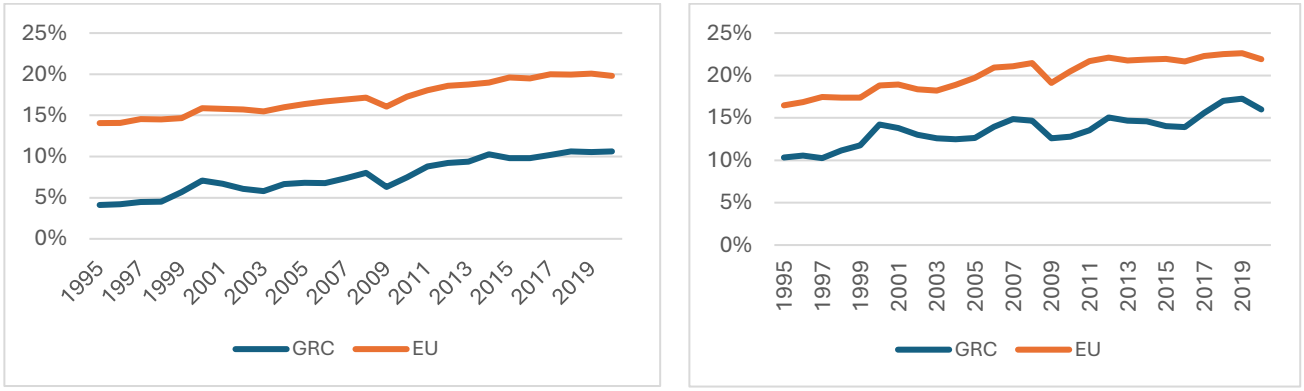


Figure 4.1. Forward (a) and backward GVC participation for Greece (GRC) and the EU from 1995 to 2020.

Source: Author's elaboration based on calculations on OECD's 2023 ICIOTs
Notes: Cutoff value of 10^{-2} used.

Delving deeper into the intricacies of GVC participation, we separate simple from complex GVC participation activities in Figure 3. It is evident that simple and complex forward participation patterns between Greece and the EU are quite similar, but again at a different scale (EU participation is nearly twice as high as Greece). In terms of backward participation, we observe that simple backward participation for Greece and the EU is approximately at the same level for the examined period, while complex backward participation for the EU is significantly higher (but again the trend is similar). In both cases, complex GVC activities appear to be the most affected by the financial crisis effects in 2009.

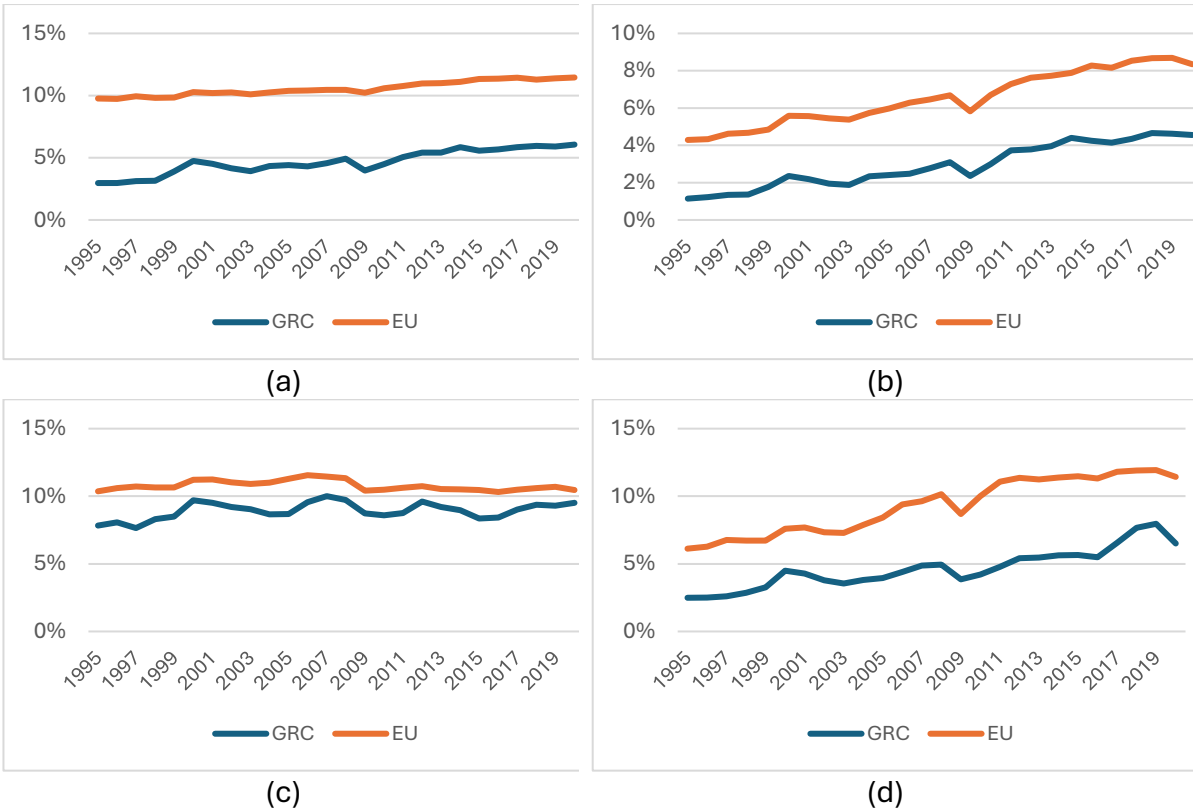


Figure 4.2. Timeline of Greece's simple forward (a), complex forward (b), and simple backward (c) and complex backward (d) GVC participation from 1995 to 2020.

Source: Author's elaboration based on calculations on OECD's 2023 ICIOTs
Notes: Cutoff value of 10^{-2} used.

But GVC participation is not merely a matter of national economies; it is deeply influenced by sectoral specialization and industrial dynamics. Following this, we disaggregate the national GVC performance into the participation patterns of each of Greece's 45 NACE Rev-2 sector that OECD's ICIOTs cover. In Table 1, we present the top performing sectors in terms of forward GVC participation in three cut-off points, 1995 (beginning), 2010 (middle) and 2020 (end). The top performing sectors retain their status across the examined period, and include basic metals (C24), water transports (H50), mining supporting activities (B09), and mining of metals and mines and quarries (B07_08). Other notable sectors include petrochemicals (C19), chemicals (C20), and rubbers and plastic products (C22). It is worth noting that the latter three manufacturing sectors have significantly increased their participation since 1995, with petrochemicals (C19) in particular emerging as a top exporter of Greek intermediates from 2010 onwards.

Table 4.1. Top performing sectors (NACE Rev. 2 classification) in forward GVC participation (%) for 1995, 2010, and 2020.

1995	2010	2020
C24 (36.9%)	H50 (59.9%)	C24 (84.7%)
C19 (21.6%)	C24 (50.1%)	B07_08 (73.2%)
H50 (21.4%)	B09 (31.7%)	B09 (61.4%)
B07_08 (18.4%)	B07_08 (30.1%)	H50 (56.9%)
C20 (17.9%)	H52 (28.5%)	H51 (42.5%)
C22 (16.6%)	H51 (28.1%)	C19 (42.3%)
A03 (16.2%)	C20 (24.0%)	C20 (34.4%)
B09 (16.0%)	C19 (23.4%)	H52 (34.4%)
H52 (10.9%)	C22 (21.5%)	B05_06 (31.8%)
C27 (9.84%)	A03 (17.6%)	C22 (31.0%)

Source: Author's elaboration based on calculations on OECD's 2023 ICIOTs
Notes: Cutoff value of 10^{-2} used.

To contrast sectoral embedment in forward and backward production linkages, we plot the two GVC participation components for 2020 in Figure 4, where the diagonal is useful in the identification of sector orientation, i.e., to which direction of GVC participation is more inclined. It is evident from the graph that electronics and opticals (C26), machinery and equipment (C28), electrical equipment (C27), fabricated metals (C25), and petroleum products (C19) are heavily orientated towards backward participation, while sectors such as water transports (H50), rubbers and plastics (C22), non-metallic minerals (C23), and software and computer services (J62-J63) present a more balanced orientation pattern in their GVC participation activities. It should be noted that, most of the Greek manufacturing sectors are in fact backward orientated, a finding that implies a high dependency in critical inputs from abroad. On the other hand, mining, and quarrying activities (B sectors) along with basic metals (C24) dominate the landscape of forward participation, as we already discussed in Table 1.

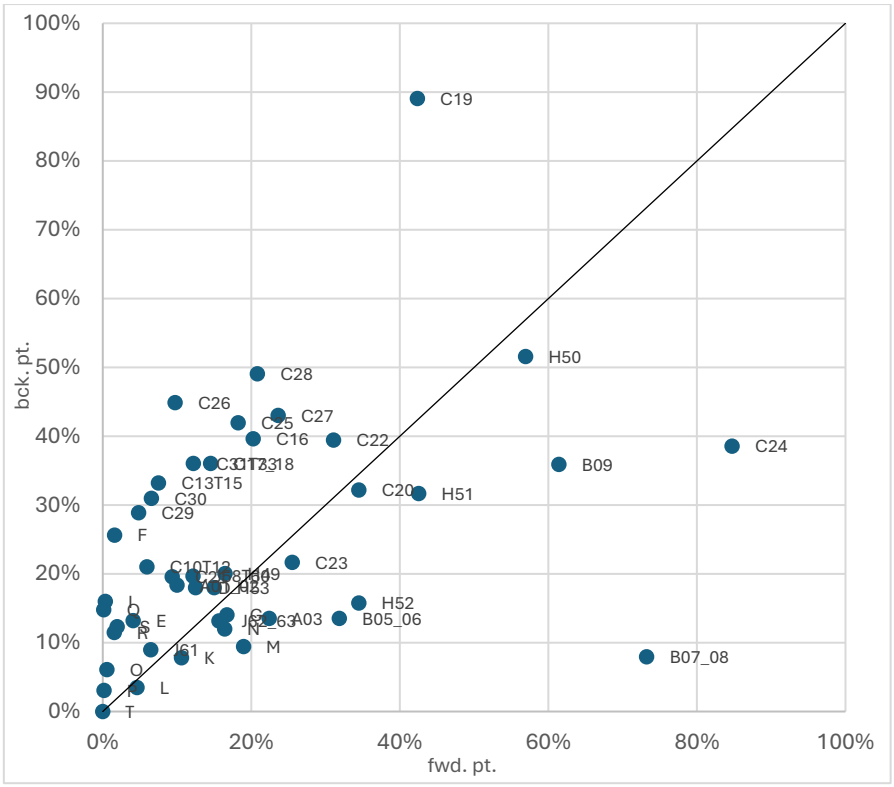


Figure 4.3. A snapshot of backward and forward GVC participation of Greek sectors (NACE Rev.2 classification) in 2020
Source: Author's elaboration based on calculations on OECD's 2023 ICIOTs
Notes: Cutoff value of 10^{-2} used.

At the last stage of this section of analysis, we divide the available time frame in three periods: 1995-2007 which covers a period of global GVC deepening and national economic prosperity for Greece, 2008-2014, a period characterized by the economic crisis, the disruptions caused in global supply chains and the stagnation/recovery years that followed shortly after, and 2015-2020, which entailed the new steady-state in global markets and value chain trade right before the COVID-19 pandemic. For each period, we estimate the relative changes of forward GVC participation in industrial sectors (including mining, quarrying, manufacturing, energy and water supply, and waste treatment), in Table 2. Different leading sectors emerge in each time frame, with interesting observation being the significant increase of forward participation in mining and quarrying activities (B sectors) emerging in the 2015-2020 period, which signals a new emerging dimension to the country's GVC participation patterns, that is its role as supplier of raw materials and energy inputs.

Table 4.2. Top performing industrial sectors (NACE Rev. 2 classification) in forward GVC participation (%) for 1995-2007, 2008-2014, and 2015-2020.

1995-2007	2008-2014	2015-2020
C21 (195%)	C30 (267%)	B07_08 (50.4%)
C31T33 (125%)	C23 (164%)	B05_06 (33.6%)
D (117%)	B07_08 (124%)	C19 (31.1%)
C25 (98.2%)	C16 (122%)	C21 (22.6%)
C28 (59.9%)	C19 (87.2%)	C24 (18.2%)
C27 (57.1%)	C26 (79.1%)	C20 (16.9%)
C22 (56.7%)	D (71.6%)	C28 (12.5%)
C16 (53.4%)	C31T33 (65.1%)	C17_18 (11.7%)
E (51.6%)	C25 (64.6%)	C27 (11.7%)
C13T15 (50.6%)	C29 (62.5%)	C13T15 (11.0%)

Source: Author's elaboration based on calculations on OECD's 2023 ICIOTs
Notes: Cutoff value of 10^{-2} used.

4.2 Results from network analysis

The second part of the results contains the main findings and implications that emanate from Greece's participation and position in the value-added networks that are formed in the context of GVCs. In this sense, it serves as the natural continuation of the rationale and discussion of Section 4.1. The first results concern the average number of connections from all Greek industrial sectors towards other sectors abroad within GVCs.

According to Fig. 4.4, the increase in outgoing GVC connections over the available period indicates that Greece appears to be roughly on par with the EU average, though some interesting points emerge. Its convergence in most cases begins after around 2004-2005, and in recent years a downward trend in maintaining its connections is more apparent. After the 2008 crisis, the outgoing GVC connections trended upwards, surpassing the EU average for some time before converging again recently. On the contrary, incoming GVC connections during the same time consistently fell and rapidly receded below EU average. These patterns outline an apparent extroversion strategy adopted by Greek industrial firms, led by forward-oriented sectors that became more export-intensive (see Table 5.1). The fact that this pattern becomes more evident in the aftermath of the economic crisis, from which arguably Greece was the most affected economy in the EU, can lead to two non-mutually exclusive observations: on the one hand, the country appears to have adopted and exports-oriented

strategy to rejuvenate its economy during a period of financial turmoil, while on the other, the increased number of outgoing connections could be linked to a decrease in domestic demand due to financial constraints of local industrial firms. Similar trends are also observable when we account for the difference between complex vs. simple outgoing connections (Figures 4.5a and b, respectively).

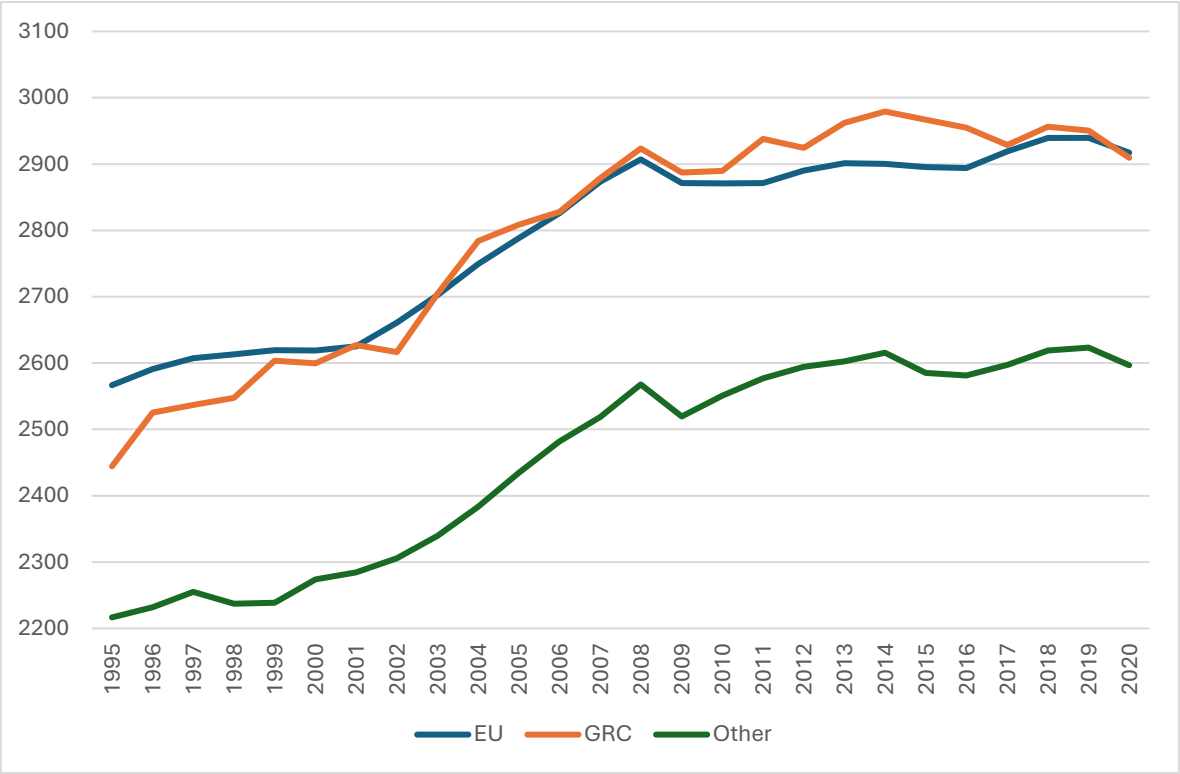
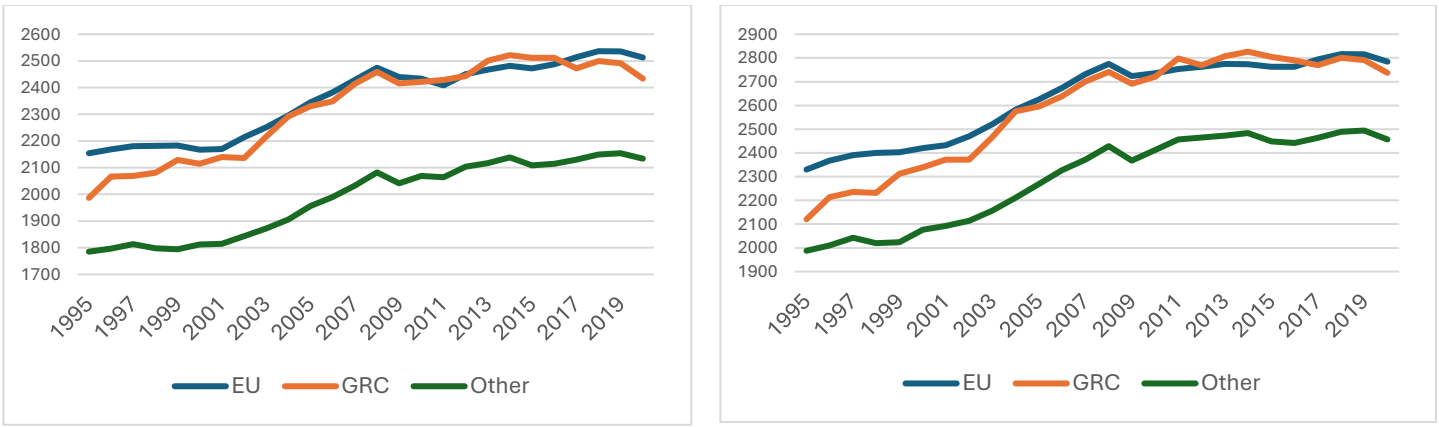


Figure 4.4. Evolution of outgoing connections (out-degree) of Greece, EU27 and the rest of the world economies between 1995 and 2020 within GVCs.
Source: Author's elaboration based on calculations on OECD's 2023 ICIOTs
Notes: Cutoff value of 10^{-2} used. Vertical axis shortened.



(a) (b)

Figure 4.5. Evolution of outgoing connections (out -degree) of Greece, EU27 and the rest of the world economies in the simple (a) and complex (b) GVC network between 1995 and 2020 based on random walks (pagerank)

Source: Author's elaboration based on calculations on OECD's 2023 ICIOTs
Notes: Cutoff value of 10^{-2} used. Vertical axis shortened.

To what concerns incoming connections (Figure 4.6), Greece appears to follow a similar trend with the EU-average during the examined period, although at a slightly higher rate between 1999 and 2013. In the early 2000s, we can observe a significant increase in the number of incoming connections, which is rather expected as it signals the great deepening of GVC activities that was evident at a global scale during that period. Interestingly, while the EU appears to suffer a stiff decline in incoming connections in 2008, Greece's decline appears to be smoother, a fact that indicates the country's strong dependence on critical imported inputs and foreign suppliers. From 2012 onwards, we observe a declining trend in the country's incoming connections, which contradicts the rising trend in outgoing connections during the same period (see Figure 4.4) and indicates an apparent shift in the country's balance of trade.

In terms of simple vs. complex ingoing connections (Figures 4.7a and b, respectively), similar-to-the-aggregate patterns emerge, which are more evident in the case of simple ingoing connections.

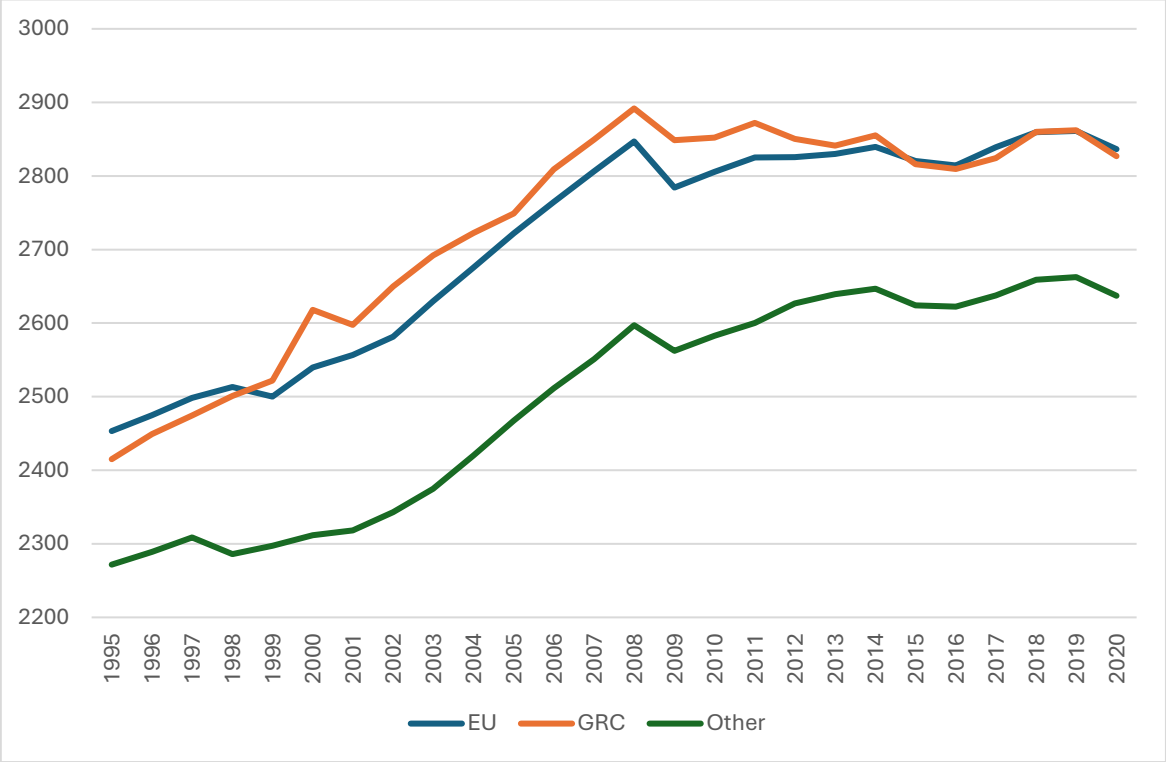


Figure 4.6. Evolution of incoming connections (in-degree) of Greece, EU27 and the rest of the world economies between 1995 and 2020 within GVCs.
Source: Author's elaboration based on calculations on OECD's 2023 ICIOTs
Notes: Cutoff value of 10^{-2} used. Vertical axis shortened.

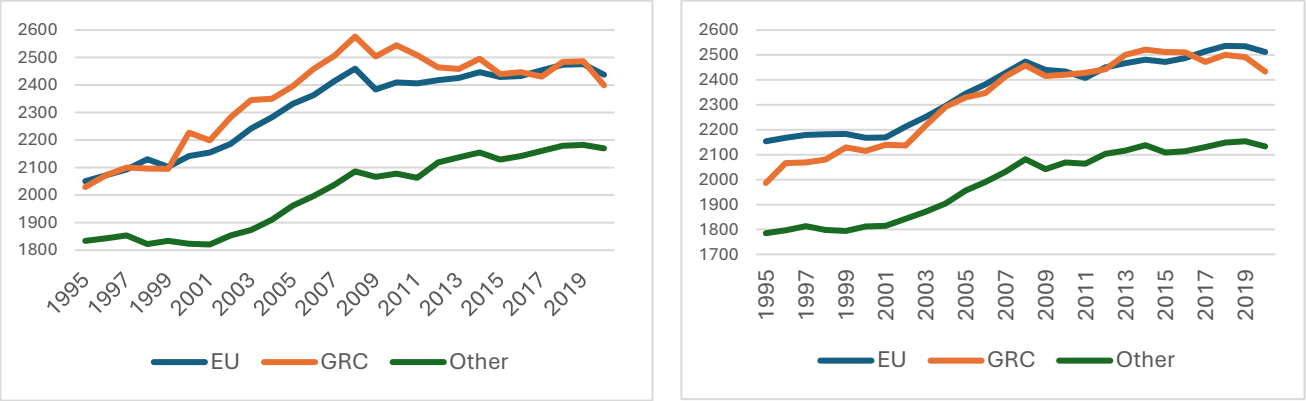


Figure 4.7. Evolution of incoming connections (in-degree) of Greece, EU27 and the rest of the world economies in the simple (a) and complex (b) GVC network between 1995 and 2020 based on random walks (pagerank)
Source: Author's elaboration based on calculations on OECD's 2023 ICIOTs
Notes: Cutoff value of 10^{-2} used. Vertical axis shortened.

When we examine production proximity to its international GVC suppliers (Figure 4.8), no notable difference is observed between Greece and the averages for the EU and the rest of the world, other than a small overperformance of Greece for most of the time. In contrast, its production proximity to its downstream GVC partners (Figure 4.9), follows EU and world averages until the economic crisis, where it then diverges, and while it mirrors the changes in other regions, it never again reaches their level.

An interesting finding emerges when we jointly consider the evidence depicted in Figures 4.4 and 4.9. On the one hand, Greek sectors become increasingly connected with more downstream GVC partners (out-degree deepening) while at the same time, these connections are growing "*thinner*" in terms of VA flows (out-closeness). This implies that most of these production linkages with downstream partners can be associated to simple arms-length trade transactions and not long-term trade relationships that could arguably include the trade of higher shares of VA. In this sense, Greece's export orientation that was highlighted in the previous sections of the analysis has yet to be solidified by long-lasting, large scale, outward VA flows from the country and hints at apparent competitiveness losses for the country. Interestingly, when we compare Figures 4.6 and 4.8 that concern the country's production network relations with upstream suppliers, we observe similar patterns that depict a certain degree of stability in what concerns the country's imports of intermediates.

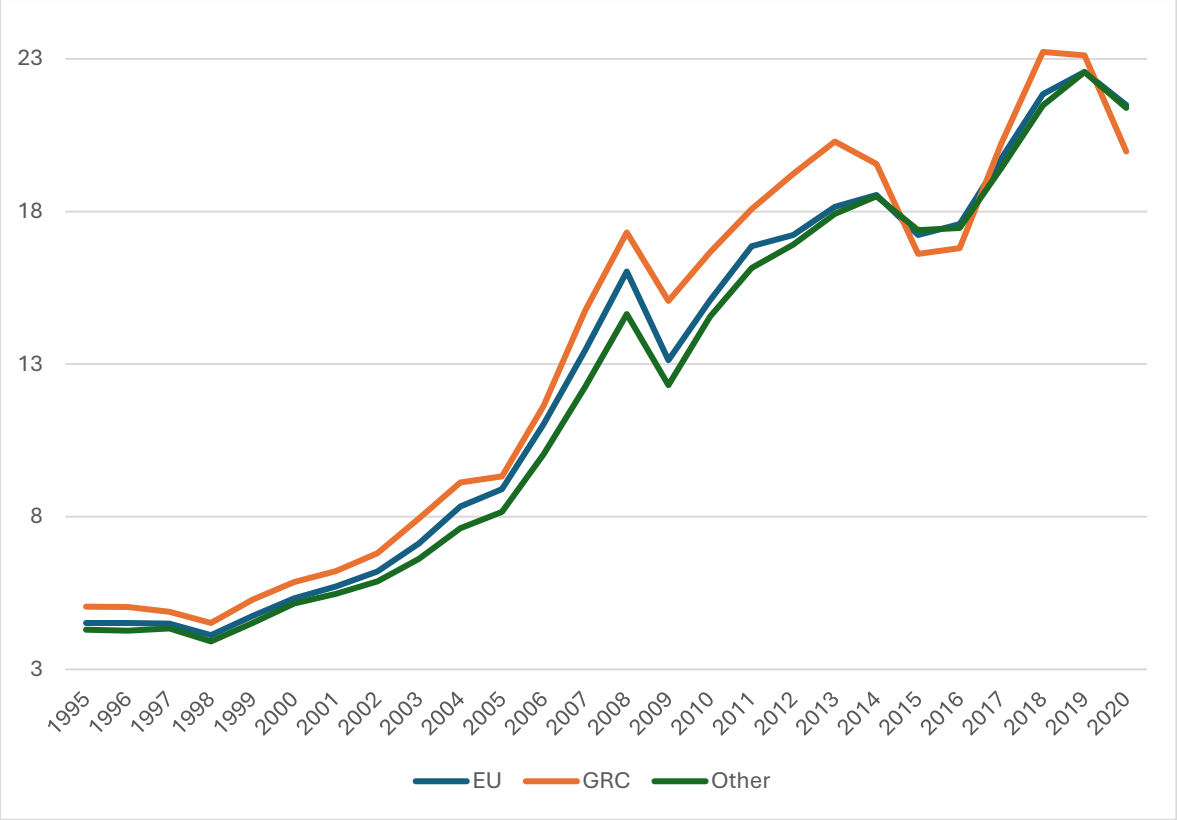


Figure 4.8. Evolution of in-closeness of Greece and average in-closeness of EU27 and the rest of the world economies between 1995 and 2020
Source: Author's elaboration based on calculations on OECD's 2023 ICIOTs
Notes: Cutoff value of 10^{-2} used. Vertical axis shortened.

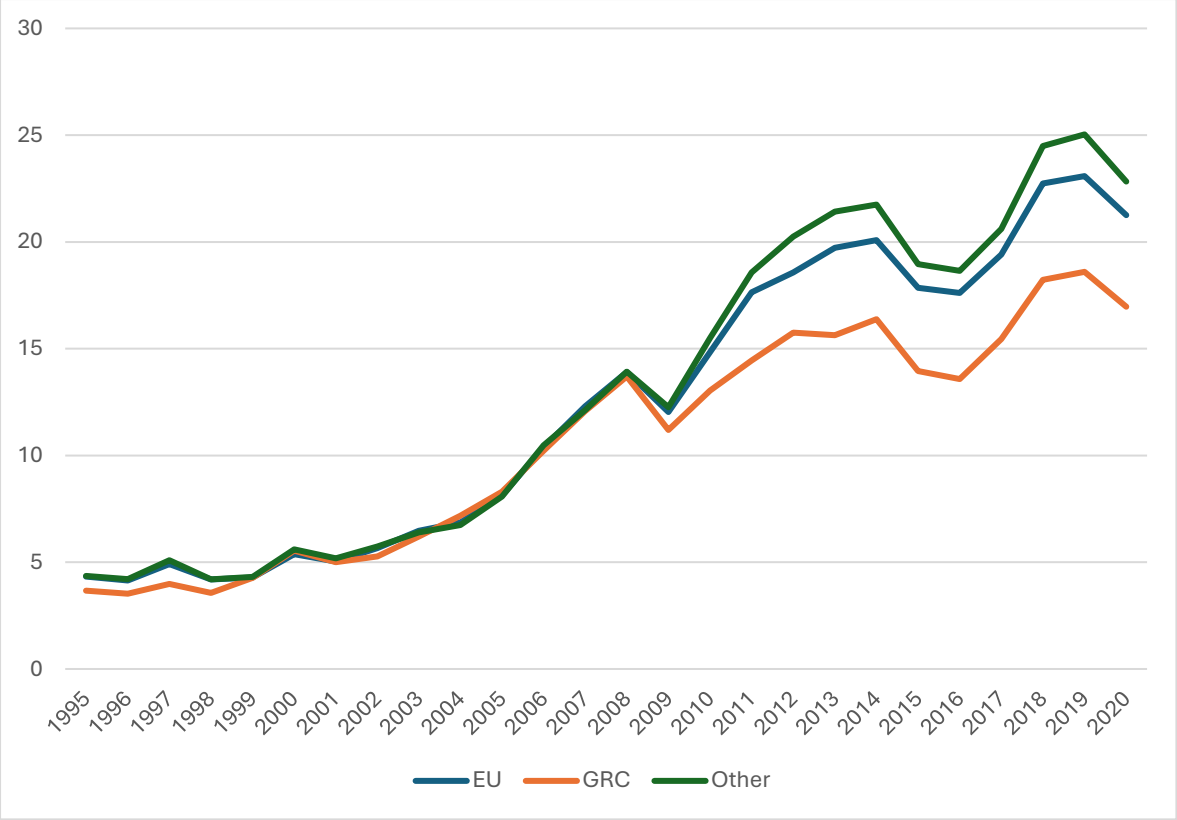


Figure 4.9. Evolution of out-closeness of Greece and average out-closeness of EU27 and the rest of the world economies between 1995 and 2020
Source: Author's elaboration based on calculations on OECD's 2023 ICIOTs
Notes: Cutoff value of 10^{-2} used.

Another notable trend for Greece's and the EU's VA trade evolution is the decline in their relative importance within the GVC network (Figure 4.10). While the EU presented a stable trend until 2008, especially in simple GVC activities (Figure 4.11a), it recedes rapidly after around 2010 and is surpassed by the rest of the world regions, possibly reflecting the emergence of China, Taiwan and the broader East-Asia as dominant forces in GVCs (World Bank, 2020). This is evident for both simple and complex GVC activities (Figures 4.11a and b, respectively), and is compatible with the trends found in Ferrantino & Taglioni (2014) regarding the so-called '*global trade slowdown'*. On the other hand, Greece's trend was rather "noisy" during the period of the great GVC unbundling, signaling an unstable position in international markets for the country, and was followed by a steep decline from 2010 onwards as direct consequence of the financial crisis and the corresponding losses in terms of international competitiveness.

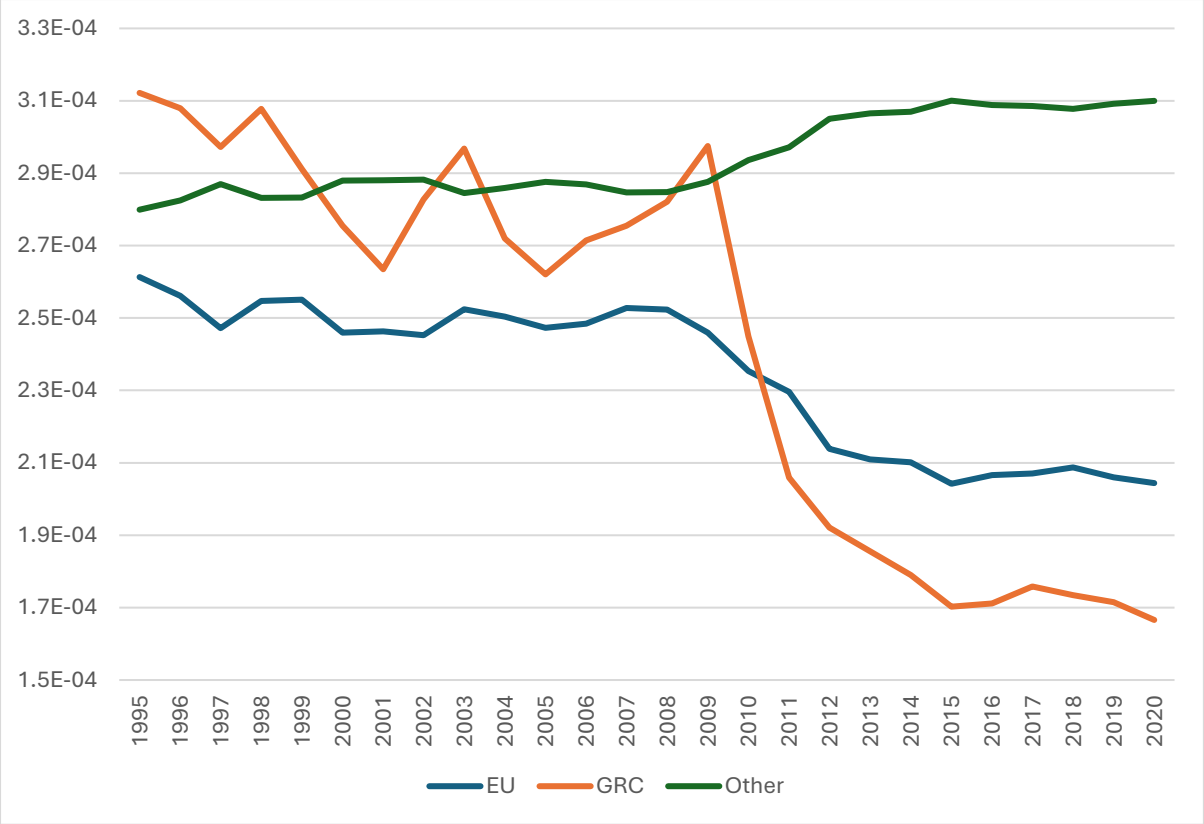
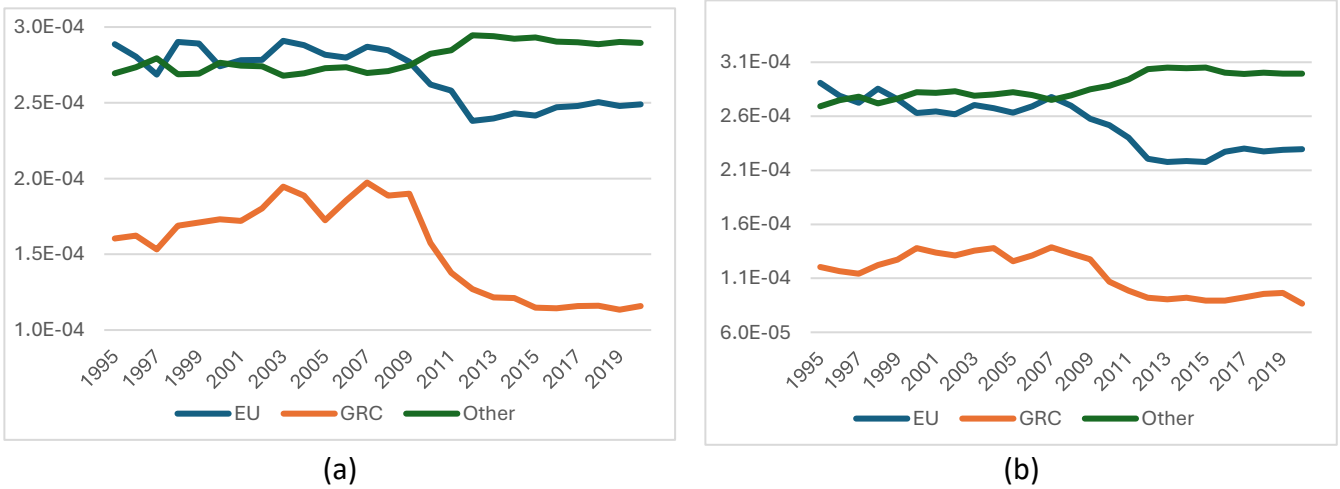


Figure 4.10. Relative importance of Greece, EU27 and the rest of the world economies in the GVC network between 1995 and 2020 based on random walks (pagerank)
Source: Author's elaboration based on calculations on OECD's 2023 ICIOTs
Notes: Cutoff value of 10^{-2} used. Vertical axis shortened.



(a) (b)

Figure 4.11. Relative importance of Greece, EU27 and the rest of the world economies in the simple (a) and complex (b) GVC network between 1995 and 2020 based on random walks (pagerank)
Source: Author's elaboration based on calculations on OECD's 2023 ICIOTs
Notes: Cutoff value of 10^{-2} used. Vertical axis shortened.

From a different standpoint, these patterns can also be captured by contrasting the GVC embeddedness of each country at the start and end of the data coverage (1995 and 2020, Figures 4.12 and 4.13 respectively) in terms of their betweenness centrality in the GVC network. Initially the most prominent nodes are the US and Germany, with the only Asian economy close enough being Japan. In 2020, the picture is partially reversed; the US and Germany are still important economic nodes, but their relative importance has declined. China on the other hand has emerged as the most embedded GVC economy, reflecting the losses of relative importance for the EU as a whole and for its prominent member-states individually. As for Greece, it remains a relatively small and peripheral production node.

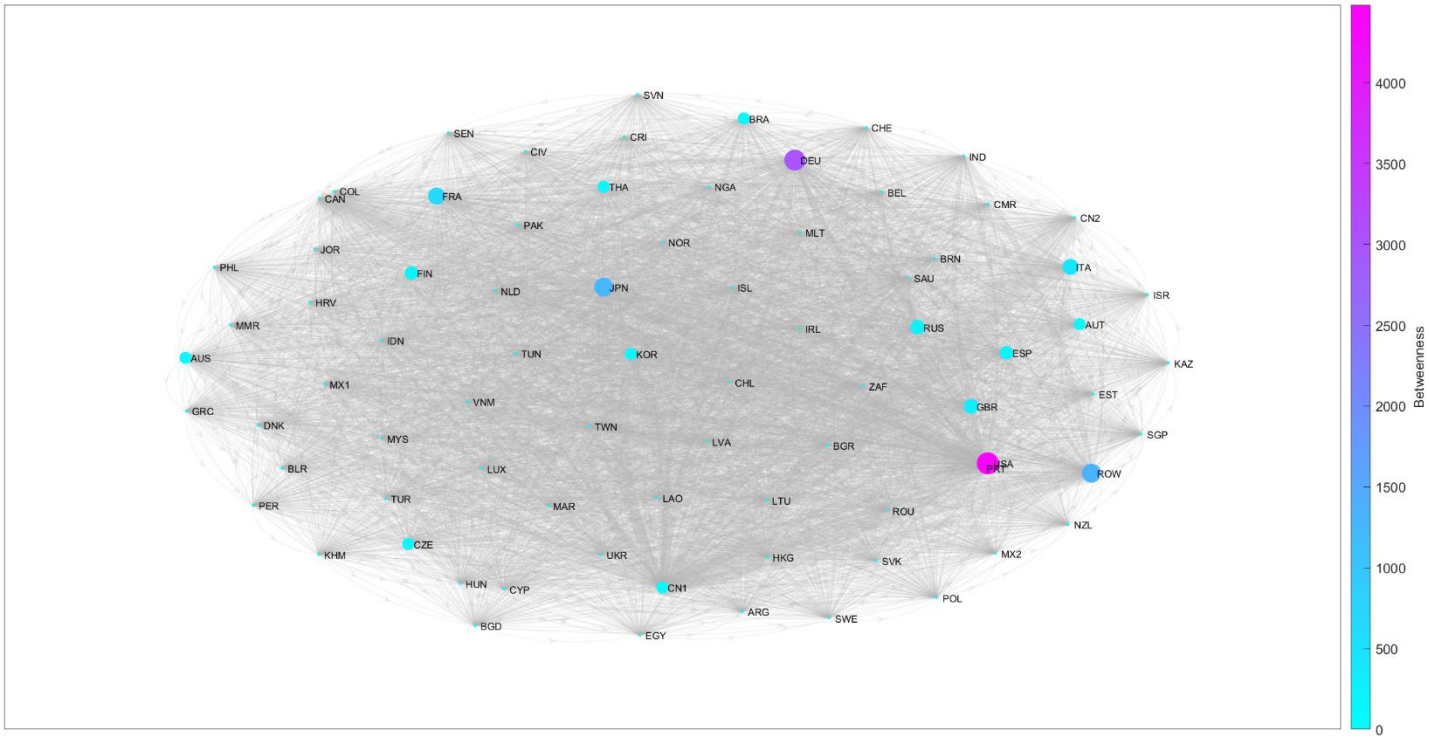


Figure 4.12. GVC embeddedness of major economies in the total GVC network for 1995

Source: Author's elaboration based on calculations on OECD's 2023 ICIOTs
Notes: Cutoff value of 10^{-2} used. Color scale used is same as in Fig. 4.13 for comparisons.

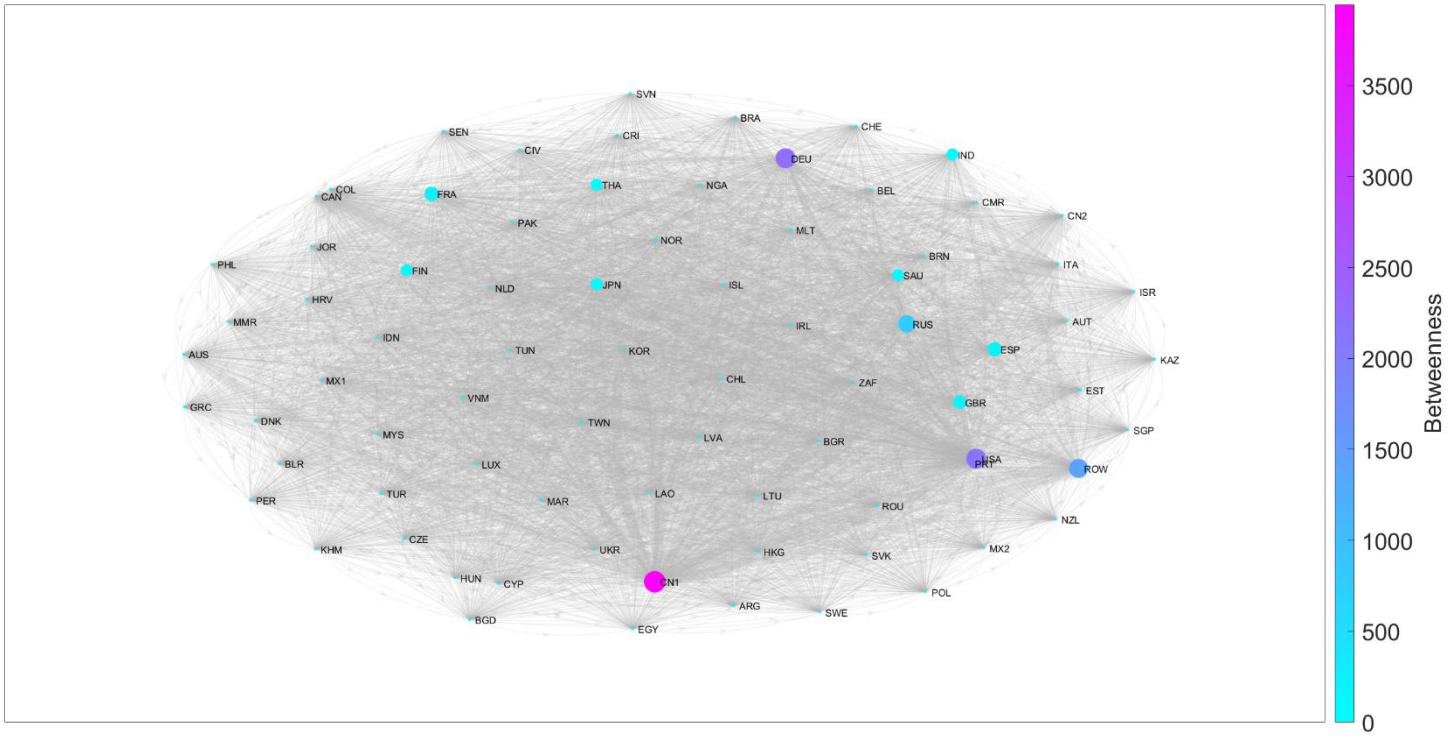


Figure 4.13**.** GVC embeddedness of major economies in the total GVC network for 2020

Source: Author's elaboration based on calculations on OECD's 2023 ICIOTs
Notes: Cutoff value of 10^{-2} used. Color scale used is same as in Fig. 4.12 for comparisons.

5. Concluding remarks

This working paper provides a mapping of Greece's participation and positioning in Global Value Chains at the national and sectoral level from the dual empirical perspectives of input-output and network analysis. The findings so far comprise of diverging trends and patterns, as Greece's trajectory though the last 25 years has been affected both by international forces (as the 2008 crisis and the post 2010 trade slowdown) and internal economic disparities and production limitations. These manifest in declining overall importance in the production network and reduction of the strength of its economic ties, but the picture is more complex than that. We aim to delve deeper into the results in upcoming and updated versions of this paper.

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